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Investment under Borrowing Constraints: Theory and Evidence from Turkey

by

Cemile Sancak

A thesis submitted to
the Faculty of Graduate Studies and Research
in partial fulfillment of
the requirements for the degree of
Doctor of Philosophy

Department of Economics
Carleton University
Ottawa, Ontario, Canada

May 2000

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the Faculty of Graduate Studies and Research
acceptance of the thesis,

**"Investment Under Borrowing Constraints
Theory and Evidence from Turkey"**

submitted by

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in partial fulfilment of the requirements
for the degree of Doctor of Philosophy

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Abstract

The Asian economic crisis has reinforced the importance of efficient financial markets for sustained real investment and economic growth, yet there is still limited empirical research on the effects of the deregulation of financial markets on the firm's investment decisions. The purpose of this thesis is to model the impact of financial reforms on borrowing constraints faced by firms and to test the impact of financial reforms on the investment decisions of firms in Turkey. To do so, the thesis builds a dynamic investment model, where financial variables and real investment are linked through the net present value of the firm. A contribution of this thesis rests on the specification of the financial distress function. Whereas the literature uses a quadratic functional form for the cost of distress, we, instead, assume that the firm faces a risk premium over and above the riskless interest rate. The risk premium is linear in the level of debt. The derived investment model is employed to test whether Turkey's efforts at financial liberalization in 1980 were able to relax the borrowing constraints faced by Turkish firms. A dynamic panel data methodology is used on a panel data set of 1036 Turkish firms over the 1983-1986 period. In addition, time series analysis is employed on Turkish aggregate data over the 1971-1991 period. This study is the first to test the impact of financial liberalization on borrowing constraints by using Turkish firm level data. The current literature offers limited empirical research on firm level investment in a developing country. The results from both panel data and time series data analyses indicate that the financial reforms did not relax the borrowing constraints for Turkish

firms. In the post-reform period, medium firms still faced both an increasing premium and credit rationing. Large firms faced an increasing premium but no credit rationing. There is no evidence of an increasing premium nor credit rationing for small firms. [JEL E22, E44, G2, O16]

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1 Introduction

The objective of this thesis is to evaluate the impact of financial reforms on the investment decisions of the firm. The thesis builds a general framework for linking financial variables and real investment decisions. This framework is then applied to Turkey to assess whether the period of financial liberalization in 1980 relaxed the borrowing constraints faced by Turkish firms and resulted in higher levels of real investment activity.

A large body of literature now emphasizes the positive link between financial markets and economic growth.¹ However, this literature tends to focus on the macroeconomic impact of financial market deregulation and tests their predictions on aggregate data, leaving empirical research on the effects of financial reforms at the firm level limited. Firm level studies can provide more detailed information on how well a country's reforms are able to reduce the problems related to capital market imperfections. Capital market imperfections sometimes arise through direct government controls on interest rates and sector- or industry-specific credit policies. Even in the absence of government intervention, capital market imperfections arise when asymmetric information problems constrain external financing for some firms and restrict their investment. The literature on investment under capital market imperfections introduces a role for financial variables on the investment decisions of the firm. The thesis contributes

¹ See Levine (1997) for a review of this literature.

to this literature by analyzing the impact of financial reforms on the borrowing constraints faced by the firm.

The investment model builds on investment under capital market imperfections literature. The thesis extends the estimable dynamic investment model, where the net present value of a firm is maximized subject to capital market imperfections, to a more precise specification of borrowing constraints. Two types of borrowing constraints are considered: an increasing premium on the firm's debt-to-capital ratio and credit rationing. The paper adopts a specific functional form for the financial distress premium.² This is the first paper to use this functional form for the financial distress function together with a credit-rationing constraint.³ In doing so, the model provides a framework that can be used for analyzing both developing and industrial countries and for addressing the impact of different deregulation policies on financial markets and firms.

This thesis is the first study to use firm level data to investigate the impact of the financial liberalization in the 1980s on the borrowing constraints faced by Turkish firms. It uses the Generalized Method of Moments (GMM) estimation on a panel data set of 1036 Turkish firms over the 1983-1986 period. The current empirical literature provides little research on the impact of financial reforms on firm level investment in a developing country. The few empirical studies on real investment in Turkey, for example, focus on aggregate investment (Conway, 1990; Anand *et al.*, 1990; Günçavdı *et al.*, 1998).

² We prefer to formulate financial distress as a premium rather than a cost because this fits better the practice of giving loans in Turkey.

³ The paper by Jaramillo *et al.* (1996) uses an agency cost function together with a credit-rationing constraint. In their paper, the agency cost function has a quadratic functional form and is treated as a cost rather than a premium.

The advantage of the functional specifications of the thesis is that it is possible to use the same estimable investment equation for both firm level and aggregate data.⁴ Hence, using empirical evidence from panel data, we can determine whether the 1980 financial reforms were successful in relaxing borrowing constraints for small, medium, and large firms in the manufacturing sector in the 1983-1986 period. In addition, the large number of firms in the data set makes it possible to study Turkey's largest industry, the textile industry, in more detail. Then, employing the same model, we can use aggregate data from the 1971-1991 period to provide a comparison between pre- and post-liberalization periods and test for structural change in the financial parameters of the model across time.

The outline of the thesis is as follows. Chapter 1 introduces the motivation for the thesis and discusses its contribution to the literature. Chapter 2 provides the background to the thesis. Section 2.1 provides the macroeconomic background prior to the financial liberalization years in Turkey, outlines the financial liberalization process, and provides an overview of empirical studies on real investment in Turkey. Section 2.2 surveys the literature on investment under capital market imperfections. Chapter 3 develops the theoretical model. It starts with perfect capital markets and sets up the standard model of investment with convex adjustment costs from the literature. It then introduces to this model two types of costs arising from capital market imperfections: a financial distress premium and credit rationing. Chapter 4 presents the empirical analysis with panel data. It describes the nature of the data set and the variables, provides an overview of the

⁴ As a caveat, we emphasize that although we acknowledge that issues of aggregation are important, we abstract from them in our aggregate analysis.

GMM method, and discusses the results of the estimation. Chapter 5 presents the empirical analysis with time series data. Chapter 6 concludes by discussing the results and the contribution of the thesis to the literature.

2 Background

2.1 Financial Liberalization in Turkey

2.1.1 Developments Leading to the Stabilization and Liberalization Program

In the early 1970s, the Turkish economy recorded high growth rates together with a low rate of inflation and a current account surplus. The high growth rate of the economy, which averaged 7.9% in the 1971-1973 period, was primarily due to the high growth rate of real private fixed investment, which averaged 8.1% in the same period. During this period, the Turkish government adopted an inward-looking import substitution strategy. Under the five-year development plans, the government reallocated resources to the manufacturing sector. Intermediate inputs to production were subsidized since the government ensured that the domestic prices of the imported goods were kept below world prices. The overvalued currency and the redistribution of income to state-oriented industrialization policies helped to keep production costs down (Nas, 1992). This strategy created an industry that relied heavily on government protection and on the importation of certain key raw materials and intermediate goods. The investment was financed through domestic borrowing, the remittances of the Turkish workers in Western European countries, and borrowing from international institutions.

The existing inefficiencies of the Turkish industry were soon exacerbated by external shocks initiated by the first oil crisis of 1974. Since Turkey is heavily dependent on the

import of oil, the sharp increase in the price of oil led to a deterioration of Turkey's terms of trade. The government did not devalue in line with the terms of trade, resulting in the real appreciation of the Turkish lira.⁵ While the real appreciation of the currency helped to finance the imports of raw materials and intermediate goods for the Turkish industry, it also led to the stagnation of exports. Furthermore, as the Western European countries were also adversely affected by the oil crisis, the remittances from the Turkish migrant workers started slowing down. As a result of these developments, the current account moved from a surplus of 3.0% of GNP in 1973 to a deficit of 6.5% by 1977. Initially, the current account deficit was financed by foreign exchange reserves, then, as these reserves were depleted, by short-term borrowing. By 1977, the share of short-term debt in total external debt had reached 54.0% from 8.3% in 1973 (Rodrik, 1988; Uygur, 1993). Under these circumstances, Turkey experienced ever-increasing difficulties in financing import and debt service payments. By 1978, the country was insolvent.

At the same time, the fall in exports adversely affected the manufacturing sector with investment in that sector experiencing a particularly sharp decline. Overall, the macroeconomic picture presented a stark contrast with the early 1970s. In the 1978-1980 period, the Turkish economy recorded an average growth rate of only 0.5% with negative growth rates in both 1979 and 1980. The increasing inaccessibility of foreign borrowing led to an inflation rate of 71.1% in 1979 and 105.7% in 1980 as the current account deficit rose to 5.8% of GNP.

⁵ Turkey was following a fixed exchange rate regime in this period. Due to the fast depletion of the foreign exchange reserves, there were later large devaluations (of 23 percent in March 1978 and 44 percent in June 1979 (Kopits, 1987)).

2.1.2 The Financial Liberalization Policies and Developments

In January 1980, Turkey introduced a macroeconomic stabilization and a liberalization program, which was supported by the multilateral institutions, including the IMF, the World Bank, and the OECD. In terms of ordering of policies, the government decided to implement stabilization and liberalization policies simultaneously. In terms of speed of policies, different methods were used for stabilization and liberalization. The government opted for the cold turkey method to bring inflation down but adopted gradualism to implement the liberalization policies. Since the focus of this thesis is financial liberalization, and more specifically, the impact of financial liberalization on real investment, we believe that the Turkish liberalization program constitutes a natural experiment. We therefore start by providing a brief overview of the objectives of the stabilization and liberalization program.

The primary objective of the stabilization program was to reduce the rate of inflation without decreasing the output growth. The program also aimed to reduce the current account deficit. The liberalization program called for adopting flexible commodity and factor prices, liberalization of foreign trade and investment, financial sector liberalization, liberalization of the foreign exchange and payments system, reduction of the size of government, and privatization of public sector enterprises.

Financial sector liberalization began in July 1980 as part of the comprehensive stabilization and liberalization program.⁶ Until this period, the financial sector in Turkey

⁶ The financial policies of the 1980s are explained in detail in Akyüz (1989).

was highly repressed with imposed ceilings on deposit and lending rates. By 1980, these had resulted in negative real interest rates, credit rationing and subsidized credits, high banking sector concentration ratios with concomitant high intermediation costs, and the absence of alternative capital markets. Financial repression and the underdeveloped state of financial markets resulted in inefficient internal savings and investment decisions.

As presented in Chart 2.1, the real interest rate in the pre-reform period was consistently negative each year. The absolute value of the real interest rate increased steadily and reached very high levels in the years before 1980. After the financial reform of 1980, real interest rates were positive with the exception of 1984 and 1988, when the rates were negative, however, not very high in absolute value.

Note that the negative real interest rate in the post-liberalization years is somewhat puzzling. Kopits (1987) provides an explanation for the negative interest rate observed in 1984. He explains that the interest rate increases were insufficient against the reacceleration of inflation in 1984. In other words, the government did not anticipate the inflation rate to jump up and hence, targeted too low nominal interest rates. In fact, Table 2.1 shows that while the inflation rate was steady between 1982 and 1983, with 27.2% in 1982 and 28.0% in 1983, it jumped up to 49.9% in 1984. Similarly, the inflation rate was fairly steady between 1986 and 1987, with 29.6% in 1986 and 32.0% in 1987. However, it increased drastically to 70.5% in 1988. It seems that these sudden increases in the inflation rate were not anticipated by the government.

There were two main objectives in the 1980 financial reforms. One objective was to remove the restrictions on interest rates and to encourage competition in the banking

system through the entry of new financial institutions and instruments. The other objective was to develop a better functioning capital market through the development of bond and equity markets outside the banking system.

This thesis focuses on the banking sector within the Turkish financial system. The reason is that the banking sector has dominated the Turkish financial system both before and after the financial reforms. For example, in terms of the stock of financial assets, bank deposits amounted to 57% of all financial assets in 1979 and 70% in 1986, and in terms of new issues, the share of bank deposits was 64% of all new issues of financial assets in 1979 and about 70% in 1986 (Akyüz, 1990). In this respect, Turkey is similar to many developing economies. The World Development Report 1999/2000 states that the banking sector typically accounts for a high share of the financial market in developing countries. This share is defined as the ratio of the banking sector's assets to the assets of all financial institutions (World Bank, 1999).

The first step in the Turkish financial liberalization was the removal of upper limit on interest rates in July 1980. Banks chose not to raise interest rates despite the increasing upward pressure. The newly established brokers took advantage of this situation and offered higher interest rates than the banks. To compete in the market, banks started offering interest rates comparable to those offered by brokers. As a result, real interest rates increased significantly. Given the underdeveloped state of capital markets, firms continued to borrow at high real interest rates. As the brokers became less selective with the investment projects, the share of nonperforming loans started to increase. By late 1981, several brokers were no longer able to make the interest payments and went

bankrupt. The financial crisis reached its peak when the largest broker declared bankruptcy in June 1982.

In May 1985, new banking legislation was passed to address the structural weakness of the banking system. It included provisions to protect deposits through deposit insurance, standardization of auditing and accounting systems, and the treatment of nonperforming loans.

2.1.3 Empirical Studies on Real Investment in Turkey

There are no empirical studies of the cost and availability of credit for Turkish firms in the post-reform period. More generally, the investment literature on Turkey is limited, with existing research focusing on aggregate investment. Conway (1990) identifies some factors that stimulated aggregate real private investment in Turkey in the 1962-1986 period. However, his model does not capture credit-rationing constraints. Anand *et al.* (1990) provide an econometric study of aggregate real private investment for the 1970-1986 period. They use a proxy for credit rationing, the ratio of credit to the private sector over output, as an explanatory variable and find their proxy to have a strong and significant impact on private sector investment. The most recent study, Günçavdı *et al.* (1998), estimates the impact of financial liberalization on borrowing constraints in the 1964-1993 period, again using aggregate investment. They test for structural change in the equation as a whole and for a shift in the coefficient that captures the binding credit constraints. Their results indicate binding borrowing constraints both before and after the liberalization. Our work is the first to use firm level data to analyze the impact of financial liberalization on investment in Turkey.

2.2 Overview of Investment Literature under Capital Market Imperfections

Capital market imperfections sometimes arise due to government controls on interest rates and directed credit programs. These types of government controls and programs are especially relevant to developing countries. Capital market imperfections also arise due to asymmetric information between borrowers and lenders (Greenwald *et al.*, 1984; Myers and Majluf, 1984), costs of financial distress including bankruptcy costs (Bond and Meghir, 1994), agency costs, transactions costs, and costs of enforcing contracts (Mark and Gertler, 1991). These types of imperfections are relevant to both developing and industrial countries.

The investment literature with capital market imperfections focuses mostly on asymmetric information as the underlying cause of capital market imperfections. This literature does not differentiate between the costs due to misdirected government policies and costs due to asymmetric information. However, most of the discussion is centered around industrial countries, where costs are expected to be due to asymmetric information rather than government-induced costs. Costs due to government controls and programs are more relevant to developing countries. While we believe that it is difficult to separate these two types of costs in an economy, we will aim to focus on government-induced costs in our empirical work. Our goal is to build on the existing investment literature with capital market imperfections and derive an investment model that could be used to test the impact of financial reforms in Turkey. The following is an overview of the existing literature on investment under capital market imperfections.

The assumption of perfect capital markets implies that a firm's financial structure is irrelevant to its real investment decisions. Under perfect capital markets, external financing, that is borrowing and issuing new equity shares, is a perfect substitute for internal financing, that is cash flow and retained earnings. The importance of financial factors in real investment decisions has been emphasized in applied research as early as in the 1950s (Meyer and Kuh, 1957; Duesenberry, 1958). However, since the mid-1960s, there has been a shift in approach to separate financial factors and real investment decisions. Following the work of Modigliani-Miller (1958, 1961), real investment decisions of the firm are separate from its financial structure. According to the Modigliani-Miller theorem, under the absence of (distortionary) taxes and transaction costs and under the assumptions of perfect capital markets and identical corporate and individual borrowing rates, the market value of the firm is independent of leverage (i.e. its debt-to-equity ratio). The cost of capital for the firm is determined by the markets, not by the financial structure of the firm. In this case, real investment decisions, which are obtained by maximizing shareholders' claims, will not depend on financial factors such as liquidity, leverage, or dividends. More recently, an increasing number of investment studies have begun to view external financing as an imperfect substitute for internal financing (Myers and Majluf, 1984; Fazzari *et al.*, 1988; Bond and Meghir, 1994, among others).

If internal and external financing are not perfect substitutes, investment decisions will depend on financial factors such as the availability of internal funds and the firm's access to equity or debt financing. Problems in capital markets, especially asymmetric

information, make it costly for credit institutions to evaluate the quality of firms' investment proposals. This implies that the cost of financing through new debt and equity can be substantially higher than the opportunity cost of using internally generated cash flow and retained earnings. In these cases, real investment decisions will depend on financial factors.

In many of the investment models where financial factors play a role, the reasoning is that if there is a significant cost advantage to internal financing, then investment will be highly correlated with cash flow for those firms that finance their investment primarily through cash flow and retained earnings.

The lemons problem (Akerlof, 1970) as applied to the investment literature is that since creditors cannot evaluate the quality of firms' projects due to asymmetric information, they require a premium to cover the losses from credits given to the "lemons" in the market. The cost of equity financing or debt financing will then be higher than the opportunity cost of internal financing. We will focus our discussion primarily on debt financing since the equity markets were not well-developed in Turkey in the early 1980s.

Increased leverage ratio increases the marginal cost of new debt due to costs of financial distress and agency costs. Asymmetric information in credit markets increases the cost of new debt and can, in the extreme, lead to credit rationing. Based on the lemons argument, lenders cannot differentiate between good loans and bad loans due to asymmetric information. Lenders charge a premium on the interest rate to account for the possibility of default (Stiglitz and Weiss, 1981). In countries where the cost of

obtaining information about firms is very high, lending institutions may prefer to establish long-term relationships with firms. While this is a favourable policy for small and mature firms, it could put young firms at a disadvantage.

The empirical research on investment and financing constraints have used different approaches in modelling the firm's investment decisions. We will now describe the two most common frameworks: Models based on the Q-theory and Euler equation models.

Q-Theory Framework

A number of papers have set up a Tobin's Q investment model and then added financial variables, particularly cash flow, to the model. According to this framework, under perfect capital markets, a value-maximizing firm will invest if the shadow value of an additional unit of capital, that is marginal q, is greater than unity. This framework allows for modelling of the effects of internal finance since q reflects the market's valuation of the firm's investment opportunities. If internal and external financing are perfect substitutes, then a firm's cash flow should not be correlated with its investment. This is due to the fact that under perfect capital markets, internal funds are only one of many sources of investment financing. Unless the cost of external financing is higher than that of internal financing, the availability of internal funds will not constrain investment.

Within this framework, Fazzari *et al.* (1988) explain the significance of financial variables by the hypothesis that firms face a lemons premium, as in Akerlof (1970), associated with new share issues. They test whether the determinants of investment vary between firms for which, a priori, the costs of internal and external financing are similar

and firms for which the costs of external financing exceeds that of internal financing. If financing constraints are important, the investment of firms with good investment opportunities that retain all of their earnings will be more sensitive to cash flow than for high payout firms. They use a panel data set on 421 U.S. manufacturing firms over the period from 1970 to 1984. They estimate their investment equation across firms classified by their dividend behaviour, that is low-dividend-payout firms and high-dividend-payout firms. They find that investment is more sensitive to cash flow and liquidity for firms that retain all of their income.

Alternatively, Devereux and Schiantarelli (1990) hypothesize that it is costly for the lenders to assess the risk involved in a firm's investment project. Lenders, therefore, charge a risk premium for agency costs above the risk-free interest rate. Galeotti *et al.* (1994) consider both agency costs and costs of financial distress. All of these studies find that there is a significant departure from the hypothesis of perfect substitutability between internal and external sources of funds.

In the Q-theory, average Q is used as a proxy for marginal q since marginal q cannot be observed while average Q can be constructed from financial data. However, marginal q is only equal to average Q under the assumptions of perfect competition in the product market and of a constant returns to scale production function. If either of these two assumptions does not hold, the use of average Q will lead to measurement errors. This criticism of Q-theory is exacerbated in investment models with financing constraints due to capital market imperfections.

The use of average Q as a measure of investment opportunities under asymmetric information has been a major criticism of the use of Q -theory in the financing constraints literature. The problems due to proxies for marginal q can be avoided if we use the Euler equation model to describe the firm's optimal investment decision.

The Euler Equation Method

At the optimum, the firm will choose a level of investment such that the marginal cost of investing is equal to the discounted sum of expected future marginal revenue products of capital net of marginal adjustment costs. According to the Euler equation approach, the latter is explicitly modelled instead of assuming that it is equal to marginal q .

A number of papers have used panel data on manufacturing firms to estimate the Euler equations. Whited (1992) parameterizes the unobservable Lagrange multiplier associated with debt such that it is a function of variables in the firm's balance sheets. In this paper, firms are grouped into high-dividend-payout and low-dividend-payout classes. The paper finds that the Euler equation model with perfect capital markets is rejected for firms with low-dividend-payout but cannot be rejected for firms with high-dividend-payout. Bond and Meghir (1994), who use panel data on U.K. firms, find that investment is correlated with lagged cash flow after controlling for leverage and output fluctuations. Jaramillo *et al.* (1996) apply the Euler equation model to a developing country, Ecuador. They test the significance of borrowing constraints and find that these constraints were significant for young or small firms but not significant for large or mature firms. Other research papers provided further evidence to reject the hypothesis of perfect capital

markets using the Euler equation model. Schiantarelli *et al.* (1993), Hubbard *et al.* (1995), Galeotti *et al.* (1994), and Ng and Schaller (1996) are among some of these papers.

Both the Q-theory approach and the Euler equation approach are based on the neoclassical model of investment with convex costs of adjusting the capital stock. An alternative approach that could be used in the investment literature with financing constraints is irreversibility and uncertainty on the firm's investment decisions. These models assume that there does not exist an efficient secondary market for capital goods. Investment decisions are similar to call options. Irreversibility models could make a contribution to this literature in explaining ranges of inaction in investment. We have preferred using the Euler equation technique for the following reasons.

First, we wanted to avoid the common criticisms of the Q-theory, as described above. Furthermore, Q-theory would not be appropriate for Turkey since Turkey did not have well-developed equity markets in the 1980s. We have preferred using the Euler equation technique over irreversible investment since we wanted to estimate our investment equation using Turkish panel data. The panel data set is available for a short time period, too short to be able to estimate an irreversible investment equation.

The thesis uses Euler equations to examine the effects on investment of two types of costs related to debt financing. The first one is the premium above the risk-free interest rate faced by firms that borrow, arising from the risk of financial distress and increasing in the firm's debt-to-capital ratio. Costs of financial distress occur when it becomes difficult for a firm to honour the interest or even principal payments of its debt. The

extreme case of financial distress is bankruptcy. The second type of cost arises when firms face credit rationing, that is, when there is an exogenous upper limit on the debt-to-capital ratio (Jaffe and Russell, 1976; Stiglitz and Weiss, 1981; Schiantarelli *et al.*, 1993). These two types of costs arising from financial market imperfections can occur in both developing and industrial countries. However, they are likely to be more pronounced in developing countries, where the infrastructure for the lending institutions is not as well established as in industrial countries. In addition, in developing countries, there are often administrative controls on bank borrowing and lending rates and limited alternative sources for external financing.

2.3 Summary

This chapter provided an account of the macroeconomic developments in the 1970s leading to the stabilization and liberalization program in Turkey. It explained that the main objectives of the 1980 financial liberalization were to remove the upper limit on the interest rates and to encourage competition in the banking sector. The review of empirical studies on real investment in Turkey showed that there are only a few studies in the literature, and furthermore, all of these studies are on aggregate investment.

The chapter also provided an overview of the investment literature under capital market imperfections. Possible reasons for capital market imperfections, such as asymmetric information problems, were discussed. The chapter then described the most commonly used investment models and reviewed some of the empirical papers that have used these models to test for financing constraints. The chapter provided two main reasons as to why we have chosen the Euler equation method rather than the Q-theory

framework in this thesis. The first one is the common criticism that average Q may not be a good proxy for marginal q , and the second one is the absence of well-developed equity markets in the 1980s in Turkey.

2.4 Tables and Charts

Table 2.1
Selected Economic Indicators of Turkey, 1971-1991

	1971- 1973	1974- 1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Real GNP	7.9	7.8	3.9	2.9	-0.4	-1.1	4.1	4.5	3.3	5.9	5.1	8.1	7.5	3.6	1.9	9.2	0.3
Real Fixed Investment	5.7	19.4	3.9	-10.0	-3.6	-10.0	1.7	3.5	3.0	0.4	16.9	11.0	5.4	-1.3	-1.0	13.9	-0.4
Public	3.5	23.0	11.0	-13.7	4.6	-3.7	9.4	2.2	1.9	-4.7	23.1	7.5	-3.7	-13.7	-5.8	8.0	3.8
Private	8.1	16.3	-2.7	-6.0	-11.6	-17.3	-8.7	5.5	4.7	8.4	8.2	16.4	18.6	13.5	3.3	18.8	-3.5
Implicit GNP Deflator	18.1	20.4	24.5	43.7	71.1	105.7	41.9	27.2	28.0	49.9	43.2	29.6	32.0	70.5	64.0	52.3	55.3
Real Interest Rate	-7.9	-12.5	-15.5	-33.7	-53.8	-79.7	6.7	22.8	14.5	-4.9	6.8	22.7	17.8	-1.3	3.0	5.1	11.7
Current Account	1.5	-3.7	-6.5	-2.4	-2.0	-5.8	-3.3	-1.8	-3.8	-2.8	-1.9	-2.5	-1.2	2.3	1.2	-2.4	0.2
Total Debt	26.3	19.1	23.2	27.6	22.2	25.0	28.6	32.8	35.6	41.0	47.5	54.7	59.0	57.5	52.0	44.5	44.6
Exchange Rate	14	15	18	24	31	76	111	163	225	367	522	675	857	1422	2122	2609	4172
	(Liras per U.S. Dollar)																

Sources: The International Financial Statistics Yearbook of the IMF, various issues; The Economic Surveys, Turkey, of the OECD, various issues.

Chart 2.1
Real Interest Rate

3 Theoretical Model

3.1 The Standard Model of Investment with Perfect Capital Markets

In this section, it is assumed that external financing is a perfect substitute for internal financing. Hence, the investment decision of the firm is modelled as independent of its financial structure. We take this model from the literature and will later use it as the benchmark for our model, where external financing is no longer a perfect substitute for internal financing due to capital market imperfections.

3.1.1 Definitions and Assumptions

We assume that the firm faces strictly convex costs of adjustment in changing its capital stock. The cost of adjustment function is $G(I_t, K_t) = \frac{1}{2}bK_t\left[\frac{I_t}{K_t}\right]^2$, where b is the marginal adjustment cost parameter, I_t is investment, and K_t is the capital stock. $G(\cdot)$ is a time-invariant, symmetric adjustment cost function and is convex in the rate of investment or disinvestment. Adjustment costs arise because there are costs associated with the installation or disinstallation of capital. The production function is $F(K_t, L_t)$, where L_t denotes all variable (costlessly adjustable) factors of production. We assume that the production function displays constant returns to scale. It is increasing, concave, and satisfies the Inada conditions. The price of output is p_t , and the vector of prices for the variable inputs is w_t . The price of output, p_t , and the price of investment goods, p_t^K ,

are stochastic. $p_t = \bar{p} + u_t$, and $p_t^K = \bar{p}^K + u_t^K$, where u_t and u_t^K are independently and identically distributed (i.i.d.) $\forall t$. We will assume that p_t is a function of output so that we can allow for imperfect competition. The price elasticity of demand, ε , is constant. Finally, we assume symmetric information.

3.1.2 The Model and the Solution

The optimal choice of variable factors involves static optimization under certainty. We can define the short-run (restricted) profit function at time t , $R(K_t, I_t, w_t, p_t)$, as

$$\begin{aligned} R(K_t, I_t, w_t, p_t) &\equiv \max_{L_t \geq 0} \left\{ p_t F(K_t, L_t) - w_t L_t - p_t G(I_t, K_t) \right\} \\ &\equiv p_t F(K_t, L^*(K_t, w_t, p_t)) - w_t L^*(K_t, w_t, p_t) - p_t G(I_t, K_t) \end{aligned} \quad (1.1)$$

where $L_t^* = L^*(K_t, w_t, p_t)$ denotes the optimal choice of the costlessly variable factors.

The cash flow function is given by

$$\Pi(K_t, I_t, w_t, p_t, p_t^K) = R(K_t, I_t, w_t, p_t) - p_t^K I_t. \quad (1.2)$$

For notational simplicity, in our solution to the optimization problem, we will keep $\Pi(\cdot)$ in its implicit form.

The representative firm has an infinite horizon. r_t is the firm's nominal required rate of return between periods t and $t+1$, and $\beta_t = \frac{1}{(1+r_t)}$ is the firm's discount factor,

$0 < \beta_t < 1$, as in Bond and Meghir (1992)⁷. In the absence of taxes, r_t is equal to the interest rate on default-free bonds.

In this framework, we are assuming that the firm uses a deterministic and constant (though possibly time-varying) discount factor. The constancy of the discount factor is clearly an assumption made for convenience since the conditions under which this assumption is appropriate will rarely hold in practice for any firm.

To see this, consider a general equilibrium framework where consumers own the firms.⁸ They maximize the expected present value of utility subject to a wealth constraint by choosing sequences for consumption, shares of equity, and bonds. The goal of the firm is to maximize the wealth of its shareholders by maximizing the expected present value of future net revenues. In this context, the appropriate discount factor for the firm is given by the optimality conditions of the consumer's problem and is equal to the consumers' intertemporal rate of substitution (MRS), that is $\frac{U'(C_{t+1})}{U'(C_t)}$. Unless individuals are identical, their MRSs will differ across states of the world, and therefore, so will the firm's discount factor. However, when there exist complete contingent claims markets, the heterogeneous consumers will equate their respective MRSs to the prices of the state-contingent commodities (expressed in terms of the current commodity). Thus, the MRS

⁷ In the investment literature, r_t is called the required rate of return due to the arbitrage condition between the shares of a firm and a riskless asset. Let V_t be the value of the firm at time t and D_t be the dividends of the firm at time $t+1$. If risk neutral individuals arbitrage between the shares of the firm and the riskless asset, then the expected rate of return on the shares must equal the riskless rate:

$$\frac{(E_t V_{t+1} - V_t) + E_t D_{t+1}}{V_t} = r_t$$

⁸ The following discussion is based on Blanchard and Fischer (1992), Chapter 6.

of all of the different individual consumers will be the same for each state of the world. The firm will then use these state-contingent prices to obtain the present value of their stream of profits. However, the existence of complete state-contingent markets is still not enough to justify the use of a deterministic and constant discount factor for the firm. We need to make one additional assumption. If consumers are risk neutral, and therefore have linear utility functions, then the firms' discount factor will be equal to the consumers' own subjective discount factor.

Hence clearly, since these conditions do not usually hold, the assumption of a constant discount factor is simply made for convenience. (In this respect, we follow the great majority of the literature on investment.)

Alternatively, instead of using a uniform constant discount factor across all firms, we could take into account the correlation between the firm's returns and the returns to the "market portfolio." Thus, for example, a firm with highly pro-cyclical cash flows would adjust the "risk-free rate" r by a higher risk premium than a firm whose cash flow is less pro-cyclical since the latter constitutes less of a risk for consumers. A firm whose cash flow is counter-cyclical would have a negative premium to reflect the fact that its assets constitute a hedge for consumers. However, again in the interest of simplicity, we will use a constant discount factor for the firms in our study.

We will now set up the model. The objective of the firm is to maximize the wealth of the marginal shareholder. The firm chooses a sequence of future investment plans, $\{I_t\}_{t=0}^{\infty}$, to maximize the expected present value of future cash flows, subject to the law of motion for the capital stock, $K_t = (1 - \delta)K_{t-1} + I_t$, where $0 < \delta < 1$ is the constant rate

of depreciation for capital. At t , the firm chooses I_t , which augments its capital stock to K_t . The firm's time t investment is immediately productive at t . In this model, the timing is such that investment decisions taken within one period become productive in the same period. While this timing is somewhat unusual relative to the investment literature, it is often used in the empirical literature on credit rationed firms (see, for example, Bond and Meghir, 1994). In our framework, this assumption is motivated by data availability, more specifically, by the short time span of the panel data set that is available. Given that we will be using annual data (as opposed to quarterly data), this assumption is relatively innocuous since it is plausible that decisions taken at the beginning of a year be also executed within the same year. The firm solves the following dynamic problem:

$$\max_{\{I_t\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t \Pi(K_t, I_t, w_t, p_t)$$

subject to

$$K_t = (1 - \delta)K_{t-1} + I_t \quad t = 0, \dots, \infty \quad (1.3)$$

given K_1 . The expectations operator, $E_t[\cdot]$, is conditional on the information available at the beginning of period t .

Using Bellman's Principle of Optimality, we can derive the maximal expected present value of the future net revenues of the firm as

$$V(K_{t-1}) = \max_{I_t} \left\{ \Pi(K_t, I_t, w_t, p_t, p_t^K) + \beta_t E_t[V(K_t)] \right\}$$

subject to

$$K_t = (1 - \delta)K_{t-1} + I_t, \quad (1.4)$$

given K_{-1} .

$$\Rightarrow V(K_{t-1}) = \max_{I_t} \left\{ \Pi \left([(1 - \delta)K_{t-1} + I_t], I_t, w_t, p_t \right) + \beta_t E_t \left[V \left((1 - \delta)K_{t-1} + I_t \right) \right] \right\} \quad (1.5)$$

The first order condition for investment is

$$I_t: \quad \frac{\partial \Pi}{\partial K_t} (1) + \frac{\partial \Pi}{\partial I_t} + \beta_t E_t \frac{\partial V}{\partial K_t} (1) = 0. \quad (1.6)$$

Multiply this equation by $(1 - \delta)$ to get

$$(1 - \delta) \frac{\partial \Pi}{\partial K_t} + (1 - \delta) \frac{\partial \Pi}{\partial I_t} + (1 - \delta) \beta_t E_t \frac{\partial V}{\partial K_t} = 0. \quad (1.7)$$

Using the envelope theorem, we obtain

$$\frac{\partial V}{\partial K_{t-1}} = (1 - \delta) \frac{\partial \Pi}{\partial K_t} + (1 - \delta) \beta_t E_t \left[\frac{\partial V}{\partial K_t} \right], \quad (1.8)$$

and updating (1.8), we get

$$\frac{\partial V}{\partial K_t} = (1 - \delta) \frac{\partial \Pi}{\partial K_{t+1}} + (1 - \delta) \beta_{t+1} E_{t+1} \left[\frac{\partial V}{\partial K_{t+1}} \right]. \quad (1.9)$$

We next use the updated first order condition for investment.

$$\frac{\partial \Pi}{\partial K_{t+1}} + \frac{\partial \Pi}{\partial I_{t+1}} + \beta_{t+1} E_{t+1} \left[\frac{\partial V}{\partial K_{t+1}} \right] = 0 \quad (1.10)$$

$$\Rightarrow \beta_{t+1} E_{t+1} \left[\frac{\partial V}{\partial K_{t+1}} \right] = - \frac{\partial \Pi}{\partial K_{t+1}} - \frac{\partial \Pi}{\partial I_{t+1}}. \quad (1.11)$$

Therefore, we obtain

$$\frac{\partial V}{\partial K_t} = (1 - \delta) \frac{\partial \Pi}{\partial K_{t+1}} - (1 - \delta) \frac{\partial \Pi}{\partial K_{t+1}} - (1 - \delta) \frac{\partial \Pi}{\partial I_{t+1}}. \quad (1.12)$$

$$\Rightarrow \frac{\partial V}{\partial K_t} = - (1 - \delta) \frac{\partial \Pi}{\partial I_{t+1}} \quad (1.13)$$

Hence, by substituting for $\frac{\partial V}{\partial K_t}$ into the first order condition for investment, we obtain the following Euler equation.

$$\frac{\partial \Pi}{\partial K_t} + \frac{\partial \Pi}{\partial I_t} - \beta_t E_t (1 - \delta) \left[\frac{\partial \Pi}{\partial I_{t+1}} \right] = 0. \quad (1.14)$$

To interpret the above Euler equation, recall the optimality condition for the choice of investment, equation (1.6), where the firm equates the marginal cost of investing, $\frac{\partial \Pi}{\partial I_t}$, to the sum of the current marginal benefit, $\frac{\partial \Pi}{\partial K_t}$, and of the discounted future marginal value of an additional unit of capital, $\beta_t E_t \frac{\partial V}{\partial K_t}$. Due to the assumption of rational expectations and the use of explicit functional forms of the $\Pi(.)$ function, the first order difference equation (1.14) represents an estimable form of this relationship. (Please note that within the cash flow function, we would also parameterize the production and the adjustment cost functions.)

3.2 The Model of Investment with Borrowing Constraints

The standard model of investment derived in the previous section incorporates the assumptions underlying the Modigliani-Miller theorem, which states that the firm's financing decisions are irrelevant to its optimal investment choice. As shown in equation (1.14), the firm's optimal investment choice depends only on the firm's production decisions, such as how much to invest, how much labour to hire, and how much to produce. The optimal investment choice does not depend on the financial structure of the firm, such as the amount of equity issues, the debt-to-capital ratio, or retained earnings. As long as the firm issues risk-free debt, debt policy is irrelevant to the firm's investment decisions.

In this section, we will modify the assumption of symmetric information. We will then build on the above benchmark model by introducing borrowing constraints. Hence, we now assume asymmetric information

We modify the standard model of investment with perfect capital markets so that there are imperfections with respect to the loan market (however, there are no imperfections in equity markets). For debt financing, the firm faces a premium —above the risk-free interest rate— that increases with the debt-to-capital ratio. In addition, there is a maximum limit on the debt-to-capital ratio.

Since our model is based on imperfect capital markets and, hence, on incomplete markets, it is not completely comparable with a general equilibrium framework. In other words, issues arise in regard to the appropriate objective function and discount factor used by the firm. In the sequel, we follow the literature on investment and focus on the

real physical investment activity of business firms. Hence, we sidestep the issues pertaining to the separation of ownership from control of business firms.

3.2.1 Definitions and Assumptions

We will assume that there is asymmetric information between the borrower (shareholders) and the lender. Define D_t as dividends paid in period t , and N_t as the value of new shares issued in period t . The value of the firm at time t , V_t , is given by the expected present value of the future stream of dividends minus the expected present value of the future stream of new shares. Following Bond and Meghir (1994), we introduce a difference between the personal income tax rate on dividend and interest income (m_t) and the tax rate on capital gains (z_t). We define γ_t as $\gamma_t = \frac{1 - m_t}{1 - z_t}$. Note that since we have now introduced taxes, the firm's nominal required rate of return, r_t , will no longer be equal to the interest rate on default-free bonds.

The value of the firm is given by

$$V_t = E_t \sum_{j=0}^{\infty} \beta_t^j \left[\gamma_{t+j} D_{t+j} - N_{t+j} \right], \quad (2.1)$$

where $\beta_t^j = \prod_{i=0}^j \left(\frac{1}{1 + r_{t+i}} \right)$ and $0 < \beta_t^j < 1 \quad \forall t$. Firms maximize the value of the firm subject to the following constraints.

1) Cash flow identity:

A cash flow identity holds between the firm's sources of funds (i.e. internally generated funds plus external financing) and expenditures. External financing consists of

new share issues plus borrowing (by issuing new debt) less the costs of borrowing. Note that there is no time structure of debt in this model, that is, debt is repaid each period. The cash flow identity for a firm that issues both new shares and one-period debt can be represented as follows:

$$D_t = (1 - \tau_t) \left[p_t F(K_t, L_t^*) - p_t G(I_t, K_t) - w_t L_t^* - \left(i_{t-1} + \Psi(B_{t-1}, v_{t-1}) \right) B_{t-1} \right] + (B_t - B_{t-1}) - p_t^K I_t + N_t \quad (2.2)$$

where τ_t is the corporate tax rate, and i_{t-1} is the nominal interest rate (determined in period $t-1$) on one-period loans issued in period $t-1$. The number of one-dollar, one-period loans is denoted by B_t . $(B_t - B_{t-1})$ is the increase in nominal debt at time t , $\Psi(\cdot)$ is the financial distress function (we will comment more on this function in section 3.2.2), and $v_{t-1} = p_{t-1}^K K_{t-1}$. $\Psi(\cdot)$ represents the premium paid above the nominal interest rate. This premium is due to the asymmetric information between the borrower and the lender. In the literature, this nominal interest rate, i_{t-1} , is referred to as the risk-free interest rate. What we mean by risk-free is that the interest rate is free of financial distress risk associated with the firm's leverage ratio, however, it does capture the risk associated with macroeconomic conditions in the country. For example, the one-year interest rate on government Treasury bills would be considered the risk-free interest rate.

2) Credit-rationing constraint:

The firm also faces an upper limit (credit ceiling) on its debt-to-capital ratio. Beyond this limit, the firm becomes too risky for lenders and, therefore, credit is rationed (Whited, 1992).

$$\frac{B_{t-1}}{p_{t-1}^K K_{t-1}} \leq \bar{B} \quad (2.4)$$

3) Capital accumulation constraint:

$$K_t = I_t + (1 - \delta)K_{t-1} \quad (2.5)$$

4) Nonnegativity constraints:

$$\begin{aligned} D_t &\geq 0 \\ B_t &\geq 0 \\ N_t &\geq 0 \end{aligned} \quad (2.6)$$

3.2.2 Functional Specifications

The Financial Distress Function

We parameterize the financial distress function as

$$\Psi(B_{t-1}, v_{t-1}) = a \left(\frac{B_{t-1}}{v_{t-1}} \right) \quad a > 0. \quad (2.3)$$

Given this specification, the interest rate on debt issued at the end of period $t-1$ is equal to the nominal interest rate, i_{t-1} , plus a premium that is constant with respect to the leverage

ratio, i.e. $\frac{\partial \Psi}{\partial \left(\frac{B_{t-1}}{v_{t-1}}\right)} = a > 0$. The marginal financial distress premium with respect to B_{t-1} is

$$\frac{\partial \Psi}{\partial B_{t-1}} = \frac{a}{v_{t-1}} > 0, \text{ which implies that the higher the amount borrowed, the higher the}$$

financial distress premium. The marginal financial distress premium with respect to v_{t-1}

$$\text{is } \frac{\partial \Psi}{\partial v_{t-1}} = -a \frac{B_{t-1}}{v_{t-1}^2} < 0, \text{ which implies that the higher the collateral of the firm, the lower}$$

the financial distress premium.

There are a number of alternative functional forms that the financial distress function could take. We will consider three different alternatives.

First, we could have a function such as $\Psi(B_{t-1}, v_{t-1}) = \frac{a}{2} \left(\frac{B_{t-1}}{v_{t-1}}\right) B_{t-1}$, which is convex

in the leverage ratio, that is $\frac{\partial^2 \Psi}{\partial \left(\frac{B_{t-1}}{v_{t-1}}\right)^2} = \frac{a}{2} v_{t-1} > 0$. In this case, we would have an

increasing risk premium at the margin. When we tried incorporating this function to the model, we found that it is difficult to collect the terms and interpret the results of the final estimable equation since the above convex function has to be multiplied by B_{t-1} in the model. We have also tried incorporating the convex financial distress function as an added term on its own, as opposed to being multiplied by B_{t-1} . In this case, the results we obtained were similar to the results presented in the thesis.

Second, $\Psi(\cdot)$ could be any smooth function satisfying an Inada condition in the following sense. If $\left(\frac{B_{t-1}}{v_{t-1}}\right)$ ratio reaches an exogenously determined ceiling, $\left(\frac{B_{t-1}}{v_{t-1}}\right)_{MAX}$, then financial distress costs are infinite, that is

$$\lim_{\left(\frac{B_{t-1}}{v_{t-1}}\right) \rightarrow \left(\frac{B_{t-1}}{v_{t-1}}\right)_{MAX}} \Psi\left(\frac{B_{t-1}}{v_{t-1}}\right) = \infty.$$

Currently our model is designed to test for two separate conditions: an increasing premium for borrowing and a credit-rationing constraint. With the current specification, the empirical results can indicate that the firm is facing the former but not the latter. The drawback with a more general functional form such as the one described above is that these two conditions cannot be separated, that is, as $\left(\frac{B_{t-1}}{v_{t-1}}\right)$ increases, the firms will face an increasing premium, but they will never hit a credit ceiling.

A third possible form for the financial distress function could be that $\Psi(\cdot)$ is no longer smooth but has kinks, that is, different terms of loans apply to different ranges of $\left(\frac{B_{t-1}}{v_{t-1}}\right)$ ratios (Eaton and Gersovitz, 1981). Within each range, there is a ceiling, $\left(\frac{B_{t-1}}{v_{t-1}}\right)^*$, and a corresponding amount of loan, B_{t-1}^* . If a firm wishes to borrow an amount $B_{t-1} > B_{t-1}^*$, it is rationed. If the firm wishes to borrow an amount $B_{t-1} < B_{t-1}^*$, then the credit ceiling is not binding. However, this functional form is difficult to work with since the standard rules of differentiation do not apply in this case.

We will use the linear specification of the financial distress function, $\Psi(B_{t-1}, v_{t-1}) = a\left(\frac{B_{t-1}}{v_{t-1}}\right)$, as described earlier and add the explicit credit-rationing constraint $\frac{B_{t-1}}{p_{t-1}^K K_{t-1}} \leq \bar{B}$. For notational simplicity, until the empirical part of the thesis, we will express $\Psi(\cdot)$ as a general function of B_{t-1} and v_{t-1} .

The Cash Flow Function

As explained earlier, the cash flow function is parameterized as

$$\Pi(K_t, L_t, I_t) = p_t F(K_t, L_t) - p_t G(I_t, K_t) - w_t L_t - p_t^K I_t, \quad (1.2)$$

where $G(I_t, K_t) = \frac{1}{2} b K_t \left[\frac{I_t}{K_t} \right]^2$. The variable p_t in the cash flow function represents marginal revenue. If we want to allow for imperfect competition, we can set the marginal revenue equal to $p_t \left[1 - \frac{1}{|\varepsilon|} \right]$, where ε is the constant elasticity of demand facing the

imperfectly competitive firm, i.e. $\varepsilon(y) = \frac{p}{y} \frac{dy}{dp}$. Then,

$$\frac{\partial \Pi}{\partial I_t} = -\alpha b p_t \frac{I_t}{K_t} - p_t^K,$$

where $\alpha = 1 - \frac{1}{\varepsilon}$, and

$$\frac{\partial \Pi}{\partial K_t} = \alpha p_t \frac{Y_t}{K_t} - \alpha p_t \left(\frac{\partial F}{\partial L_t} \frac{L_t}{K_t} \right) + \frac{1}{2} b \alpha p_t \left(\frac{I_t}{K_t} \right)^2.$$

In the above equation, we have assumed that $F(K_t, L_t)$ is homogeneous of degree one in its arguments. (Given the functional specification for $G(I_t, K_t)$, we know that the adjustment cost function is also homogeneous of degree one.) By Euler's Theorem,

$$Y_t = \frac{\partial F}{\partial K_t} K_t + \frac{\partial F}{\partial L_t} L_t$$

$$\Rightarrow \quad \frac{\partial F}{\partial K_t} = \frac{Y_t}{K_t} - \frac{\partial F}{\partial L_t} \frac{L_t}{K_t}.$$

3.2.3 The Model and the Solution

The firm solves the following discrete time problem to determine the optimal levels of K_t , I_t , D_t , B_t , and N_t .

$$\max E_t \sum_{j=0}^{\infty} \beta_t^j \left[\gamma_{t+j} D_{t+j} - N_{t+j} \right]$$

subject to

$$D_t = (1 - \tau_t) \left[p_t F(K_t, L_t^*) - p_t G(I_t, K_t) - w_t L_t^* - (i_{t-1} + \Psi(B_{t-1}, v_{t-1})) B_{t-1} \right] + (B_t - B_{t-1}) - p_t^K I_t + N_t \quad (2.2)$$

$$\frac{B_{t-1}}{v_{t-1}} \leq \bar{B} \quad (2.4)$$

$$K_t = I_t + (1 - \delta) K_{t-1} \quad (2.5)$$

$$\begin{aligned} D_t &\geq 0 \\ B_t &\geq 0 \\ N_t &\geq 0 \end{aligned} \quad (2.6)$$

The Lagrangian function is

$$\begin{aligned} Z_t = E_t \sum_{j=0}^{\infty} \beta_t^j \{ & \gamma_{t+j} ((1 - \tau_{t+j}) [p_{t+j} F(K_{t+j}, L_{t+j}^*) - p_{t+j} G(I_{t+j}, K_{t+j}) - w_{t+j} L_{t+j}^* \\ & - (i_{t+j-1} + \Psi(B_{t+j-1}, v_{t+j-1})) B_{t+j-1}] + (B_{t+j} - B_{t+j-1}) - p_{t+j}^K I_{t+j} + N_{t+j}) - N_{t+j} \} \\ & + \lambda_t^c \left[\bar{B} - \frac{B_{t-1}}{v_{t-1}} \right] \end{aligned} \quad (2.4)$$

$$+ \lambda_t^K \left[I_t + (1 - \delta) K_{t-1} - K_t \right] \quad (2.5)$$

$$+ \lambda_t^D D_t \quad (2.6)$$

$$+ \lambda_t^B B_t \quad (2.6)$$

$$+ \lambda_t^N N_t \quad (2.6)$$

where λ_t^C , λ_t^K , λ_t^D , λ_t^B , and λ_t^N are the Lagrange multipliers associated with the credit-rationing constraint, the law of motion for the capital stock, the non-negativity constraint on dividends, the non-negativity constraint on debt (implying no lending for the firm), and the non-negativity constraint on new shares, respectively.

The Kuhn-Tucker conditions are

$$\frac{\partial Z_t}{\partial K_t} = (\gamma_t + \lambda_t^D) (1 - \tau_t) \left(\alpha p_t \frac{\partial F}{\partial K_t} - \alpha p_t \frac{\partial G}{\partial K_t} \right) - E_t \beta_{t+1} (\gamma_{t+1} + \lambda_{t+1}^D) (1 - \tau_{t+1}) \frac{\partial \Psi}{\partial v_t} p_t^K B_t \quad (2.7)$$

$$+ \lambda_t^C \frac{B_t}{p_t^K K_t^2} + E_t \beta_{t+1} \lambda_{t+1}^K (1 - \delta) - \lambda_t^K \leq 0$$

$$K_t \geq 0 \quad (2.8)$$

$$\frac{\partial Z_t}{\partial K_t} K_t = 0 \quad (2.9)$$

$$\frac{\partial Z_t}{\partial I_t} = -(\gamma_t + \lambda_t^D) (1 - \tau_t) \left(\alpha p_t \frac{\partial G}{\partial I_t} \right) - (\gamma_t + \lambda_t^D) p_t^K + \lambda_t^K = 0 \quad (2.10)$$

$$\begin{aligned} \frac{\partial Z_t}{\partial B_t} = & -E_t \beta_{t+1} (\gamma_{t+1} + \lambda_{t+1}^D) (1 - \tau_{t+1}) i_t - E_t \beta_{t+1} (\gamma_{t+1} + \lambda_{t+1}^D) (1 - \tau_{t+1}) \left(\Psi + B_t \frac{\partial \Psi}{\partial B_t} \right) \\ & + (\gamma_t + \lambda_t^D) - E_t \beta_{t+1} (\gamma_{t+1} + \lambda_{t+1}^D) - E_t \beta_{t+1} \lambda_{t+1}^C \frac{1}{p_t^K K_t} + \lambda_t^B \leq 0 \end{aligned} \quad (2.11)$$

$$B_t \geq 0 \quad (2.12)$$

$$\frac{\partial Z_t}{\partial B_t} B_t = 0 \quad (2.13)$$

$$\frac{\partial Z_t}{\partial N_t} = (\gamma_t + \lambda_t^D) + \lambda_t^N - 1 \leq 0 \quad (2.14)$$

$$N_t \geq 0 \quad (2.15)$$

$$\frac{\partial Z_t}{\partial N_t} N_t = 0 \quad (2.16)$$

$$\frac{\partial Z_t}{\partial \lambda_t^C} \geq 0 \quad (2.17),$$

$$\lambda_t^C \geq 0 \quad (2.18),$$

$$\frac{\partial Z_t}{\partial \lambda_t^C} \lambda_t^C = 0 \quad (2.19)$$

$$\frac{\partial Z_t}{\partial \lambda_t^K} \geq 0 \quad (2.20),$$

$$\lambda_t^K \geq 0 \quad (2.21),$$

$$\frac{\partial Z_t}{\partial \lambda_t^K} \lambda_t^K = 0 \quad (2.22)$$

$$\frac{\partial Z_t}{\partial \lambda_t^D} \geq 0 \quad (2.23),$$

$$\lambda_t^D \geq 0 \quad (2.24),$$

$$\frac{\partial Z_t}{\partial \lambda_t^D} \lambda_t^D = 0 \quad (2.25)$$

$$\frac{\partial Z_t}{\partial \lambda_t^B} \geq 0 \quad (2.26),$$

$$\lambda_t^B \geq 0 \quad (2.27),$$

$$\frac{\partial Z_t}{\partial \lambda_t^B} \lambda_t^B = 0 \quad (2.28)$$

$$\frac{\partial Z_t}{\partial \lambda_t^N} \geq 0 \quad (2.29),$$

$$\lambda_t^N \geq 0 \quad (2.30),$$

$$\frac{\partial Z_t}{\partial \lambda_t^N} \lambda_t^N = 0 \quad (2.31)$$

In the finite horizon problem, the complementary slackness conditions for B_t and K_t would imply that it is not optimal to have the present values of terminal debt and capital stock positive. Taking the limit at $T \rightarrow \infty$ yields the transversality conditions for the infinite horizon problem. Namely,

$$\lim_{T \rightarrow \infty} (\beta_T B_T) = 0 \text{ and } \lim_{T \rightarrow \infty} (\beta_T K_T) = 0 \quad \forall t. \quad (2.32)$$

The case of $D_t > 0$ and $N_t > 0$

It is not optimal for the firm to issue new shares and pay dividends at the same time, provided $\gamma_t \left(= \frac{1 - m_t}{1 - z_t} \right) < 1$ (which implies that the personal income tax rate is higher than the tax rate on capital gains). If $N_t > 0$, then $\lambda_t^N = 0$ from the complementary slackness condition (2.31). Then, equation (2.14) implies that $\lambda_t^D = 1 - \gamma_t > 0$, and, therefore, $D_t = 0$ from the complementary slackness condition (2.25). Similarly, if $D_t > 0$, then $\lambda_t^D = 0$, and $\lambda_t^N > 0$, which implies that $N_t = 0$.

The case of $D_t = 0$ and $N_t > 0$

Alternatively, we could derive the Euler equation for capital when the firm finances its investment at the margin by new equity and does not pay dividends. In this case, even though λ_t^D and λ_{t+1}^D are unobservable, we could obtain $\lambda_t^D = 1 - \gamma_t$ from equation (2.14).

The case of $D_t = 0$ and $N_t = 0$

If a firm uses up all its retained earnings such that dividends are zero and it is optimal not to issue new shares, then investment is financed only through debt. In this case,

$\lambda_t^N, \lambda_{t+1}^N \geq 0$, and $\lambda_t^D, \lambda_{t+1}^D \geq 0$, which implies that the unobservable multipliers $\lambda_t^D, \lambda_{t+1}^D$ cannot be eliminated from the Euler equation for capital.

The case of $D_t > 0$ and $N_t = 0$

Assume that current and future dividends are positive and no new shares are issued. In this case, from the above argument, $\lambda_t^D = \lambda_{t+1}^D = 0$. The Euler equation for capital is determined by using the first order conditions for investment, equation (2.10), and for capital, equation (2.7). Using equation (2.10) and assuming that $\lambda_t^D = \lambda_{t+1}^D = 0$, we get

$$\lambda_t^K = \gamma_t (1 - \tau_t) \left(\alpha p_t \frac{\partial G}{\partial I_t} \right) + \gamma_t p_t^K. \quad (2.33)$$

With $K_t > 0$, equation (2.7) equals zero. Hence, substituting the above expression into (2.7) with $\lambda_t^D = 0$, we get

$$\begin{aligned} & \gamma_t (1 - \tau_t) \left(\alpha p_t \frac{\partial F}{\partial K_t} - \alpha p_t \frac{\partial G}{\partial K_t} \right) - E_t \beta_{t+1} \gamma_{t+1} (1 - \tau_{t+1}) \frac{\partial \Psi}{\partial v_t} p_t^K B_t \\ & + E_t \beta_{t+1} \lambda_{t+1}^c \frac{B_t}{p_t^K K_t^2} + E_t \beta_{t+1} (1 - \delta) \left(\gamma_{t+1} (1 - \tau_{t+1}) \left(\alpha p_{t+1} \frac{\partial G}{\partial I_{t+1}} \right) + \gamma_{t+1} p_{t+1}^K \right) \\ & - \left(\gamma_t (1 - \tau_t) \left(\alpha p_t \frac{\partial G}{\partial I_t} \right) + \gamma_t p_t^K \right) = 0 \end{aligned} \quad (2.34)$$

If we set $\gamma_t = \gamma_{t+1} = 1$ and $\tau = 0$, we could write the above equation in a more implicit form as

$$- E_t \beta_{t+1} (1 - \delta) \left[\frac{\partial \Pi}{\partial I_{t+1}} \right] = - \frac{\partial \Pi}{\partial K_t} - \frac{\partial \Pi}{\partial I_t} + E_t \beta_{t+1} \lambda_{t+1}^c \frac{B_t}{p_t^K K_t^2} + E_t \beta_{t+1} \frac{\partial \Psi}{\partial v_t} p_t^K B_t. \quad (2.35)$$

Let us compare equation (2.35) to the Euler equation for capital obtained from the standard model of investment, equation (1.14). Except for the last two expressions on the right hand side, all other expressions are the same, that is, the unconstrained model is nested within the finance-constrained model (note that previously $\gamma_t = \gamma_{t+1} = 1$). The last two expressions are associated with the credit-ceiling constraint and the financial distress premium, respectively. Note that in this equation, λ_t^C , the multiplier associated with the debt ceiling is unobservable.

In our analysis, we will consider the case where $D_t > 0$ and $N_t = 0$. This case is the most relevant for a developing country where the cost and availability of debt are of great importance for the firm's investment decisions. The dominance of the banking system within the financial system of the developing country and the relatively undeveloped nature of bond and equity markets are the main reasons why borrowing is the most common method of financing investment. In Turkey, the share of equities and corporate bonds in the total stock of financial assets was only 8.4% in 1979 and 4.3% in 1986. The share of new issues of equities and corporate bonds in the total new issues of financial assets was 5.1% in 1979 and 3.4% in 1986 (Akyüz, 1990). In this case, the relevant equation is equation (2.35).

3.2.4 Euler Equation with a Non-binding Credit Constraint

In this section, we consider the case where the firm finances its investment through retained earnings and new debt, i.e. $D_t > 0$ and $N_t = 0$, but the credit rationing constraint is not binding, i.e. $\lambda_t^C = 0$.

We would now like to explain how we deal with expectations. We use rational expectations and assume that the expected and actual values differ by a random forecast error, v_{t+1} . This error term is uncorrelated with any information known at time t . If we now replace expected by actual values, we can rewrite equation (2.35) as

$$\begin{aligned}
 & -\beta_{t+1}\gamma_{t+1}(1-\delta)\left((1-\tau_{t+1})\left(\alpha_{p_{t+1}}\frac{\partial G}{\partial I_{t+1}}\right)+p_t^\kappa\right)= \\
 & \gamma_t(1-\tau_t)\left(\alpha_{p_t}\frac{\partial F}{\partial K_t}-\alpha_{p_t}\frac{\partial G}{\partial K_t}\right) \\
 & -\gamma_t\left((1-\tau_t)\left(\alpha_{p_t}\frac{\partial G}{\partial I_t}\right)+p_t^\kappa\right)-\beta_{t+1}\gamma_{t+1}(1-\tau_{t+1})\frac{\partial \Psi}{\partial v_t}p_t^\kappa B_t+v_{t+1}
 \end{aligned} \tag{2.36}$$

$$\begin{aligned}
 & -\beta_{t+1}\gamma_{t+1}(1-\delta)\left((1-\tau_{t+1})\alpha_{p_{t+1}}b\frac{I_{t+1}}{K_{t+1}}+p_t^\kappa\right)= \\
 & \gamma_t(1-\tau_t)\left(\alpha_{p_t}\frac{Y_t}{K_t}-\alpha_{p_t}\left(\frac{\partial F}{\partial L_t}\frac{L_t}{K_t}\right)+\frac{1}{2}\alpha_{p_t}b\left(\frac{I_t}{K_t}\right)^2\right) \\
 & -\gamma_t\left((1-\tau_t)\alpha_{p_t}b\frac{I_t}{K_t}+p_t^\kappa\right)-\beta_{t+1}\gamma_{t+1}(1-\tau_{t+1})a\left(\frac{B_t}{v_t}\right)^2p_t^\kappa+v_{t+1}
 \end{aligned} \tag{2.37}$$

$$\begin{aligned}
 & -\beta_{t+1}\gamma_{t+1}(1-\delta)(1-\tau_{t+1})\alpha_{p_{t+1}}b\frac{I_{t+1}}{K_{t+1}}= \\
 & \beta_{t+1}\gamma_{t+1}(1-\delta)p_t^\kappa \\
 & +\gamma_t(1-\tau_t)\left(\alpha_{p_t}\frac{Y_t}{K_t}-\alpha_{p_t}\left(\frac{w_t}{\alpha_{p_t}}\frac{L_t}{K_t}\right)+\frac{1}{2}\alpha_{p_t}b\left(\frac{I_t}{K_t}\right)^2\right) \\
 & -\gamma_t(1-\tau_t)\alpha_{p_t}b\frac{I_t}{K_t}-\gamma_t p_t^\kappa+\beta_{t+1}\gamma_{t+1}(1-\tau_{t+1})a\left(\frac{B_t}{v_t}\right)^2p_t^\kappa+v_{t+1}
 \end{aligned} \tag{2.38}$$

In equation (2.38), we have used the first order condition where the marginal products of the variable factors, $\frac{\partial F}{\partial L_t}$, are equal to $\left(\frac{w_t}{\alpha p_t}\right)$. Divide equation (2.38) by

$-\beta_{t+1}\gamma_{t+1}(1-\delta)(1-\tau_{t+1})\alpha p_{t+1}b$ to get

$$\begin{aligned} \frac{I_{t+1}}{K_{t+1}} = & -\frac{\beta_{t+1}\gamma_{t+1}(1-\delta)p_{t+1}^\kappa}{\beta_{t+1}\gamma_{t+1}(1-\delta)(1-\tau_{t+1})\alpha p_{t+1}b} - \frac{\gamma_t(1-\tau_t)\alpha p_t}{\beta_{t+1}\gamma_{t+1}(1-\delta)(1-\tau_{t+1})\alpha p_{t+1}b} \frac{Y_t}{K_t} \\ & + \frac{\gamma_t(1-\tau_t)}{\beta_{t+1}\gamma_{t+1}(1-\delta)(1-\tau_{t+1})\alpha p_{t+1}b} \frac{w_t L_t}{K_t} - \frac{\gamma_t(1-\tau_t)\alpha p_t b}{2\beta_{t+1}\gamma_{t+1}(1-\delta)(1-\tau_{t+1})\alpha p_{t+1}b} \left(\frac{I_t}{K_t}\right)^2 \\ & + \frac{\gamma_t(1-\tau_t)\alpha p_t b}{\beta_{t+1}\gamma_{t+1}(1-\delta)(1-\tau_{t+1})\alpha p_{t+1}b} \frac{I_t}{K_t} + \frac{\gamma_t}{\beta_{t+1}\gamma_{t+1}(1-\delta)(1-\tau_{t+1})\alpha p_{t+1}b} p_t^\kappa \\ & - \frac{\beta_{t+1}\gamma_{t+1}(1-\tau_{t+1})}{\beta_{t+1}\gamma_{t+1}(1-\delta)(1-\tau_{t+1})\alpha p_{t+1}b} \left(a\left(\frac{B_t}{v_t}\right)^2 p_t^\kappa\right) + v_{t+1} \\ \\ \frac{I_{t+1}}{K_{t+1}} = & -\frac{1}{(1-\tau_{t+1})\alpha b} \frac{p_{t+1}^\kappa}{p_{t+1}} - \frac{\gamma_t(1-\tau_t)}{\beta_{t+1}\gamma_{t+1}(1-\delta)(1-\tau_{t+1})b} \frac{p_t}{p_{t+1}} \frac{Y_t}{K_t} \\ & + \frac{\gamma_t(1-\tau_t)}{\beta_{t+1}\gamma_{t+1}(1-\delta)(1-\tau_{t+1})\alpha p_{t+1}b} \frac{w_t L_t}{K_t} - \frac{\gamma_t(1-\tau_t)}{2\beta_{t+1}\gamma_{t+1}(1-\delta)(1-\tau_{t+1})} \frac{p_t}{p_{t+1}} \left(\frac{I_t}{K_t}\right)^2 \\ & + \frac{\gamma_t(1-\tau_t)}{\beta_{t+1}\gamma_{t+1}(1-\delta)(1-\tau_{t+1})} \frac{p_t}{p_{t+1}} \frac{I_t}{K_t} + \frac{\gamma_t}{\beta_{t+1}\gamma_{t+1}(1-\delta)(1-\tau_{t+1})\alpha b} \frac{p_t^\kappa}{p_{t+1}} \\ & - \frac{1}{(1-\delta)\alpha b} \frac{p_t^\kappa}{p_{t+1}} a\left(\frac{B_t}{v_t}\right)^2 + v_{t+1} \end{aligned}$$

After some rearrangements, we get

$$\begin{aligned} \frac{I_{t+1}}{K_{t+1}} = & -\frac{1}{(1-\tau_{t+1})\alpha b} \frac{p_{t+1}^\kappa}{p_{t+1}} - \frac{\phi_{t+1}}{b} \frac{Y_t}{K_t} + \frac{\phi_{t+1}}{\alpha b} \frac{w_t L_t}{p_t K_t} \\ & - \frac{\phi_{t+1}}{2} \left(\frac{I_t}{K_t}\right)^2 + \phi_{t+1} \frac{I_t}{K_t} + \frac{\phi_{t+1}}{(1-\tau_t)\alpha b} \frac{p_t^\kappa}{p_t} \\ & - \frac{a}{(1-\delta)\alpha b} \frac{p_t^\kappa}{p_{t+1}} \left(\frac{B_t}{v_t}\right)^2 + v_{t+1} \end{aligned} \quad (2.39)$$

where $\phi_{t+1} = \frac{\gamma_t(1-\tau_t)}{\gamma_{t+1}(1-\tau_{t+1})(1-\delta)\beta_{t+1}} \frac{p_t}{p_{t+1}}$, and $\frac{1}{\beta_{t+1}} \frac{p_t}{p_{t+1}}$ is the real discount rate, as in

Bond and Meghir (1994). Collecting the terms in equation (2.39), we get

$$\begin{aligned} \frac{I_{t+1}}{K_{t+1}} = & \frac{\phi_{t+1}}{(1-\tau_t)\alpha b} \frac{p_t^\kappa}{p_t} - \frac{1}{(1-\tau_{t+1})\alpha b} \frac{p_{t+1}^\kappa}{p_{t+1}} - \frac{\phi_{t+1}}{b} \frac{Y_t}{K_t} + \frac{\phi_{t+1}}{\alpha b} \frac{w_t L_t}{p_t K_t} \\ & - \frac{\phi_{t+1}}{2} \left(\frac{I_t}{K_t} \right)^2 + \phi_{t+1} \frac{I_t}{K_t} - \frac{a}{(1-\delta)\alpha b} \frac{p_t^\kappa}{p_{t+1}} \left(\frac{B_t}{v_t} \right)^2 + v_{t+1} \end{aligned} \quad (2.40)$$

Rearrange the above equation so that it is exactly identified, that is, all structural parameters of the model can be recovered.

$$\begin{aligned} \frac{I_{t+1}}{K_{t+1}} - \phi_{t+1} \left(\frac{I_t}{K_t} \right) + \frac{\phi_{t+1}}{2} \left(\frac{I_t}{K_t} \right)^2 + \eta_1 \left(\phi_{t+1} \frac{w_t L_t}{p_t K_t} + \frac{\phi_{t+1}}{(1-\tau_t)} \frac{p_t^\kappa}{p_t} - \frac{1}{(1-\tau_{t+1})} \frac{p_{t+1}^\kappa}{p_{t+1}} \right) \\ + \eta_2 \left(\phi_{t+1} \frac{Y_t}{K_t} \right) + \eta_3 \left(\frac{1}{(1-\delta)} \frac{p_t^\kappa}{p_{t+1}} \left(\frac{B_t}{v_t} \right)^2 \right) = v_{t+1} \end{aligned} \quad (2.41)$$

where $\eta_1 = \frac{-1}{\alpha b}$, $\eta_2 = \frac{1}{b}$, $\eta_3 = \frac{a}{\alpha b}$. The slope of the financial distress function, coefficient a , determines the relationship between the interest rate faced by the firm and its debt-to-capital ratio.

3.2.5 Euler Equation with a Binding Credit Constraint

If the credit constraint is binding, then λ_t^c in equation (2.34) will no longer be equal to zero. In this case, we can eliminate λ_t^c by using the first order condition for debt. Assuming dividends are still positive, we have $\lambda_t^D = E_t \lambda_{t+1}^D = 0$. Since debt is also

positive, $\lambda_t^B = 0$. Then, from the equation for the first order condition of B_t , equation (2.11), we have

$$E_t \beta_{t+1} \lambda_{t+1}^C \frac{1}{p_t^K K_t} = -E_t \beta_{t+1} \gamma_{t+1} (1 - \tau_{t+1}) i_t - E_t \beta_{t+1} \gamma_{t+1} (1 - \tau_{t+1}) \left(\Psi + B_t \frac{\partial \Psi}{\partial B_t} \right) + \gamma_t - E_t B_{t+1} \gamma_{t+1}$$

$$\Rightarrow E_t \beta_{t+1} \lambda_{t+1}^C = p_t^K K_t \left(\gamma_t - E_t \beta_{t+1} \gamma_{t+1} - E_t \beta_{t+1} \gamma_{t+1} (1 - \tau_{t+1}) \left(i_t + 2a \frac{B_t}{v_t} \right) \right). \quad (2.42)$$

The Euler equation for capital is again determined by using the first order conditions for investment, equation (2.10), and for capital, equation (2.7). Recall that combining equations (2.7) and (2.10), we had obtained equation (2.34). We now substitute equation (2.42) into equation (2.34). After we substitute in the appropriate derivatives and replace the expected values with the actual values, as we did in the previous section, we get

$$\begin{aligned} & -\beta_{t+1} \gamma_{t+1} (1 - \delta) (1 - \tau_{t+1}) \alpha p_{t+1} b \frac{I_{t+1}}{K_{t+1}} = \\ & \beta_{t+1} \gamma_{t+1} (1 - \delta) p_{t+1}^K \\ & + \gamma_t (1 - \tau_t) \left(\alpha p_t \frac{Y_t}{K_t} - \alpha p_t \left(\frac{w_t}{\alpha p_t} \frac{L_t}{K_t} \right) + \frac{1}{2} \alpha p_t b \left(\frac{I_t}{K_t} \right)^2 \right) \\ & - \gamma_t (1 - \tau_t) \alpha p_t b \frac{I_t}{K_t} - \gamma_t p_t^K \\ & + \beta_{t+1} \gamma_{t+1} (1 - \tau_{t+1}) a \left(\frac{B_t}{v_t} \right)^2 p_t^K \\ & + p_t^K K_t \left(\gamma_t - \beta_{t+1} \gamma_{t+1} - \beta_{t+1} \gamma_{t+1} (1 - \tau_{t+1}) \left(i_t + 2a \frac{B_t}{v_t} \right) \right) \left(\frac{B_t}{p_t^K K_t^2} \right) + v_{t+1} \end{aligned} \quad (2.43)$$

Rewrite the expression before the error term in equation (2.43) as

$$\gamma_t \left(\frac{B_t}{K_t} \right) - \beta_{t+1} \gamma_{t+1} \left(\frac{B_t}{K_t} \right) - \beta_{t+1} \gamma_{t+1} (1 - \tau_{t+1}) \left(i_t + 2a \frac{B_t}{p_t^K K_t} \right) \left(\frac{B_t}{K_t} \right).$$

Now divide this expression by $-\beta_{t+1} \gamma_{t+1} (1 - \delta) (1 - \tau_{t+1}) \alpha p_{t+1} b$ to get

$$\begin{aligned} & \frac{-\gamma_t}{\beta_{t+1} \gamma_{t+1} (1 - \delta) (1 - \tau_{t+1}) \alpha p_{t+1} b} \left(1 - \beta_{t+1} \frac{\gamma_{t+1}}{\gamma_t} \right) \left(\frac{B_t}{K_t} \right) \\ & + \frac{\beta_{t+1} \gamma_{t+1} (1 - \tau_{t+1})}{\beta_{t+1} \gamma_{t+1} (1 - \delta) (1 - \tau_{t+1}) \alpha p_{t+1} b} i_t \left(\frac{B_t}{K_t} \right) \\ & + \frac{\beta_{t+1} \gamma_{t+1} (1 - \tau_{t+1})}{\beta_{t+1} \gamma_{t+1} (1 - \delta) (1 - \tau_{t+1}) \alpha p_{t+1} b} 2a \frac{B_t}{p_t^K K_t} \left(\frac{B_t}{K_t} \right) \end{aligned} \quad (2.44)$$

$$\begin{aligned} & - \frac{1}{\alpha b} \phi_{t+1} \frac{1}{(1 - \tau_t)} \frac{p_t^K}{p_t} \left(1 - \beta_{t+1} \frac{\gamma_{t+1}}{\gamma_t} \right) \left(\frac{B_t}{v_t} \right) \\ & + \frac{1}{\alpha b} \frac{1}{1 - \delta} \frac{p_t^K}{p_{t+1}} i_t \left(\frac{B_t}{v_t} \right) + \frac{2a}{\alpha b} \frac{1}{1 - \delta} \frac{p_t^K}{p_{t+1}} \left(\frac{B_t}{v_t} \right)^2 \end{aligned}$$

$$\Rightarrow - \frac{1}{\alpha b} \left(\phi_{t+1} \frac{1}{1 - \tau_t} \frac{p_t^K}{p_t} \left(1 - \beta_{t+1} \frac{\gamma_{t+1}}{\gamma_t} \right) - \frac{1}{1 - \delta} \frac{p_t^K}{p_{t+1}} i_t \right) \left(\frac{B_t}{v_t} \right) \quad (2.45)$$

Adding the expression in equation (2.45) to equation (2.40) and rearranging the new equation so that it is exactly identified, we get

$$\begin{aligned}
& \frac{I_{t+1}}{K_{t+1}} - \phi_{t+1} \left(\frac{I_t}{K_t} \right) + \frac{\phi_{t+1}}{2} \left(\frac{I_t}{K_t} \right)^2 \\
& + \eta_1 \left(\phi_{t+1} \frac{w_t L_t}{p_t K_t} + \frac{\phi_{t+1}}{(1 - \tau_t)} \frac{p_t^K}{p_t} - \frac{1}{(1 - \tau_{t+1})} \frac{p_{t+1}^K}{p_{t+1}} \right) \\
& + \eta_2 \left(\phi_{t+1} \frac{Y_t}{K_t} \right) \\
& + \eta_3' \left(\frac{1}{(1 - \delta)} \frac{p_t^K}{p_{t+1}} \left(\frac{B_t}{v_t} \right)^2 \right) \\
& + \eta_4 \left(\left(\frac{\phi_{t+1}}{1 - \tau_t} \frac{p_t^K}{p_t} \left(1 - \beta_{t+1} \frac{\gamma_{t+1}}{\gamma_t} \right) - \frac{1}{1 - \delta} \frac{p_t^K}{p_{t+1}} i_t \right) \left(\frac{B_t}{v_t} \right) \right) \\
& = v_{t+1}
\end{aligned} \tag{2.46}$$

where $\eta_1 = \frac{-1}{\alpha b}$, $\eta_2 = \frac{1}{b}$, $\eta_3' = \frac{-a}{\alpha b}$, $\eta_4 = \frac{1}{\alpha b}$.

In equation (2.46), η_1 and η_2 are precisely the same as in equation (2.41), $\eta_3' = -\eta_3$, and we have an additional coefficient, η_4 . In other words, the equation for the model with a non-binding credit constraint is nested within the equation for the model with a binding credit constraint (with the note that the sign of η_3 is reversed). The coefficients, η_3' and η_4 will determine the importance of capital market imperfections. If $\eta_3' < 0$ and $\eta_4 > 0$, then coefficient a from the financial distress function is positive and significantly different from zero, which implies that the firm faces an increasing premium for external finance, and in addition, the firm's credit constraint is binding. If $\eta_3' > 0$ and η_4 is not significantly different from zero, we return to the case of non-binding credit constraint. If $\eta_3' = 0$ and $\eta_4 = 0$, then there are no financial constraints.

3.3 Summary

This chapter first introduced the standard model of investment with perfect capital markets from the literature. In this model, the firm's financing decisions are irrelevant to its optimal investment choice. The chapter then introduced to this model two types of borrowing constraints arising from capital market imperfections: a financial distress premium due to asymmetric information between the borrower and the lender, and a credit ceiling on the firm's debt-to-capital ratio. Two Euler equation models were derived. The first one assumed a non-binding credit constraint whereas the second one assumed a binding credit constraint. It was found that the standard model of investment with perfect capital markets is nested within the Euler equation model with a non-binding credit constraint. Furthermore, it was also found that the Euler equation model with a non-binding credit constraint is nested within the Euler equation model with a binding credit constraint. These results imply that by estimating the Euler equation model with a binding credit constraint, we can determine which of the three models actually holds for the Turkish case. The results of the econometric estimations are discussed in the next two chapters.

4 Empirical Analysis with Panel Data

In Chapter 3, we modified the standard model of investment with perfect capital markets and introduced two types of borrowing constraints to this model. One constraint is the increasing premium based on debt-to-capital ratio, and the other one is the credit-rationing constraint. We first derived an Euler equation with a non-binding credit constraint. We found that the standard model of investment with perfect capital markets is nested within the Euler equation model with a non-binding credit constraint. We then considered the case of a binding credit constraint and derived another Euler equation. We found that the former Euler equation model is nested within the latter Euler equation model (with the note that the sign of η_3 is reversed). This means that in our empirical analysis, we need to estimate only the Euler equation with a binding credit constraint. Based on the significance of the coefficients of this model, there are three possibilities. One possibility is that the Euler equation model with a binding credit constraint holds, which would imply that firms face both an increasing premium and credit rationing. The second possibility is that the Euler equation model with a non-binding credit constraint holds, which would imply that firms face an increasing premium but no credit rationing. Finally, a third possibility is that the standard model of investment holds, which would imply that firms face neither an increasing premium nor credit rationing.

4.1 Description of the Data Set

Firm level data are collected by the Industrial Statistics Section of the State Institute of Statistics (SIS) of Turkey. The SIS conducts an annual census of the manufacturing

industry using the Annual Manufacturing Industry Questionnaire. The census covers all manufacturing establishments in the public sector and establishments with 25 or more employees in the private sector. The questionnaires are sent to the plants (establishments) and are later collected in person on the premises and are processed by the personnel of the SIS. Note that the SIS does not provide information on the percentage of manufacturing establishments in the private sector with 25 or more employees relative to the total number of firms in the manufacturing sector. However, the SIS does publish information on the manufacturing establishments in the private sector employing between 10 and 24 persons. Based on this information, we find that the establishments employing 25 or more persons constitute about 63% of the establishments employing 10 or more persons in Turkey.

The available firm level data set is balanced with annual observations on 1655 plants from 1983 to 1986. The data cover all plants in the greater Istanbul area, which has a heavy concentration of the manufacturing sector in Turkey. The plants are identified only by a code, and if a firm has multiple plants, then each plant is counted individually. In our empirical analysis, we use the terms plant and firm interchangeably. The plants are classified by type of activity according to International Standard Industrial Classification (ISIC Rev. 2) – Manufacturing Industry Classification. The panel data set classifies firms with the four-digit industry code.

4.2 Description of Variables

This section provides a general description of the variables used in the regressions with panel data and explains how these variables were constructed.

Investment (I_t): The sum of reported net expenditure (expenditure less sales) on machinery, transportation equipment, and buildings.

Capital stock (K_t): The reported value of the capital stock is, in general, not equal to its replacement (market) value. In order to calculate the replacement value of the capital stock, we use the perpetual inventory method suggested by Salinger and Summers (1983). The perpetual inventory method is commonly used in the investment literature (e.g. Bond and Meghir, 1992; Whited, 1992; Galeotti *et al.*, 1994, among others) and is explained as follows. The reported value of the capital stock in the first year is assumed to be equal to its replacement value. We then use the following formula to calculate the replacement value of the capital stock in the subsequent years.

$$K_t = \left(K_{t-1} \left(\frac{P_t^K}{P_{t-1}^K} \right) + I_t \right) \left(1 - 2 / LF \right),$$

where LF indicates the useful life of the capital good. In this expression, the second term represents the amount of capital that depreciates each year. In deriving this expression, Salinger and Summers (1983) have made the following three assumptions. (1) All of a firm's capital has the same useful life. (2) Firms use the straight-line method for book depreciation. (3) Both tax and actual depreciation are exponential with depreciation rate $2 / LF$. We can estimate the useful life in any year by

$$LF_t = \frac{RK_{t-1} + I_t}{DEPR_t},$$

where RK_t is the reported value of the capital stock in year t , and $DEPR_t$ is the reported (book) depreciation in year t . Since LF_t can differ from year to year, we can calculate the final LF as the average of the LF_t s over the relevant years of analysis.

In our data set, investment and depreciation are reported for different types of investment, that is for machinery, transportation equipment, and buildings. However, capital is reported as the sum of all types of capital stock. We should preferably account for the capital stock for different types of capital separately (see Hayashi and Inoue, 1991). However, since in the original questionnaires the capital is reported as the sum of all types of capital stock, the replacement value of capital that we calculate has to be the sum of the whole capital stock. Due to this nature of the reporting of data, we cannot calculate LF using the above formula. We use an approximate value and assume that $LF = 10$ for the whole capital stock for all firms. This method also avoids the issue of not knowing how firms calculate the depreciation value. The Annual Manufacturing Industry Questionnaire does not indicate how depreciation is calculated. Hulten and Wykoff (1981) summarize the rates of depreciation reported for different types of capital in a number of studies. Based on these reported rates of depreciation, we choose an approximate value for the useful life of capital that would be appropriate for the manufacturing sector. We assume that, in the manufacturing sector, most of the value of capital would come from machinery.

Output (Y): The value of goods sold plus the change in finished goods inventories.

Value of Variable Inputs (wL_t): The total annual payments to the production workers, managerial, administrative, and other personnel plus the payments for intermediate inputs.

Borrowing (B_t): This variable includes both short-term and long-term loans.

Price of capital goods (p^k): The price index for investment is not reported for the Turkish manufacturing sector. We proxy this index by the manufacturing general price index. Note that we use this index to determine the ratio of the price of capital goods to the price of output. We do not use it to calculate the value of investment since the reported I_t is the value of investment.

Price of output (p_t): We use the three-digit industry-specific output price index for this variable.

Risk-free interest rate (i_t): We would like to use an interest rate that is free of financial distress risk associated with the firm's leverage ratio but will include risks associated with macroeconomic conditions in the country. We choose the one-year interest rate on Turkish Treasury bills as reported in the Quarterly Bulletin of the Central Bank of Turkey. Note that while the U.S. Treasury Bill is a risk-free asset since the probability that the U.S. will default is nil, the Turkish Treasury bill is not a comparably risk-free asset since the probability of default is positive. Hence, the return on Turkish Treasury bill incorporates a risk premium due to the probability of default. An alternative would have been to use the capital asset pricing model (CAPM) approach and take into account the correlation between the firm's returns and the returns to the "market portfolio", where

each firm would adjust the “risk-free” rate by a risk premium that would reflect the degree of correlation. However, since for the relevant time period the Turkish equity markets were not well-developed, the diversification would not be present. Hence, we simply resort to the Turkish Treasury bill and acknowledge that it does not constitute a totally risk-free asset.

4.3 Descriptive Statistics

The initial data set consisted of 1655 firms. We performed five consistency tests that are commonly used in the investment literature to eliminate firms with inconsistent data. The first test eliminated firms that had a reported capital value of less than or equal to zero in any year. The second test eliminated firms that had a replacement value of capital less than or equal to zero in any year. This test was performed after we used the perpetual inventory method to calculate the replacement value of capital. The third test eliminated firms with total sales less than or equal to zero in any year. The fourth test eliminated firms which had a leverage ratio, $\left(\frac{B_t}{p_t^K K_t}\right)$, greater than or equal to ten in any year. These firms were predominantly small firms, some of which had a leverage ratio as high as 250. We interpreted this high ratio to be due to misreporting of data. Finally, the fifth test eliminated firms that invested more than ten times the value of their capital or disinvested more than their capital in any year. This elimination step is used in the literature to screen out the cases of mergers and acquisitions. In the end, the sample contained 1036 firms, or in other words, 62.5% of the 1655 firms passed all five tests. This implies that the survival rate is fairly high in this study compared to some other

studies. For example, Whited (1992) performs similar consistency tests for the U.S. manufacturing firms and finds the survival rate to be 23.9%.

Despite the fairly high survival rate, we would still like to get a sense of what size of firms have been screened out to help us determine whether there is a sample selection bias. For this purpose, we investigate the average size of firms before and after the screening process. The mean of the 1983 capital stock for the 1655 firms is 279 million TL whereas that for the 1036 post-selection firms is 393 million TL. This implies that the firms screened out of the sample are predominantly small firms and come from the highly peaked section of the distribution in the histogram of 1983 capital stock for the total manufacturing sector (Chart A1). Given that in the post-selection sample we still have a large sample size for small firms, we do not think that the inclusion of the discarded firms would have changed the results of our estimations.

We performed econometric analysis on these 1036 firms in the manufacturing sector and on firms in the two largest industry groups in the manufacturing sector. Before starting the econometric analysis, we would like to comment on the descriptive statistics of the firms' capital stock and investment as well as investment-capital, debt-capital, and output-capital ratios. Table 4.2 presents the descriptive statistics for all firms in the manufacturing sector, Tables 4.3 and 4.4 present these statistics for the two largest industry groups, and finally, Tables A1-A7 in the appendix present the statistics for the remaining industry groups.

Capital Stock

As presented in Table 4.2, the moments of the capital stock indicate that the manufacturing sector in Turkey is identified by predominantly small firms and a few very large firms. The standard deviation of the firms' capital stocks is quite large. The distribution of capital is highly skewed to the right, as indicated by the highly positive skewness coefficient and the median lying well below the mean. The positive and high coefficient of kurtosis indicates that the distribution is highly peaked. The coefficients of skewness and kurtosis both indicate that the majority of the firms have very small levels of capital. In fact, from the histogram of the 1983 capital stock for the 1036 firms, we find that about 80% of the firms are clustered together in the highly peaked section of the distribution.⁹ The remaining 20% of the firms are spread out to form an overall right skewed distribution. From 1983 to 1986, the capital stock becomes less skewed and the coefficient of kurtosis decreases.

Tables 4.3-4.4 (and Tables A1-A7 in the appendix) present that the coefficients of skewness and kurtosis are positive and high for each of the nine industries. While these coefficients decrease in some industries over the studied period, they increase in others. The thesis primarily focuses on the two largest industries in Turkey: the textile industry (ISIC 32) and fabricated metal products, machinery and equipment industry (ISIC 38). The firms in these two industries together represent 57% of the total sample of 1036 firms. While the coefficients of skewness and kurtosis both decline substantially for the

⁹ The histograms of 1983 capital stock for the 1036 firms and for firms in each industry group are presented in the appendix.

textile industry, they decline only slightly for the fabricated metal products, machinery and equipment industry.

Investment

Overall investment is also highly skewed to the right and highly peaked. While the coefficients of skewness and kurtosis increase over time for the manufacturing sector, this is clearly not the case for each industry, including the textile industry.

Investment-Capital Ratio

The average mean of the investment-capital ratio over the entire period is 0.16. This is consistent with the investment-capital ratios reported in other studies, e.g. 0.15 for the manufacturing firms in Italy (Galeotti *et al.*, 1994) and 0.19 for those in the U.S. (Whited, 1992).

The average mean of the $\frac{I}{K}$ ratio for the textile industry is 0.18, and that for the fabricated metal products, machinery, and equipment industry is 0.16.

Debt-Capital Ratio

The average mean of the debt-capital ratio over the entire period is 1.4. This ratio is slightly higher than the leverage ratios reported in other studies, e.g. 1.05 for the manufacturing firms in Italy (Galeotti *et al.*, 1994) and 0.96 for small manufacturing firms in Ecuador (Jaramillo *et al.*, 1996). We would expect the debt-capital ratio to be higher in a country where bond and equity markets are not well-developed, and hence, external financing takes place mostly through the issuance of debt. The higher debt-capital ratio for Turkish manufacturing firms compared to that for Italian manufacturing

firms is then not surprising. As for Ecuador, the debt-capital ratio is reported only for small manufacturing firms. The econometric estimation results of Jaramillo *et al.* (1996) show that these firms faced credit-rationing constraints. This may explain the relatively low debt-capital ratio reported for the small manufacturing firms of Ecuador.

The average mean of the $\frac{B}{K}$ ratio for the textile industry is 1.46, and that for the fabricated metal products, machinery, and equipment industry is 1.34.

Output-Capital Ratio

The average mean of the output-capital ratio over the entire period is 7.5 and is fairly stable over the years.

The average mean for the textile industry is above the overall average at 9.4, and that for the fabricated metal products, machinery and equipment industry is below overall average at 6.7.

We will now comment on the distribution of firms across industries based on their size as measured by their capital stock. Table 4.5 presents the numbers and percentages for each industry. The row headings indicate industries, and the column headings indicate the deciles of firm sizes across the manufacturing sector. Each decile contains either 103 or 104 firms. The numbers within each cell of the table can be read as follows. The number in the top left corner indicates how many firms in the industry specified in the row heading belong to the decile specified in the column heading. The percentage value in the middle indicates what percentage of the firms in the specified industry

belongs to the specified decile. The percentage value in the bottom right corner indicates what percentage of the firms in the specified decile belongs to the specified industry.

For example, the cell in the second row and the first column, cell (2,1), indicates that 43 out of 268 firms or, in other words, 16% of the firms in the textile industry (ISIC 32) are in the first decile of the manufacturing sector. Looking across all deciles we see that the textile industry has relatively higher concentration of firms in the lower deciles. Cell (2,1) also indicates that 43 out of 104 firms or, in other words, 41% of the firms in the first decile come from the textile sector. Given that the textile sector is 26% of the manufacturing sector, again we see that there is a proportionately higher concentration of the textile sector in the first decile.

The industries which have relatively higher concentration of firms in the higher deciles are food, beverages, and tobacco industry (ISIC 31), chemicals, chemical petroleum, coal, rubber, and plastic industry (ISIC 35), non-metallic minerals industry (ISIC 36), and basic metal industries (ISIC 37). All these industries tend to be capital intensive and, hence, are expected to have firms with relatively large capital stocks. As for the two largest industries, the textile industry (ISIC 32) has a larger concentration of smaller firms, and the fabricated metal products, machinery and equipment industry (ISIC 38) has close to a uniform distribution across the deciles. This implies that the distribution of firms in the latter industry is similar to the distribution of all firms in the manufacturing sector.

4.4 Econometric Estimation based on Cost of Adjustment Model

We estimate the investment equation derived from the cost of adjustment model, equation (2.46), by using the GMM estimator on a panel data set for Turkish firms. Before we discuss our estimation and results, we would like to provide an overview of panel data analysis, dynamic panel data models, and the GMM estimation technique.

4.4.1 Overview of Panel Data Analysis

This section introduces the unobserved individual-specific and time-specific effects as they relate to panel data. It discusses how we can control for these effects to avoid specification bias and to improve the efficiency of the estimates.

Using standard notation from the literature on panel data analysis, we will first list the various possible forms for the slope coefficients and the intercept term of a single equation model. We will then explain why we have chosen to use a specific form for these coefficients in the estimation of our panel data model.

A single equation model, where y is the dependent variable and x is the independent variable, can take the following forms (not all possibilities are listed):

1. All coefficients vary over time and across individuals.

$$y_{it} = \alpha_{it} + \sum_{k=1}^K \beta_{kit} x_{kit} + u_{it} \quad i = 1, \dots, N \quad t = 1, \dots, T$$

2. All coefficients vary across individuals but not over time.

$$y_{it} = \alpha_i + \sum_{k=1}^K \beta_k x_{kit} + u_{it} \quad i = 1, \dots, N \quad t = 1, \dots, T$$

3. The slope coefficients remain constant, but the intercept term varies across individuals.

$$y_{it} = \alpha_i + \sum_{k=1}^K \beta_k x_{kit} + u_{it} \quad i = 1, \dots, N \quad t = 1, \dots, T$$

4. The slope coefficients remain constant, but the intercept term varies over time and across individuals.

$$y_{it} = \alpha_{it} + \sum_{k=1}^K \beta_k x_{kit} + u_{it} \quad i = 1, \dots, N \quad t = 1, \dots, T$$

5. Both the slope coefficients and the intercept term remain constant over time and across individuals.

$$y_{it} = \alpha + \sum_{k=1}^K \beta_k x_{kit} + u_{it} \quad i = 1, \dots, N \quad t = 1, \dots, T$$

We can consider model (1) to be the unrestricted model and model (5) to be the most restricted model. For example, let us assume that model (5) represents a Cobb-Douglas function, where y is the logarithm of output, and $x_1, \dots, x_K$ are the logarithm of respective inputs. This model assumes that the omitted variables are independent of x and are i.i.d.. Such a model ignores managerial and other technical differences across firms and the general factors that affect the productivity of all firms over time.

A common way to account for heterogeneity across individuals and/or over time is to use variable-intercept models such as (3) and (4). These models assume that the effects of the omitted variables are driven mainly by two types of variables. One is the individual time-invariant variable that varies across cross-sectional units but remains constant for a given cross-sectional unit over time. The other one is the time individual-invariant variable that varies over time but remains constant across all cross-sectional units at a given point in time. The literature refers to the first type of variables as the individual-specific effects, and the second type as the time-specific effects.

i) Individual-specific Effects: Fixed Effects vs. Random Effects

a) Fixed-effects Model

In this model, we treat the effects of omitted individual-specific variables (α_i) as fixed constants over time. Model (3) is an example of a fixed-effects model (we assume that there are no time-specific effects):

$$y_{it} = \alpha_i + \sum_{k=1}^K \beta_k x_{kit} + u_{it}$$

In this case, α_i are assumed to be fixed parameters to be estimated, and $u_{it} \sim \text{i.i.d. } (0, \sigma_u^2)$.

The x_{it} are independent of u_{it} for all i and t . The fixed-effects model is an appropriate specification if we focus on a specific set of N individuals (i.e. the data exhaust the population), and our reference is limited to the behaviour on these N individuals.

b) Random-effects Model (a.k.a. Variance- or Error-Components Model)

In this model, we treat the individual-specific effects as random variables. The error term, v_{it} , now consists of two components (again, we assume that there are no time-specific effects).

$$v_{it} = \alpha_i + u_{it} ,$$

where $\alpha_i \sim \text{i.i.d.} (0, \sigma_\alpha^2)$, $u_{it} \sim \text{i.i.d.} (0, \sigma_u^2)$, and the α_i are independent of the u_{it} . The x_{it} are independent of the α_i and u_{it} for all i and t . Since $\sigma_v^2 = \sigma_\alpha^2 + \sigma_u^2$, the variance σ_α^2 and σ_u^2 are called variance components (or error components). The random effects model is an appropriate specification if we randomly draw N individuals from a large population.

ii) Time-specific Effects

Similar to individual-specific effects, time-specific effects can also be treated as fixed-effects or random-effects.

a) Fixed-effects Model

Assuming that there are no individual specific effects, we get

$$y_{it} = \alpha + \sum_{k=1}^K \beta_k x_{kit} + \lambda_t + u_{it} ,$$

where λ_t are assumed to be fixed parameters to be estimated, and $u_{it} \sim \text{i.i.d.} (0, \sigma_u^2)$.

b) Random-effects Model

$$v_{it} = \lambda_t + u_{it} ,$$

where $\lambda_i \sim \text{i.i.d. } (0, \sigma_\lambda^2)$, $u_{it} \sim \text{i.i.d. } (0, \sigma_u^2)$, λ_i are independent of u_{it} , and $\sigma_v^2 = \sigma_\lambda^2 + \sigma_u^2$

The choice between the fixed effects and the random effects depends on the nature of the panel data set. In general, if the observations exhaust the population, the fixed-effects model is reasonable. On the other hand, if the observations are randomly selected from a large population, the random-effects model is more reasonable. Since our data set is collected by a census of all manufacturing firms in the Istanbul area, we will use the fixed-effects model for both the individual-specific effects and the time-specific effects. In other words, we will update model (3), which includes fixed individual-specific effects, to also incorporate fixed time-specific effects.

Hausman (1978) developed a specification test to determine whether fixed or random effects are present in a panel data set. However, as explained by Keane and Runkle (1992), the Hausman test requires exogeneity of the independent variables. Since our model is a dynamic panel data model, that is, we have a lagged dependent variable on the right-hand-side, the Hausman test is not applicable.

There are a number of methods suggested in the literature to eliminate fixed individual-specific effects. Using dummy variables for individuals, subtracting individual means, or first differencing are some of the commonly used methods. In a panel data set where N is very large, as in our data set, using dummy variables is not appropriate due to large loss of degrees of freedom. In a dynamic panel data set subtracting individual means is also not appropriate because lagged dependent variables cannot be used as instruments since they are correlated with the mean of the error term by construction. Keane and Runkle (1992) explain that transformation of regression

equations by demeaning render predetermined variables, such as a lagged dependent variable, invalid as instruments. In this case, only strictly exogenous variables are valid. However, there are other transformations, such as first differencing, that render predetermined variables valid as instruments. As will be explained later, in our analysis, first differencing is the method that we employ to eliminate fixed individual-specific effects.

4.4.2 Overview of Dynamic Panel Data Models and the GMM Estimation

The following model is an example of a dynamic panel data model since one of the regressors is a lagged dependent variable:

$$y_{it} = \delta y_{i,t-1} + x_{it} \beta + u_{it} \quad i = 1, \dots, N \quad t = 1, \dots, T.$$

In this model, δ is a scalar, x_{it} is $1 \times K$, β is $K \times 1$, and $u_{it} \sim \text{i.i.d.} (0, \sigma_u^2)$. Equation (2.46) that we would like to estimate is also a dynamic panel data model since this equation is an Euler equation.¹⁰

A number of recent studies, such as Arellano and Bond (1991), Ahn and Schmidt (1992), and Keane and Runkle (1992) have suggested using the GMM estimator with dynamic panel data models, that is panel data models with predetermined as opposed to exogenous regressors. The advantage of the GMM estimator is that it allows us to obtain

¹⁰ We should note that we set the coefficient of the lagged dependent variable, $\frac{I_t}{K_t}$, equal to ϕ_{t+1} when we estimate the Euler equation.

asymptotically efficient estimates with dynamic panel data models without imposing independence over time or conditional homoskedasticity on the disturbances of the model. Before we provide an overview of the GMM estimation method, we would like to briefly discuss the advantages of using the GMM estimator with dynamic panel data models. What makes the GMM estimator superior to alternative estimators such as the ordinary least squares (OLS) estimator, the instrumental variable (IV) estimator, or the maximum likelihood (ML) estimator?¹¹

If the disturbances of the model are not serially correlated, the OLS estimator is biased but consistent. However, if there is serial correlation, the OLS estimator will be biased and inconsistent. In the case of serial correlation, the IV method produces consistent but not necessarily efficient estimates since it does not take into account all the available moment conditions. A third alternative is deriving the estimates by using the ML estimator, in which case the estimates would be the values for which y_{it} is most likely to be observed. The drawback of the ML estimation is that we need to specify the form of the likelihood function. As argued in Hansen and Singleton (1982), the ML estimates may fail to be consistent if the distribution of the observable variables is misspecified. The GMM estimator, on the other hand, requires specification of only certain moment conditions and produces both asymptotically consistent and efficient estimates. The large sample properties of the GMM estimator allow the disturbances to be both conditionally heteroskedastic and serially correlated. Panel data models typically provide a large

¹¹ As explained in Hansen and Singleton (1982), Davidson and MacKinnon (1993), and Hamilton (1994), all three estimators can be viewed as special cases of the GMM estimator.

sample size, which satisfies the large sample requirement for the asymptotic properties of the GMM estimates.

The GMM estimator has been popular in recent empirical research in macroeconomics and finance. This is primarily due to the fact that many models assume rational expectations, where there are underlying assumptions that can be used to form the GMM estimates. Under rational expectations, the error terms are random errors and should be orthogonal to the predetermined variables. Hansen and Singleton (1982) highlight some of the key advantages of the GMM estimator in their paper, where they estimate and test a rational expectations model from a stochastic Euler equation. First, they point out that we can allow the disturbances to be conditionally heteroskedastic and do not need to explicitly characterize the dependence of the conditional variances on the information set. Second, the instruments need not be exogenous, they need to be only predetermined as of time t . This implies that both current and lagged regressors can be selected as instruments. The GMM estimator is consistent even when the disturbances are serially correlated and the instruments are not exogenous. Third, we get asymptotically efficient estimates by choosing the smallest asymptotic covariance matrix among all possible weighting matrices by making use of moment conditions, as will be described later.

We would now like to provide an overview of the GMM estimator.¹² This overview is not intended to provide the details of the derivation, but rather simply show how the GMM estimator develops from the earlier literature on the minimum distance estimators.

¹² We will draw upon Hansen (1982), Hamilton (1994), Chapter 14, and Greene (1997), Chapter 11.

Hansen (1982) introduced the generalized method of moments estimator, which generalizes the minimum distance estimator approach and derives the asymptotic properties for serially dependent processes. In deriving the GMM estimator, it is assumed that the residual is uncorrelated with the explanatory variables, but no other assumption is made regarding the heteroskedasticity or serial correlation of the residuals. We start our discussion with minimum distance estimators.

Given a model involving unknown $(a \times 1)$ vector of parameters θ that characterizes the density of an observed variable y_i , suppose that a distinct population moments of a random variable Y_i can be calculated as functions of θ :

$$E(Y_i^i) = \mu_i(\theta) \quad i = i_1, \dots, i_a.$$

The method of moments estimator of θ is $\hat{\theta}_T$, for which the population moments are set equal to the observed sample moments, that is

$$\mu_i(\hat{\theta}_T) = \frac{1}{T} \sum_{t=1}^T y_t^i \quad i = i_1, \dots, i_a.$$

The above-explained case is called “exactly identified” because there are precisely as many moments as there are parameters to be estimated. In other words, there is a system of $(a \times 1)$ equations in $(a \times 1)$ unknown parameters. Unless the equations are functionally dependent, we will have a unique solution. However, we might have another case where there are more moment equations than parameters. In such a case, we try to use all the information in the sample and estimate the parameters so that we are as close

as possible to all moment conditions. We achieve this by minimizing the criterion function

$$Q \equiv g(\theta)' W g(\theta),$$

where g is the vector of moments, and W is a weighting matrix. An estimate of θ , based on the minimization of the above criterion function, is called a "minimum distance estimator". The question that remains is: What is the weighting matrix that will provide the most consistent and efficient estimate of θ ?

Hansen (1982) generalized the "minimum distance estimator" approach and derived the asymptotic covariance matrix that provides the most consistent and efficient estimate of θ . In Hansen (1982), the generalized method of moments estimator is the value of θ that makes the sample moment as close as possible to the population moment of zero. In other words, the GMM estimator $\hat{\theta}$ is the value that minimizes

$$Q(\theta, w) = [g(\theta, w)]' W_T [g(\theta, w)],$$

where w is the vector of predetermined variables observed at time t . In this case, the optimal value for the weighting matrix, W_T , is given by the inverse of the asymptotic variance matrix of orthogonality conditions. This matrix is constructed by using the moment conditions with the instrumental variables that are orthogonal to the residuals of the estimated equations by assumption. An initial consistent (if not efficient) estimate of θ is obtained by minimizing the above criterion function with an arbitrary weighting matrix. This initial estimate is then used in an iterative process to sequentially calculate a

new weighting matrix and a new value of the estimate $\hat{\theta}$. Eventually, the process converges such that the values of $\hat{\theta}$ obtained in the last two iterations are approximately equal. The econometric package, TSP, uses three stage least squares (3SLS) for initial estimation. The GMM estimate $\hat{\theta}$ is the solution to the following system of nonlinear equations:

$$\left[\frac{\partial g(\theta, w)}{\partial \theta} \right]' \times W_T^{-1} \times [g(\theta, w)] = 0.$$

We choose the estimator Bartlett, suggested by Newey and West (1987), for estimating the optimal weighting matrix, W_T . Note that in small samples, the results may be sensitive to the choice of the optimal weighting matrix.

We use the test of overidentifying restrictions as a specification test. When the orthogonality conditions exceed the number of parameters to be estimated, the model is overidentified, which implies that there are more orthogonality conditions than necessary to estimate θ . As explained in Hansen (1982), estimation of the model sets q linear combinations of r sample orthogonality conditions asymptotically equal to zero. If the model specification is correct, the $r-q$ linearly independent combinations of the orthogonality conditions should be close to zero. This constitutes the base for testing the overidentifying restrictions of the model. The test of overidentifying restrictions will also help us determine whether there is zero correlation between the disturbances and the set of instruments, in other words, whether the instruments are exogenous.

The GMM estimates are asymptotically consistent and efficient under fairly general stationarity conditions for the vector of observed variables. For our purposes, the short time dimension of the data set makes the potential problem of stationarity irrelevant.

4.4.3 Estimation and Results

The analysis is performed on the 1036 firms in the manufacturing sector and on firms within the largest two industries. We limit the industry analysis to the largest two industries because the GMM is an asymptotic estimation technique. Only in these two industries is the sample size large enough to get efficient estimates. It is due to the same reason that we do not take less than 20% of the whole sample of 1036 firms in any estimation. The highly right skewed nature of the skewness coefficient of the capital stock determines our method for the identification of large and small firms. We consider the largest 20% of the firms as large firms, the second largest 20% as medium firms, and the firms in the 0-60% range as small. In terms of size, these small firms are highly clustered together. For each year, we determine which size group a firm belongs to. This implies that a firm, which is within the highest 20% in 1983 and classified as a large firm could be in the 0-60% range in 1986 and classified as a small firm. With this method, we allow a firm to change its size group, that is, we endogenize size determination. We use two different methods to determine the size group.

The first method is the one that is commonly used in the literature. We rank all firms in terms of their capital stock each year. We then divide the firms into 20% size groups. This method allows mostly capital-intensive firms to fall into the large size group. However, there may be firms that do not have a high level of capital stock compared to

all firms in the manufacturing sector, but they could be one of the largest firms within their industry group, which may not be a capital-intensive industry. We believe that such firms may find it easier to borrow compared to a small firm within a highly capital-intensive industry. With this consideration in mind, we introduce a second method, which we have not encountered in the literature.

The second method also divides the firms into 20% size groups, however, it uses a different process. We first divide each industry into 20% size groups. Then, in order to determine the largest 20% size group in the manufacturing sector, we sum up the firms that belong to the largest 20% size group within each industry. We follow the same method to determine the second largest 20%, and 0-60% size groups.

Our goal is to determine the joint significance of all variables in the equation, the joint significance of the financial variables as well as the significance of each of the variables. To do so, we estimate the following Euler equation.

$$\begin{aligned}
& \frac{I_{i,t+1}}{K_{i,t+1}} - \phi_{t+1} \left(\frac{I_{it}}{K_{it}} \right) + \frac{\phi_{t+1}}{2} \left(\frac{I_{it}}{K_{it}} \right)^2 \\
& + \eta_1 \left(\phi_{t+1} \frac{w_t L_{it}}{p_t K_{it}} + \frac{\phi_{t+1}}{(1 - \tau_t)} \frac{p_t^K}{p_t} - \frac{1}{(1 - \tau_{t+1})} \frac{p_{t+1}^K}{p_{t+1}} \right) \\
& + \eta_2 \left(\phi_{t+1} \frac{Y_{it}}{K_{it}} \right) \\
& + \eta_3 \left(\frac{1}{(1 - \delta)} \frac{p_t^K}{p_{t+1}} \left(\frac{B_{it}}{v_{it}} \right)^2 \right) \\
& + \eta_4 \left(\left(\frac{\phi_{t+1}}{1 - \tau_t} \frac{p_t^K}{p_t} \left(1 - \beta_{t+1} \frac{\gamma_{t+1}}{\gamma_t} \right) - \frac{1}{1 - \delta} \frac{p_t^K}{p_{t+1}} i_t \right) \left(\frac{B_{it}}{v_{it}} \right) \right) \\
& + f_i + s_t = v_{i,t+1}
\end{aligned}$$

This equation is similar to equation (2.46) with the exception of two additional terms, f_i and s_t . f_i represents fixed firm effects, which we eliminate by first differencing. Since the data in our study have been collected by a census rather than by a random sample selection, we have chosen to use a fixed-effects model. We also introduce a time dummy, represented by s_t , to incorporate time-specific effects common to all firms. In addition, we use subscript i to indicate firm-specific variables.

First differencing the equations introduces a moving average component of the error term, MA(1). To account for this induced serial correlation —where possible— we choose our instruments from time period $t-2$. We start with three Euler equations covering time periods 1983-1984, 1984-1985, and 1985-1986. After first differencing, we have two equations covering time periods 1983-1985 and 1984-1986.

For the second equation, we use, as instruments, variables $\frac{I}{K}, \left(\frac{I}{K}\right)^2, \frac{wL}{K}, \frac{Y}{K}, \frac{B}{pK}, \left(\frac{B}{pK}\right)^2$ and time dummies, all dated $t-2$ in levels. While any variable dated t or earlier is a valid instrument, Monte Carlo experiments suggest that one should be stringent with the choice of instruments. This principle was kept in mind in choosing the instrumental variables. While appropriate instruments should be orthogonal to the vector of moments, we would also want the instruments to be as highly correlated as possible with the derivative of the moments with respect to the parameters to be estimated, that is $\frac{\partial g(\theta, w)}{\partial \theta}$. This correlation could be checked by a regression of $\frac{\partial g(\theta, w)}{\partial \theta}$ on the vector of instruments and looking at R^2 and the adjusted R^2 . We performed these

regressions for all the GMM estimations with panel data. The results are presented in Tables 4.6-4.8.

There is no generally accepted threshold for the adjusted R^2 to indicate a high degree of correlation between $\frac{\partial g(\theta, w)}{\partial \theta}$ and the instruments. However, an adjusted R^2 of greater than or equal to 0.40 could be considered to indicate a sufficiently high degree of correlation. Our regression results show that in most cases, the adjusted R^2 is reasonably high. However, for small firms, the correlation between the derivative of the moments with respect to η_1 and the instruments seems to be quite low. The adjusted R^2 is 0.09 for the second equation. The low correlation signals that the quality of the instruments is in doubt for small firms. In other words, for small firms, the coefficient estimate for η_1 will be less reliable compared to the estimates of the other coefficients, for which the correlation defined above is high.

For the first equation, we use the above listed instruments dated $t+1$. Under the assumption that the disturbances are serially independent, future values of the regressors can be used as instruments. In other words, we assume that the disturbance term and the future values of the regressors are independent (see Hayashi and Inoue (1991) for a similar assumption). We acknowledge that this is a somewhat unorthodox assumption. Under rational expectations hypothesis, we would expect that there would be some correlation between variables dated $t+1$ and the disturbances. Yet, we had to impose this assumption to be able to use the future values of the regressors as instruments since the time dimension of our data is already short, and we do not have any data available earlier

than 1983. If this assumption turns out to be incorrect, then the test of overidentifying restrictions (J test) will be rejected. In addition, as explained earlier, we also perform a formal check on the correlation of the instruments dated $t+1$ with $\frac{\partial g(\theta, w)}{\partial \theta}$. Our results show that the test of overidentifying restrictions is not rejected. Furthermore, the adjusted R^2 's indicate a reasonably high correlation between instruments dated $t+1$ and the derivative of the moments with respect to the parameters to be estimated.

Table 4.9 presents the estimates using the first method of determining size groups. The estimates for small, medium, and large firms are presented in the first, second, and third columns, respectively. Based on the J statistic, the overidentifying restrictions are not rejected, which implies that there is no sign of misspecification for any of the three regressions. Wald test 1, the test of joint significance of all coefficients of the equation, suggests that we cannot reject the model with borrowing constraints at the 1% level for small firms, 5% level for medium firms, and 10% level for large firms. Wald test 2, the test of joint significance of the two coefficients on the borrowing constraints, η'_3 and η'_4 , suggests that we cannot reject these constraints for medium and large firms, but we reject them for small firms. A further examination of the estimates of η'_3 and η'_4 reveal quite different results for all three size groups. For large firms, η'_3 is significant implying that these firms face increasing premium for external finance, and η'_4 is not significant implying that they do not face binding credit constraints. For medium firms, both η'_3 and η'_4 are significant, with the note that only η'_4 has the expected sign. The sign of η'_3 , however, is consistent with the model with an increasing premium and a non-binding

credit constraint. For small firms, neither η_3 nor η_4 is significant. The coefficients η_1 and η_2 , which are functions of the adjustment cost parameter, b , and of the elasticity of demand, ε , have the expected sign and are significant, with the exception of insignificant η_2 for large firms. The coefficient for the time dummy, η_5 , is significant only for small and medium firms. This implies that there were differences across periods for small and medium firms but not for large firms.

Table 4.10 presents the estimates using the second method of determining group sizes. The results are very similar to those obtained using the first method, and furthermore, many of the results are stronger. The test of overidentifying restrictions indicates no sign of misspecification for any of the three regressions. The p -value for the J statistic is higher for medium and large firms and about the same for small firms. The Wald test of joint significance of all coefficients of the equation suggests that we cannot reject the model at the 1% level for small and medium firms, and at the 5% level for large firms. The Wald test of joint significance of the two coefficients on the borrowing constraints now suggests more strongly that we cannot reject these constraints for medium and large firms, but we reject them for small firms. Similar to the results from method 1, the coefficient for the time dummy, η_5 , is significant for small and medium firms, but not for large firms.

In summary, the results obtained by using two different methods of size determination seem to be quite robust. While these were not the results that we expected before performing the empirical analysis, we believe that these results are quite reasonable given the size distribution of firms in the Turkish manufacturing sector. As

the capital stock histogram of the total manufacturing sector (Chart A1 in the appendix) indicates, the small firms in the manufacturing sector have very small capital stocks. The absolute amount of debt issued by these firms may not depend on their capital stock. These firms may use collateral other than capital stock (car, house, etc.), they may use their personal savings, or they may borrow within family or friends. On the other hand, the large firms have very large capital stocks. To give a sense of the size differences, for example, in 1983 when the smallest firm had only 71,000TL worth of capital stock, the largest firm had 18 billion TL worth, which is more than 250,000 times larger. When these big firms issue external debt, the amount is expected to be very large. They may face an increasing premium on their large debt, but they are not rationed out of the credit markets. The firms in the medium size group seem to be the most affected by the borrowing constraints. Although these firms lie much closer to the left on the capital stock histogram of the manufacturing sector, they are not very small. These firms are large enough that they cannot just use personal savings or family funds, but rather they have to borrow on the credit markets. Regardless of the size determination method used, the medium firms seem to face both an increasing premium and a credit-rationing constraint.

Since the unconstrained model did not support the constraint, $\eta_1 = -\eta_4$, and since the results are, in general, more consistent with the model containing a non-binding borrowing constraint rather than a binding constraint, we did not impose the constraint $\eta_1 = -\eta_4$ in any of the regressions.

Table 4.11 presents the estimates for the two largest industry groups with the textile industry in the first column and the fabricated metal products, machinery and equipment industry in the second column. The results are similar for both industries. We do not reject the test of overidentifying restrictions. This implies that there is no sign of misspecification for either industry (with the note that the p -value is much higher for the textile sector). The Wald test of joint significance of all coefficients of the equation suggests that we cannot reject the model at the 5% significance level for either industry. The Wald test of joint significance of η_3 and η_4 again suggests that we cannot reject these constraints at the 5% level for either industry. However, a further look at the individual significance of η_3 and η_4 suggests that we cannot reject the increasing premium constraint, but we can reject the credit-rationing constraint for both industries. In terms of the significance of each of the estimated coefficients, the signs are the same and as expected for both industries, but we get stronger estimates for the textile sector. In fact, even though η_2 has the expected sign, it is not significant for the fabricated metal products, machinery, and equipment industry. The coefficient of the time dummy is significant for both sectors.

We will now use the estimates of the coefficients in the textile industry to determine the magnitudes of the structural parameters of the model, namely, the elasticity of demand, ϵ , the marginal adjustment cost parameter, b , and the slope coefficient of the financial distress function, a . The reason that we highlight the results from the textile industry is that this industry is the largest manufacturing industry in Turkey. The firms in the textile industry account for more than a quarter (26%) of all firms in the Turkish

manufacturing sector. Table 4.12 presents the estimation results for the textile industry in terms of the structural parameters of the model. Using the estimates of coefficients η_1 , η_2 , and η_3 , we get $\alpha = 0.74$, $b = 27.34$ and $a = 3.55$.

Given that $\alpha = 1 - \frac{1}{\varepsilon} = 0.74$, then $\varepsilon = 3.91$. The elastic demand, that is $|\varepsilon| = 3.91 > 1$, implies that the market structure in the textile industry is characterized by imperfect competition. Using the first order condition for an imperfectly competitive firm, we can derive the mark-up over the marginal cost in the textile industry.

$$p(y) \left[1 - \frac{1}{|\varepsilon|} \right] = c'(y)$$

$$p(y) \left[1 - \frac{1}{|3.91|} \right] = c'(y)$$

$$p(y) = 1.344 c'(y)$$

The mark-up over the marginal cost is approximately 34.4%, which is a reasonable magnitude. Whited (1992) estimates the mark-up to be between 0-34% for 325 U.S. manufacturing firms in the 1975-1986 period.

The value of the marginal adjustment cost parameter is 27.34. Using the formula for the adjustment costs, we can calculate how much the adjustment costs are as a percentage of total sales.

$$G(I_t, K_t) = \frac{b}{2} K_t \left[\frac{I_t}{K_t} \right]^2$$

Dividing the above expression by Y_t , we get

$$\frac{G(I_t, K_t)}{Y_t} = \frac{b}{2} \frac{K_t}{Y_t} \left[\frac{I_t}{K_t} \right]^2.$$

From the descriptive statistics on the textile industry, Table 4.3, we obtain the sample means for $\frac{I_t}{K_t}$ and $\frac{K_t}{Y_t}$ as 0.1775 and 0.1068, respectively. Then,

$$\begin{aligned} \frac{G(I_t, K_t)}{Y_t} &= \frac{b}{2} \frac{K_t}{Y_t} \left[\frac{I_t}{K_t} \right]^2 \\ &= \frac{27.32}{2} 0.1068 [0.1775]^2 \\ &= 0.0460 \end{aligned}$$

which implies that the adjustment costs are 4.6% of total sales. This value is comparable to the adjustment costs in the manufacturing sector in other studies. Jaramillo *et al.* (1996) estimate adjustment costs to be 6.2% of total sales in manufacturing sector during 1984-1988 period in Ecuador.

The slope coefficient of the financial distress function is 3.55. It is positive as expected but quite high. The coefficient implies that as the leverage ratio increases, firms could be facing high interest rates. For example, a firm with a leverage ratio of 0.1 would face a premium of 35.5% whereas a firm with a leverage ratio of 1.0 would face a premium of 355%. The estimated premium is quite high compared to similar estimates for other countries in the literature. However, we are not aware of any other study that estimates this premium for the Turkish manufacturing sector. We could interpret the high magnitude of the rate as prohibitively high financial distress premium.

4.5 Summary

This chapter first explained the source and the nature of the Turkish panel data set. It then described the variables used in the GMM estimation and how these variables were constructed.

The chapter provided descriptive statistics on the capital stock, investment, investment-capital ratio, debt-capital ratio, and output-capital ratio for the total manufacturing sector as well as Turkey's largest two industries as defined by the number of firms. It was found that the distributions of both capital and investment are highly skewed to the right. In addition, the average means of investment-capital ratio, debt-capital ratio, and output-capital ratio were each found to be comparable to those reported in other studies.

The overview of the panel data analysis discussed the unobserved individual-specific and time-specific effects. Since the Turkish data are collected by a census, we have chosen to use the fixed-effects model for both individual-specific and time-specific effects. We eliminated the fixed individual-specific effects by first differencing and employed time dummies to account for the fixed time-specific effects.

The discussion of the GMM estimator highlighted that this estimator has developed from the literature on minimum distance estimators. We have chosen to perform the estimations with this estimator in the thesis because the GMM estimator provides asymptotically efficient estimates with dynamic panel data models, without imposing independence over time or conditional homoskedasticity on the disturbances of the model. The following are the main results from our GMM estimations.

First, we performed econometric estimation on the 1036 firms in the manufacturing sector in the greater Istanbul area. Using two different methods, we classified the firms as small, medium, and large firms with size determination based on their capital stocks. We found that large firms faced an increasing premium but no credit rationing whereas medium firms faced both an increasing premium and a credit-rationing constraint in the 1983-1986 period. We did not find any evidence that small firms faced either of the two constraints. Our interpretation of this unexpected result was that the amount of debt issued by small firms may not depend on their capital stock.

Second, we performed estimation on the two largest industry groups, that is, the two industries with the largest number of firms: the textile industry and the fabricated metal products, machinery, and equipment industry. We could not reject the increasing premium constraint, but we could reject the credit-rationing constraint for both industries.

Third, we used the estimates of the coefficients for Turkey's largest industry, the textile industry, to determine the structural parameters of the model. The elasticity of demand, the marginal adjustment cost parameter, and the slope coefficient of the financial distress function were each found to be significant. They each had the expected sign and a reasonable magnitude.

4.6 Tables

Table 4.1
Description of Industries (ISIC)

ISIC 31	Manufacture of food, beverages, and tobacco
ISIC 32	Textile, wearing apparel, and leather industries
ISIC 33	Manufacture of wood and wood products including furniture
ISIC 34	Manufacture of paper and paper products, prints, and publishing
ISIC 35	Manufacture of chemicals, and of chemical petroleum, coal, rubber, and plastic products
ISIC 36	Manufacture of non-metallic mineral products except products of petroleum and coal
ISIC 37	Basic metal industries
ISIC 38	Manufacture of fabricated metal products, machinery and equipment, transport equipment, professional, scientific, measuring and controlling equipment
ISIC 39	Other manufacturing industries

**Table 4.2: Descriptive Statistics
Total Manufacturing Sector (1036 firms)**

Capital Stock (000 TL)	1983	1984	1985	1986
Mean	393,509	448,156	484,222	547,173
Median	68,717	81,561	86,031	98,968
Standard Deviation	1,161,778	1,308,450	1,403,325	1,533,961
Skewness	7.58	6.7	6.48	6.37
Kurtosis	80.64	58.24	52.8	53.16
Minimum	71	64	403	658
Maximum	17,827,420	17,360,536	16,023,261	19,176,594
Investment (000 TL)	1983	1984	1985	1986
Mean	50,233	93,997	80,882	111,373
Median	5,044	6,783	4,024	7,217
Standard Deviation	179,713	414,398	348,075	439,521
Skewness	7.68	10.38	10.68	9.11
Kurtosis	72.82	143.08	147.13	103.65
Minimum	-197,849	-487,005	-64,620	-480,875
Maximum	2,272,009	7,570,429	6,241,405	6,707,129
Investment-Capital Ratio	1983	1984	1985	1986
Mean	0.2	0.17	0.12	0.16
Median	0.08	0.1	0.05	0.09
Standard Deviation	0.42	0.21	0.17	0.21
Skewness	10.88	0.87	1.04	1.24
Kurtosis	199.36	1.34	3.44	1.55
Minimum	-0.67	-0.78	-0.79	-0.58
Maximum	9.12	0.91	0.86	0.98
Debt-Capital Ratio	1983	1984	1985	1986
Mean	1.5	1.29	1.4	1.5
Median	0.97	0.81	0.79	0.99
Standard Deviation	1.69	1.5	1.7	1.71
Skewness	2.01	1.95	2.08	2.05
Kurtosis	4.68	4.13	4.71	4.85
Minimum	0	0	0	0
Maximum	9.84	9.14	9.82	9.78
Output-Capital Ratio	1983	1984	1985	1986
Mean	7.62	7.58	7.58	7.41
Median	4.61	4.46	4.4	4.4
Standard Deviation	17.03	20.81	10.99	9.45
Skewness	19.88	25.24	7.79	4.87
Kurtosis	506.69	741.98	105.1	41.79
Minimum	-0.2	-39.83	-0.1	-2.4
Maximum	463.41	623.32	196.61	126.34

Table 4.3: Descriptive Statistics
Textile, wearing apparel, and leather industries (268 firms)

Capital Stock (000 TL)	1983	1984	1985	1986
Mean	337,350	367,069	388,756	431,669
Median	57,947	63,311	65,860	92,404
Standard Deviation	973,956	994,023	1,012,268	1,056,599
Skewness	7.01	6.01	5.59	5.03
Kurtosis	65.93	45.51	37.84	30.44
Minimum	71	64	403	658
Maximum	11,367,290	10,229,680	9,206,712	8,845,173
Investment (000 TL)	1983	1984	1985	1986
Mean	42,905	63,454	58,394	81,789
Median	4,706	5,303	1,675	4,846
Standard Deviation	167,751	243,910	202,715	251,728
Skewness	9.55	7.1	8.62	6.62
Kurtosis	111.21	57.72	96.74	55.33
Minimum	-105,851	-487,005	-64,620	-30,315
Maximum	2,213,636	2,291,396	2,600,379	2,720,522
Investment-Capital Ratio	1983	1984	1985	1986
Mean	0.23	0.18	0.13	0.17
Median	0.08	0.1	0.04	0.08
Standard Deviation	0.38	0.23	0.19	0.22
Skewness	4.84	0.77	0.78	1
Kurtosis	41.54	0.5	3.04	0.95
Minimum	-0.17	-0.56	-0.79	-0.58
Maximum	4.15	0.91	0.86	0.92
Debt-Capital Ratio	1983	1984	1985	1986
Mean	1.6	1.18	1.38	1.67
Median	0.99	0.73	0.8	1.17
Standard Deviation	1.79	1.46	1.72	1.84
Skewness	1.7	2.44	2.28	1.98
Kurtosis	2.78	7.57	5.8	4.38
Minimum	0	0	0	0
Maximum	9.23	8.59	9.07	9.78
Output-Capital Ratio	1983	1984	1985	1986
Mean	8.92	9.96	9.25	9.31
Median	4.38	4.43	4.86	4.93
Standard Deviation	29	38.75	15.98	13.65
Skewness	14.58	15	7.26	4.9
Kurtosis	228.22	237.44	74.31	32.41
Minimum	-0.2	0.06	0.08	0.35
Maximum	463.41	623.32	196.61	126.34

Table 4.4: Descriptive Statistics
Manufacture of fabricated metal products, machinery & equipment (318 firms)

Capital Stock (000 TL)	1983	1984	1985	1986
Mean	331,306	387,722	434,837	494,993
Median	60,938	65,230	67,647	77,988
Standard Deviation	927,615	1,133,005	1,305,769	1,379,494
Skewness	5.7	6.25	6.38	5.39
Kurtosis	38.46	49	51.62	36.49
Minimum	1,141	1,027	924	832
Maximum	8,193,688	11,929,298	14,333,534	13,778,258
Investment (000 TL)	1983	1984	1985	1986
Mean	46,330	89,547	85,887	103,640
Median	4,416	6,240	4,251	6,595
Standard Deviation	153,457	373,409	388,552	385,301
Skewness	6.26	8.02	8.92	8.45
Kurtosis	48.24	77.57	92.5	92.48
Minimum	-32,310	-90,647	-10,391	-96,660
Maximum	1,525,495	4,554,979	4,804,654	5,032,757
Investment-Capital Ratio	1983	1984	1985	1986
Mean	0.18	0.17	0.12	0.16
Median	0.08	0.11	0.06	0.09
Standard Deviation	0.56	0.2	0.16	0.19
Skewness	13.14	0.93	1.04	0.99
Kurtosis	203.53	1.17	2.1	0.76
Minimum	-0.31	-0.51	-0.47	-0.39
Maximum	9.12	0.88	0.7	0.83
Debt-Capital Ratio	1983	1984	1985	1986
Mean	1.45	1.24	1.26	1.41
Median	0.92	0.78	0.71	0.84
Standard Deviation	1.73	1.46	1.59	1.73
Skewness	2.13	1.88	2.27	2.28
Kurtosis	4.97	3.5	5.87	5.96
Minimum	0	0	0	0
Maximum	9.64	7.5	8.75	9.44
Output-Capital Ratio	1983	1984	1985	1986
Mean	6.67	6.61	6.79	6.58
Median	4.43	4.49	4.12	4.41
Standard Deviation	6.95	7.14	7.13	6.85
Skewness	3.39	1.07	2.32	2.57
Kurtosis	18.5	10.69	5.71	7.82
Minimum	0.08	-39.83	0.23	0.22
Maximum	64.96	48.99	42.58	41.82

Table 4.5
Distribution of Firms

		Distribution of Firms across the Manufacturing Sector										
		1-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	81-90%	91-100%	Total
ISIC 31	# of firms	4	4	6	5	5	7	6	12	7	8	64
	row %	6%	6%	9%	8%	8%	11%	9%	19%	11%	13%	100%
	column %	4%	4%	6%	5%	5%	7%	6%	12%	7%	8%	6%
ISIC 32	# of firms	43	35	25	19	25	28	24	17	27	25	268
	row %	16%	13%	9%	7%	9%	10%	9%	6%	10%	9%	100%
	column %	41%	34%	24%	18%	24%	27%	23%	17%	26%	24%	26%
ISIC 33	# of firms	3	2	2	1	2	2	3	5	2	1	23
	row %	13%	9%	9%	4%	9%	9%	13%	22%	9%	4%	100%
	column %	3%	2%	2%	1%	2%	2%	3%	5%	2%	1%	2%
ISIC 34	# of firms	9	2	5	6	4	5	5	5	5	4	50
	row %	18%	4%	10%	12%	8%	10%	10%	10%	10%	8%	100%
	column %	9%	2%	5%	6%	4%	5%	5%	5%	5%	4%	5%
ISIC 35	# of firms	13	12	15	19	19	19	17	13	20	20	167
	row %	8%	7%	9%	11%	11%	11%	10%	8%	12%	12%	100%
	column %	13%	12%	14%	18%	18%	18%	17%	13%	19%	19%	16%
ISIC 36	# of firms	4	3	3	0	7	7	5	11	2	9	51
	row %	8%	6%	6%	0%	14%	14%	10%	22%	4%	18%	100%
	column %	4%	3%	3%	0%	7%	7%	5%	11%	2%	9%	5%
ISIC 37	# of firms	1	4	6	7	12	7	8	7	11	7	70
	row %	1%	6%	9%	10%	17%	10%	11%	10%	16%	10%	100%
	column %	1%	4%	6%	7%	12%	7%	8%	7%	11%	7%	7%
ISIC 38	# of firms	26	38	39	44	26	28	31	30	28	28	318
	row %	8%	12%	12%	14%	8%	9%	10%	9%	9%	9%	100%
	column %	25%	37%	38%	42%	25%	27%	30%	29%	27%	27%	31%
ISIC 39	# of firms	1	4	3	3	4	1	4	3	1	1	25
	row %	4%	16%	12%	12%	16%	4%	16%	12%	4%	4%	100%
	column %	1%	4%	3%	3%	4%	1%	4%	3%	1%	1%	2%
Total		104	104	104	104	104	104	103	103	103	103	1036

Note: Description of industry codes is provided in Table 4.1.

Table 4.6
Correlation of Instruments with $\frac{\partial g(\theta, w)}{\partial \theta}$
Total Manufacturing Sector (Method 1)

	Small Firms		Medium Firms		Large Firms	
	R^2	$\bar{R}^2$	R^2	$\bar{R}^2$	R^2	$\bar{R}^2$
Equation 1 (1983-1985)						
η_1	0.32	0.30	0.53	0.51	0.65	0.63
η_2	0.29	0.28	0.64	0.62	0.69	0.68
η_3'	0.55	0.54	0.67	0.65	0.58	0.56
η_4	0.49	0.48	0.51	0.48	0.36	0.32
Equation 2 (1984-1986)						
η_1	0.82	0.81	0.40	0.37	0.36	0.32
η_2	0.80	0.79	0.43	0.39	0.22	0.18
η_3'	0.44	0.43	0.65	0.63	0.54	0.51
η_4	0.11	0.09	0.35	0.30	0.40	0.37

Table 4.7
Correlation of Instruments with $\frac{\partial g(\theta, w)}{\partial \theta}$
Total Manufacturing Sector (Method 2)

	Small Firms		Medium Firms		Large Firms	
	R^2	$\bar{R}^2$	R^2	$\bar{R}^2$	R^2	$\bar{R}^2$
Equation 1 (1983-1985)						
η_1	0.32	0.31	0.48	0.44	0.67	0.65
η_2	0.29	0.27	0.66	0.64	0.70	0.68
η_3	0.56	0.55	0.65	0.63	0.64	0.61
η_4	0.53	0.52	0.62	0.59	0.38	0.35
Equation 2 (1984-1986)						
η_1	0.82	0.81	0.35	0.31	0.40	0.36
η_2	0.80	0.80	0.35	0.31	0.25	0.20
η_3	0.44	0.43	0.65	0.63	0.55	0.52
η_4	0.11	0.09	0.29	0.25	0.45	0.42

Table 4.8

Correlation of Instruments with $\frac{\partial g(\theta, w)}{\partial \theta}$

A - Textile Industry

B - Fabricated Metal Products, Machinery and Equipment Industry

	Industry A		Industry B	
	R^2	$\bar{R}^2$	R^2	$\bar{R}^2$
Equation 1 (1983-1985)				
η_1	0.44	0.41	0.77	0.76
η_2	0.27	0.24	0.70	0.69
η_3	0.53	0.50	0.63	0.62
η_4	0.16	0.12	0.15	0.12
Equation 2 (1984-1986)				
η_1	0.97	0.96	0.33	0.30
η_2	0.97	0.97	0.19	0.16
η_3	0.44	0.41	0.54	0.53
η_4	0.21	0.18	0.21	0.18

Table 4.9
GMM Estimation using Method 1
Total Manufacturing Sector (1036 Firms)

	Small Firms	Medium Firms	Large Firms
η_1	-0.0378 (4.1533)***	-0.0403 (2.2280)**	-0.0331 (1.9153)*
η_2	0.0278 (4.1739)***	0.0393 (1.9098)*	0.0216 (0.8010)
η_3	0.0809 (1.4960)	0.1112 (2.1728)**	0.2212 (3.2195)***
η_4	4.01×10^{-5} (1.5631)	1.98×10^{-5} (2.7745)***	9.17×10^{-7} (0.6153)
η_5	0.6570 (3.7499)***	0.4886 (2.1921)**	0.0826 (0.4939)
Wald test 1	14.9954	6.3385	3.0297
d.o.f.	4 [.000]	4 [.012]	4 [.082]
Wald test 2	2.2385	4.7225	10.3650
d.o.f.	2 [.135]	2 [.030]	2 [.001]
J test	4.0425	13.6275	5.8501
d.o.f.	9 [.909]	9 [.136]	9 [.755]

Notes:

- (1) The instruments are $\frac{I}{K}, \left(\frac{I}{K}\right)^2, \frac{wL}{K}, \frac{Y}{K}, \frac{B}{pK}, \left(\frac{B}{pK}\right)^2$ and time dummies, all in levels.
- (2) There are 624 small firms, 206 medium firms, and 206 large firms.
- (3) Absolute values of *t*-statistics are in parentheses, and *p*-values are in square brackets.
- (4) One, two, and three asterisks denote significance at the 10, 5, and 1 percent levels, respectively.
- (5) Wald test 1 tests the joint significance of all variables, and Wald test 2 tests the joint significance of financial variables.
- (6) d.o.f. denotes degrees of freedom.

Table 4.10
GMM Estimation using Method 2
Total Manufacturing Sector (1036 Firms)

	Small Firms	Medium Firms	Large Firms
η_1	-0.0385 (4.1682)***	-0.0466 (2.5017)**	-0.0330 (2.0030)**
η_2	0.0283 (4.1881)***	0.0411 (1.8765)*	0.0284 (1.1304)
η_3	0.0639 (1.2503)	0.1868 (2.8999)***	0.2011 (3.3794)***
η_4	$3.38 \cdot 10^{-5}$ (1.2686)	$1.78 \cdot 10^{-5}$ (2.0006)**	$2.19 \cdot 10^{-6}$ (1.5222)
η_5	0.6045 (3.4713)***	0.6612 (2.6067)***	0.1796 (1.0661)
Wald test 1	12.6523	9.4434	5.1614
d.o.f.	4 [.000]	4 [.002]	4 [.023]
Wald test 2	1.5636	8.4098	11.4204
d.o.f.	2 [.211]	2 [.004]	2 [.001]
J test	4.2446	10.2341	5.3008
d.o.f.	9 [.895]	9 [.332]	9 [.807]

Notes:

- (1) The instruments are $\frac{I}{K}, \left(\frac{I}{K}\right)^2, \frac{wL}{K}, \frac{Y}{K}, \frac{B}{pK}, \left(\frac{B}{pK}\right)^2$ and time dummies, all in levels.
- (2) There are 622 small firms, 206 medium firms, and 208 large firms.
- (3) Absolute values of t -statistics are in parentheses, and p -values are in square brackets.
- (4) One, two, and three asterisks denote significance at the 10, 5, and 1 percent levels, respectively.
- (5) Wald test 1 tests the joint significance of all variables, and Wald test 2 tests the joint significance of financial variables.
- (6) d.o.f. denotes degrees of freedom.

Table 4.11
GMM Estimation for Two Largest Industries
A - Textile Industry
B - Fabricated Metal Products, Machinery and Equipment Industry

	Industry A	Industry B
η_1	-0.0492 (5.1779)***	-0.0216 (1.9711)**
η_2	0.0366 (5.3536)***	0.0093 (0.8563)
η_3	0.1747 (2.5926)**	0.1271 (2.6472)***
η_4	1.64×10^{-5} (1.5910)	3.12×10^{-6} (0.8549)
η_5	0.4284 (1.6536)*	4.63×10^{-6} (0.8552)
Wald test 1	5.0546	7.0541
d.o.f.	4 [.025]	4 [.008]
Wald test 2	6.7223	7.0074
d.o.f.	2 [.010]	2 [.008]
J test	4.1860	14.7712
d.o.f.	9 [.899]	9 [.097]

Notes:

- (1) The instruments are $\frac{I}{K}, \left(\frac{I}{K}\right)^2, \frac{wL}{K}, \frac{Y}{K}, \frac{B}{pK}, \left(\frac{B}{pK}\right)^2$ and time dummies, all in levels.
- (2) There are 268 firms in Industry A and 318 firms in Industry B.
- (3) Absolute values of t -statistics are in parentheses, and p -values are in square brackets.
- (4) One, two, and three asterisks denote significance at the 10, 5, and 1 percent levels, respectively.
- (5) Wald test 1 tests the joint significance of all variables, and Wald test 2 tests the joint significance of financial variables.
- (6) d.o.f. denotes degrees of freedom.

Table 4.12
GMM Estimation for Textile Industry
Structural Parameters

	Textile Industry
b	27.3368 (5.3536)***
α	0.7433 (124.2980)***
a	3.5513 (2.2993)**
J test	4.1860
d.o.f.	9 [.899]

Notes:

- (1) Instruments: $\frac{I}{K}, \left(\frac{I}{K}\right)^2, \frac{wL}{K}, \frac{Y}{K}, \frac{B}{pK}, \left(\frac{B}{pK}\right)^2$
and time dummies, all in levels.
- (2) There are 268 firms in Textile Industry.
- (3) Absolute values of t -statistics are in parentheses, and p -values are in square brackets.
- (4) One, two, and three asterisks denote significance at the 10, 5, and 1 percent levels, respectively.
- (5) d.o.f. denotes degrees of freedom.

5 Empirical Analysis with Time Series Data

Chapter 4 tested the importance of two types of borrowing constraints for different sizes of firms in the post-liberalization period. This chapter investigates whether the 1980 financial liberalization has relaxed these borrowing constraints by testing for structural change in the coefficients of the financial variables of our model over the pre- and post-liberalization periods. In other words, we conduct tests of structural stability in the coefficient of the quadratic term on the debt-to-capital ratio, η'_3 , arising from the increasing premium constraint and in the coefficient of the linear term on the debt-to-capital ratio, η_4 , arising from the credit-rationing constraint. We also conduct a test of structural stability in the structural parameter α , the slope coefficient of the financial distress function. Given that firm level data are available only for the post-liberalization period, we test for structural stability by using aggregate data and time series analysis.

5.1 Description of the Data Set

The data for aggregate investment, output, and the cost of variable inputs are obtained from National Accounts Detailed Tables of the OECD. The data for aggregate borrowing are obtained from the International Financial Statistics Yearbook of the IMF. These annual data cover the period over 1971-1991. The data for interest rates and price indices are from the Quarterly Bulletin of the Central Bank of Turkey and the International Financial Statistics Yearbook of the IMF.

5.2 Description of Variables

This section provides a general description of the variables used in the regressions with aggregate data.

Investment (I_t): The sum of gross fixed capital formation for machinery and other equipment, transportation equipment, and non-residential buildings.

Capital stock (K_t): The aggregate capital stock has been derived using the following method. As explained earlier, the manufacturing sector in the greater Istanbul area has a heavy concentration of the manufacturing sector in Turkey. Based on this concentration, we use the investment-capital ratio for the whole manufacturing sector in the greater Istanbul area as a proxy for the investment-capital ratio for the Turkish economy. The investment-capital ratio is calculated to be approximately equal to 0.15 for each year between 1983 and 1986. This ratio is consistent with the average investment-capital ratio reported in other studies such as Galeotti *et al.* (1994). We use the investment-capital ratio of 0.15 to calculate the 1983 aggregate capital stock for Turkey. We then calculate the aggregate capital stock for all other years from 1970 to 1991 by using the perpetual inventory method of Salinger and Summers (1983) backwards and forwards.

Output (Y_t): The value of the gross domestic product (GDP) of Turkey.

Value of Variable Inputs ($w_t L_t$): The value for the aggregate compensation of employees, which is reported as a cost component of GDP.

Borrowing (B_t): This variable includes short-term and long-term loans to the private sector and nonfinancial public enterprises.

Price of capital goods (p_t^k): Since the price index for investment is not reported, we use the wholesale price index as a proxy for the price of capital goods.

Price of output (p_t): The GDP deflator is used as a proxy for the price of output.

Risk-free interest rate (i_t): As with panel data, we use the one-year interest rate on Turkish Treasury bills.

5.3 Estimation and Results

We estimate the Euler equation derived from the cost of adjustment model, equation (2.46), using Turkish aggregate data. We are able to use the same estimable investment equation for both firm level and aggregate data since our production function exhibits constant returns to scale, and the financial distress function takes scale into account.

We estimate the investment equation using two different estimation techniques: the instrumental variables (IV) estimation and the GMM estimation. Both techniques are appropriate in a model that includes a predetermined rather than an exogenous regressor. The main difference between the two techniques is that in the IV estimation, the Euler equation is estimated as an exactly identified equation whereas in the GMM estimation, it is estimated as an overidentified equation. In other words, in the GMM estimation, there are more moments than parameters.

For both the IV and the GMM estimations, we choose the same set of instruments, that is variables $\frac{I}{K}, \left(\frac{I}{K}\right)^2, \frac{wL}{K}, \frac{Y}{K}, \frac{B}{pK}, \left(\frac{B}{pK}\right)^2$, all dated $t-1$ in levels. This implies that in both estimations, there are more instrumental variables than parameters. In this case,

the distinction between the IV estimator and the GMM estimator could simply be explained as follows. The IV estimation resolves the overidentification by choosing a subset of instruments, in other words, by projecting the columns of regressors in the column space of instruments. However, the GMM estimation uses all of the instruments and minimizes the GMM criterion function, as explained in Chapter 4. If we were to use an identity matrix as the weighting matrix of the GMM estimator, both estimators would produce the same parameter estimates (Greene, 1997).

Note that in the time series estimation, we are using the same set of instruments that we used in the GMM estimations with panel data (with the exception of time dummies included in panel data estimation). The main difference in the choice of instruments is that the instruments in time series data estimation are dated $t-1$ in levels rather than $t-2$, as was the preferred case with panel data estimation. Recall that the reason that we suggested using instruments dated $t-2$ with panel data was the moving average component of the error term introduced by first differencing to eliminate the fixed firm effects. However, with time series data, there is no need for first differencing since there are no firm-specific effects. In this case, we use levels rather than first differences.

We test for stationarity of the variables of the model by using the augmented Dickey-Fuller (DF) unit root test. The DF test can be performed by running the regression $y_t - y_{t-1}$ on y_{t-1} with a constant and a time trend and testing whether the coefficient of y_{t-1} is zero. The variables that we conduct the unit root test on are:

$\frac{I}{K}, \left(\frac{I}{K}\right)^2, \frac{wL}{K}, \frac{Y}{K}, \frac{B}{pK}, \left(\frac{B}{pK}\right)^2$. The results of this test are presented in Table 5.1. The

null hypothesis of a unit root is rejected at the 5% level for all variables with the exception of $\frac{Y}{K}$. However, the p -value for $\frac{Y}{K}$, [.147], is not much higher than .10, either. Hence, the variables of the model are generally found to be stationary.

We next apply some of the commonly used diagnostic/misspecification tests. The results of these tests are presented in Table 5.2. The LM test for serial correlation (Breusch-Godfrey test) is a Lagrange multiplier (LM) test which tests against an alternative hypothesis of either autoregressive (AR) or moving average (MA) errors of order p . It is computed by rerunning the regression with p lagged OLS residuals in addition to the original set of regressors and testing whether the coefficients of the residuals are jointly equal to zero. The reported statistic is asymptotically distributed as $\chi^2(p)$ where p is the number of lags. The LM test for first-order serial correlation suggests that we cannot reject the null hypothesis of no serial correlation.

The LM heteroskedasticity test checks for homoskedasticity of the residual variances. It is calculated by regressing the squared residuals on a constant term and the squared fitted values. The resulting statistic is distributed as χ^2 with one degree of freedom. The obtained test statistic indicates that we cannot reject the null hypothesis that the residual variances are homoskedastic.

The Jarque-Bera (JB) test is a joint LM test of the residuals' skewness and kurtosis. It is distributed asymptotically as χ^2 with two degrees of freedom. Our test statistic indicates that we cannot reject the null hypothesis that the residuals are normally distributed.

The main purpose of the aggregate data analysis is to compare the coefficients of the financial variables of the model before and after 1980, the year of the financial reform so that we can determine whether the liberalization process led to a structural change in the financial parameters of the model. To do so, we estimate the model for the 1972-1991 period, allowing the coefficients of the financial variables to differ in the pre- and post-liberalization periods. We then perform three Wald tests. The first one tests the hypothesis that the coefficients arising from the increasing interest premium constraint are equal in the two sub periods, 1972-1979 and 1980-1991. The second one tests the hypothesis that the coefficients arising from the credit-rationing constraint are equal in the two sub periods. The third one tests the hypothesis that the slopes of the financial distress function are equal in the two sub periods.

Table 5.3 presents the results of the IV estimation. Regarding the three Wald tests described above, the results of the first two Wald tests indicate that we cannot reject the hypothesis that the coefficients of the financial variables of the model are identical in the two sub periods. The result of the third Wald test also suggests that we cannot reject the hypothesis that the slopes of the financial distress function are identical in the two sub periods.

As an additional test for structural stability of the regression coefficients of the whole model, we use the Chow test. This test statistic is calculated by running a regression from 1972 to 1991, then running the same regression for two subsample periods: 1972-1979 and 1980-1991. We then compare the sum of squared residuals. The resulting statistic has an F distribution with $(k, \text{number of observations} - k)$ degrees of freedom,

where k is the number of parameters estimated. The Chow test statistic also suggests that we cannot reject the null hypothesis that the parameters are stable. This result is consistent with the results of Günçavdı *et al.* (1998), who also show that the financial liberalization of 1980 did not lead to a structural break in a model with borrowing constraints. Their sample period is from 1964 to 1993.

As for the significance of each of the estimated coefficients, η_1 , η_2 , and η_4 , each have the expected sign and are significant at the 1% level. Coefficient η_3 is significant at the 10% level. However, it has the sign expected in a model with a non-binding credit constraint rather than in a model with a binding credit constraint. We also test for the joint significance of some of the parameters. The Wald test of joint significance of all coefficients of the equation suggests that we reject the null hypothesis that the parameters of the model are jointly equal to zero at the 10% level. The Wald test of joint significance of the coefficients of the financial variables, η_3 and η_4 , also suggest that these two parameters are jointly significant at the 10% level. The latter two Wald tests that a given set of parameters is jointly equal to zero can be considered misspecification tests, that is, as tests for omitted variables.

To determine whether the financial reforms were anticipated or whether they were delayed, we conduct the stability tests choosing different reference years for the structural break.

First, we assume that the financial liberalization process was anticipated, and the structural break took place a year earlier than the financial reforms. Hence, we assume that 1979 is the year of the structural break. The Wald test results suggest that we cannot

reject the hypothesis that the coefficients on the financial variables of the model were equal before and after 1979. The Wald test statistic for the equality of η_3' is 0.3031 with a p -value of [.582], and the Wald test statistic for the equality of η_4 is 0.017 with a p -value of [.896]. Furthermore, the Wald test statistic for the equality of coefficient of the financial distress function, α , is 0.3040 with a p -value of [.581], which suggests that the slopes were equal before and after 1979. In addition, the Chow statistic, 0.6387 with a p -value of [.644], also suggests that there is no structural change in the model after 1979.

Second, we assume that the impact of the financial liberalization was delayed, and the structural break took place a year after the financial reforms. In this case, we assume that 1981 is the year of the structural break. The Wald test results once again suggest that we cannot reject the hypothesis that the coefficients on the financial variables of the model were identical in the 1972-1980 and 1981-1991 periods. The Wald test statistic for the equality of η_3' is 0.1.6468 with a p -value of [.199], and the Wald test statistic for the equality of η_4 is 0.4273 with a p -value of [.513]. The Wald test statistic for the equality of coefficient α is 1.6658 with a p -value of [.197]. The Chow statistic, 1.4909 with a p -value of [.262], also suggests that we cannot reject that the model parameters are stable after 1981.

Third, we perform four more Chow tests to determine whether the structural break took place in any of the later years following the financial reform (1982–1985). However, as presented in Table 5.4, we do not find evidence of a structural break. These results indicate that even if the financial reforms were anticipated or delayed, they were not able to relax the credit constraints on borrowing constraints.

Table 5.5 presents the results of the GMM estimation. Based on the J test, the overidentifying restrictions are not rejected, which implies that there is no sign of misspecification. The estimated coefficients are similar in magnitude to those obtained from the IV estimation. However, the significance of the coefficients is higher in the case of the GMM estimation. The three Wald tests of structural stability indicate no sign of a structural break. As in the case of the IV estimation, the coefficient arising from the increasing interest premium constraint, the coefficient arising from the credit-rationing constraint, and the slope of the financial distress function are all found to be stable.

There are recent papers that have developed tests for structural change in models estimated using the GMM. For example, Ghysels and Hall (1990) suggest a test for structural stability, where parameter estimates from a first subsample are employed to evaluate moment conditions in the second subsample. The main idea behind such tests is that in the absence of structural change, the predicted moment conditions should not be statistically different from zero. In another paper, Ghysels *et al.* (1997) extend the work by Ghysels and Hall (1990) by allowing to test for structural change when the point of structural break is unknown. In other words, this test allows testing for structural stability over all points in the sample whereas a Chow test requires the point of structural break to be specified. While we acknowledge the contribution of the tests developed in the GMM framework to econometrics, we leave the application of these tests to our model for future work.

5.4 Concluding Remarks

The Euler equation model with a binding credit constraint has one more constraint in addition to the constraints in the Euler equation model with a non-binding credit constraint. Similarly, the Euler equation model with a non-binding credit constraint has more constraints than the standard model of investment. Since we are solving a constrained optimization problem in the thesis, the optimal value of $\frac{I}{K}$ obtained from the standard model of investment will be at least as large as that obtained from the Euler equation model with a non-binding credit constraint. Similarly, the optimal value of $\frac{I}{K}$ obtained from the Euler equation model with a non-binding credit constraint will be at least as large as that obtained from the Euler equation model with a binding credit constraint.

The thesis demonstrates that the additional financial constraints in the model with a binding credit constraint are statistically significant. This implies that as we relax these constraints, $\frac{I}{K}$ will increase. We can then argue that policies addressed at alleviating these financial constraints will contribute to raising investment.

The results from both panel data and aggregate data analyses indicate that the liberalization process did not relax the borrowing constraints for Turkish firms. The poor response of the borrowing constraints to the reforms could be explained by the poor implementation of the reforms. In the 1980s, Turkey still lacked well-established and well-functioning financial institutions, instruments, and procedures (Inselbag and Gültekin, 1988). The banks and brokers were not well regulated or supervised. The

banking sector presented a highly concentrated market structure and an inefficient banking system (Öniş and Riedel, 1993; Denizer, 1997).

The market concentration rate has not improved from 1980 to 1991. The measures of concentration indicate that the top eight banks controlled 82% of total deposits both in 1980 and 1991. In terms of total assets, the top eight banks controlled 76% of assets in 1980 and about 70% in 1991 (Denizer, 1997).

The inefficiency of the Turkish banking sector also continues in the post-liberalization years. A comparison of operating costs and profitability of banking between OECD countries and Turkey in 1990 provides the following results. The operating costs as a percentage of total assets were 2.0% for OECD countries while they were 5.1% for Turkey. The profits before taxes were 0.7% for OECD countries while they were 3.6% for Turkey (Denizer, 1997). This implies that in Turkey banking is 2.5 times more costly than in OECD countries, yet it is more than 5 times more profitable.

5.5 Summary

The main purpose of this chapter was to test for structural change in our investment model over the pre- and post-liberalization years. Since firm level data are available only for the post-liberalization years, we performed tests of structural stability using aggregate data from 1971 to 1991.

We used two different estimation techniques to estimate the Euler equation: the IV estimation and the GMM estimation. The results from both estimations provide support for the investment equation with borrowing constraints. The coefficient estimates

obtained from both estimations were similar in magnitude, with the note that they were slightly more significant in the GMM estimation.

We tested for structural stability by employing four different tests. The first one tested the stability of the coefficient arising from increasing interest premium. The second one tested the stability of the coefficient arising from the credit-rationing constraint. The third one tested the stability of the slope of the financial distress function. Finally, the fourth one tested the structural stability of all coefficients of the model. All four tests indicated that there is no structural change in the model after 1980. To determine whether the financial liberalization was anticipated or delayed, we chose different reference years for the structural break and performed the same set of tests. The results still indicated that there is no structural change in the model.

5.6 Tables

Table 5.1
Unit Root Tests

$\frac{I}{K}$	-3.582
	[.031]
$\left(\frac{I}{K}\right)^2$	-3.484
	[.041]
$\frac{B}{pK}$	-3.623
	[.028]
$\left(\frac{B}{pK}\right)^2$	-4.207
	[.004]
$\frac{Y}{K}$	-2.949
	[.147]
$\frac{wL}{K}$	-3.738
	[.020]

Note:

(1) *P*-values are in square brackets.

Table 5.2
Diagnostic/Misspecification Tests

LM test for serial correlation	0.3699
d.o.f.	1
	[.543]
LM heteroskedasticity test	0.1188
d.o.f.	1
	[.730]
JB test for normality	0.8552
d.o.f	2
	[.652]

Notes:

- (1) *P*-values are in square brackets.
- (2) d.o.f. denotes degrees of freedom.

Table 5.3
IV Estimation

η_1	-0.4136 (7.8945)***
η_2	0.3714 (9.7429)***
η_3	9.0159 (1.6585)*
η_4	0.3744 (9.4627)***
Wald test 1 d.o.f.	2.8534 4 [.091]
Wald test 2 d.o.f.	2.8817 2 [.089]
Test for Stability of η_3 d.o.f.	1.0540 2 [.305]
Test for Stability of η_4 d.o.f.	0.78×10^{-3} 2 [.978]
Test for Stability of α d.o.f.	1.0637 2 [.302]
Chow test d.o.f.	0.8206 (4, 13) [.535]

Notes:

- (1) Absolute values of t -statistics are in parentheses, and p -values are in square brackets.
- (2) One, two, and three asterisks denote significance at the 10, 5, and 1 percent levels, respectively.
- (3) d.o.f. denotes degrees of freedom.

Table 5.4
Chow Tests

Year of Structural Break	
1979	0.6387 (4, 13) [.644]
1980	0.8206 (4, 13) [.535]
1981	1.4909 (4, 13) [.262]
1982	1.4977 (4, 13) [.260]
1983	1.6314 (4, 13) [.226]
1984	1.7503 (4, 13) [.199]
1985	1.8157 (4, 13) [.186]

Notes:

(1) *P*-values are in square brackets.

(2) Degrees of freedom are in parentheses.

Table 5.5
GMM Estimation

η_1	-0.4155 (8.0185)***
η_2	0.3722 (10.2345)***
η_3	11.3901 (2.3820)**
η_4	0.3782 (9.0692)***
Wald test 1 d.o.f.	6.0101 4 [.014]
Wald test 2 d.o.f.	6.0547 2 [.014]
J test d.o.f.	143.5614 128 [.1643]
Test for Stability of η_3 d.o.f.	0.3122 2 [.576]
Test for Stability of η_4 d.o.f.	0.9366 2 [.333]
Test for Stability of α d.o.f.	0.3151 2 [.575]

Notes:

- (1) Instruments: $\frac{I}{K}, \left(\frac{I}{K}\right)^2, \frac{wL}{K}, \frac{Y}{K}, \frac{B}{pK}, \left(\frac{B}{pK}\right)^2$.
- (3) Absolute values of t -statistics are in parentheses, and p -values are in square brackets.
- (4) One, two, and three asterisks denote significance at the 10, 5, and 1 percent levels, respectively.
- (5) d.o.f. denotes degrees of freedom.

6 Conclusion

The purpose of this thesis was to evaluate the impact of financial reforms on the borrowing constraints faced by the firm. An estimable investment equation with borrowing constraints was derived and tested using Turkish firm level and aggregate data. The results from both panel data and time series data analyses indicate that the model with borrowing constraints cannot be rejected in the post-reform period.

In the panel data analysis, first, we performed the GMM estimation on the 1036 firms in the manufacturing sector in the greater Istanbul area. We classified the firms into three size groups based on their capital stock. Our estimation results show that medium firms faced both an increasing premium and credit rationing in the post-liberalization period in Turkey. Large firms also faced an increasing premium but were not rationed out of credit markets. As for small firms, there is no evidence of either an increasing premium or credit rationing. This unexpected result could be due to the very small value of the capital stocks of the small firms. These firms would be expected to issue a very small amount of debt and, hence, may have used collateral other than their capital stock to borrow. Alternatively, these firms may not have borrowed on the credit markets at all, but, rather, they may have used personal savings or borrowed from family or friends.

Second, we performed the GMM estimation on Turkey's two largest industries as defined by the number of firms: the textile industry and the fabricated metal products, machinery, and equipment industry. The results indicated that both industries faced an increasing interest premium but neither industry faced a credit-rationing constraint.

Third, using the estimates of the coefficients for the textile industry, we determined the structural parameters of the model, that is the elasticity of demand, the marginal adjustment cost parameter, and the slope coefficient of the financial distress function. All three structural parameters were found to be significant, with the expected signs and reasonable magnitudes.

In the time series data analysis, we tested for structural stability of the model over the pre- and post-liberalization periods. We performed the structural stability tests using aggregate data rather than firm level data since firm level data are available only for the post-liberalization years. The functional specifications of the thesis made it possible to use the same estimable investment equation for both firm level and aggregate data. We found that the coefficients associated with the two credit constraints are significant both before and after the liberalization process and, hence, there is no structural change in the model after 1980.

The thesis makes a contribution to the literature on investment under capital market imperfections. It builds an estimable dynamic investment model with borrowing constraints based on the existing models in the literature. This framework of analysis can be used to analyze the degree of credit constraints in other countries. The framework can also be applied to different financial deregulation policies. This study is the first to test the impact of financial liberalization on borrowing constraints by using microeconomic data on Turkish firms. The current literature offers very limited empirical research on the impact of financial reforms on firm level investment in the context of a developing

country. Future research with firm level data can provide insights on the impact of deregulation on the investment decisions of the firm.

The main limitation of this study is that for the panel data set, we do not have any years before the financial reform and we have only a few years after the reform. Availability of these data would allow us to test for structural break for different sizes of firms. In addition, the availability of more years after the reform would allow us to assess the long-term impact of the reform. As an extension to the thesis, we would consider further work on other countries where panel data sets with a longer time dimension are available.

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Appendix

Tables and Charts

Table A1: Descriptive Statistics
Manufacture of food, beverages, and tobacco (64 firms)

Capital Stock (000 TL)	1983	1984	1985	1986
Mean	365,436	522,491	541,352	588,732
Median	123,206	117,923	119,239	140,235
Standard Deviation	669,791	1,258,364	1,291,428	1,403,315
Skewness	3.32	5.07	4.85	4.92
Kurtosis	12.12	29.92	27.02	27.98
Minimum	2,492	2,243	2,019	1,817
Maximum	3,592,742	8,719,325	8,689,128	9,524,517
Investment (000 TL)	1983	1984	1985	1986
Mean	65,732	193,599	71,110	101,515
Median	2,493	5,127	5,538	5,876
Standard Deviation	247,394	956,604	195,937	311,078
Skewness	5.01	7.53	3.83	3.93
Kurtosis	26.48	58.61	14.94	15.36
Minimum	-197,849	-14,031	-6,952	0
Maximum	1,549,723	7,570,429	1,058,920	1,704,302
Investment-Capital Ratio	1983	1984	1985	1986
Mean	0.19	0.17	0.11	0.15
Median	0.03	0.09	0.05	0.05
Standard Deviation	0.3	0.22	0.15	0.18
Skewness	0.88	1.24	1.59	1.27
Kurtosis	1.68	0.93	2.64	0.65
Minimum	-0.67	-0.07	-0.08	0
Maximum	1	0.87	0.64	0.63
Debt-Capital Ratio	1983	1984	1985	1986
Mean	1.18	1.21	1	1.28
Median	0.76	0.78	0.45	0.67
Standard Deviation	1.62	1.46	1.43	1.7
Skewness	3.22	2.04	3.22	2.22
Kurtosis	13.29	3.91	13.71	4.77
Minimum	0	0	0	0
Maximum	9.84	6.6	8.79	7.58
Output-Capital Ratio	1983	1984	1985	1986
Mean	7.9	5.98	6.03	5.91
Median	5.16	4.15	4.03	3.63
Standard Deviation	11.56	5.62	5.8	6.25
Skewness	5.29	2.46	1.73	2.33
Kurtosis	34.6	8.81	3.15	6.56
Minimum	-0.09	0.56	-0.1	-0.57
Maximum	86.54	33.99	27.51	33.13

Table A2: Descriptive Statistics				
Manufacture of wood and wood products including furniture (23 firms)				
Capital Stock (000 TL)	1983	1984	1985	1986
Mean	204,537	200,160	204,811	235,455
Median	97,057	94,372	87,198	121,339
Standard Deviation	362,425	345,977	384,411	373,825
Skewness	3.49	3.55	3.86	3.51
Kurtosis	13.41	14.02	16.35	14.11
Minimum	3,564	3,586	3,227	2,905
Maximum	1,681,901	1,625,393	1,842,832	1,780,618
Investment (000 TL)	1983	1984	1985	1986
Mean	13,173	16,076	24,667	51,125
Median	1,375	3,015	1,765	10,322
Standard Deviation	23,792	29,027	79,581	74,880
Skewness	2.99	2.63	4.43	1.61
Kurtosis	10.62	6.55	20.3	1.78
Minimum	-2,350	0	0	-156
Maximum	105,904	111,682	379,978	255,245
Investment-Capital Ratio	1983	1984	1985	1986
Mean	0.17	0.11	0.08	0.21
Median	0.01	0.07	0.03	0.15
Standard Deviation	0.28	0.12	0.11	0.25
Skewness	1.45	1.48	1.18	1.54
Kurtosis	0.94	1.32	-0.04	2.71
Minimum	-0.12	0	0	-0.04
Maximum	0.89	0.4	0.33	0.98
Debt-Capital Ratio	1983	1984	1985	1986
Mean	1.22	1.14	1.64	1.28
Median	0.93	0.59	0.99	0.85
Standard Deviation	1.2	1.24	1.92	1.63
Skewness	1.55	1.01	1.48	2.11
Kurtosis	1.88	-0.17	1.24	4.12
Minimum	0	0	0	0
Maximum	4.48	4.06	6.54	6.36
Output-Capital Ratio	1983	1984	1985	1986
Mean	4.66	4.94	4.38	3.89
Median	2.4	2.22	2.51	2.05
Standard Deviation	4.94	5.6	5.17	5.05
Skewness	1.32	2	1.76	2.11
Kurtosis	0.79	4.26	2.33	3.95
Minimum	0.16	0.25	0.11	0.15
Maximum	16.98	23.27	19.21	18.5

Table A3: Descriptive Statistics				
Manufacture of paper and paper products, prints, and publishing (50 firms)				
Capital Stock (000 TL)	1983	1984	1985	1986
Mean	279,283	282,855	308,703	356,023
Median	62,074	89,953	88,250	100,544
Standard Deviation	597,249	551,338	550,369	589,643
Skewness	3.35	3.24	2.71	2.21
Kurtosis	10.93	10.15	6.65	3.71
Minimum	5,984	5,681	5,113	4,601
Maximum	2,807,169	2,526,452	2,273,807	2,122,079
Investment (000 TL)	1983	1984	1985	1986
Mean	40,486	31,500	54,134	78,190
Median	6,134	6,692	4,896	3,694
Standard Deviation	93,826	66,126	129,702	232,750
Skewness	3.58	1.5	3.66	5.32
Kurtosis	13.44	4.14	14.01	31.71
Minimum	-40	-142,606	-18,658	-7,145
Maximum	481,399	256,358	641,322	1,524,188
Investment-Capital Ratio	1983	1984	1985	1986
Mean	0.26	0.17	0.12	0.16
Median	0.15	0.06	0.07	0.09
Standard Deviation	0.29	0.27	0.22	0.24
Skewness	0.84	-0.01	-0.56	1.67
Kurtosis	-0.44	2.19	5.56	2.31
Minimum	0	-0.78	-0.77	-0.13
Maximum	0.98	0.77	0.69	0.91
Debt-Capital Ratio	1983	1984	1985	1986
Mean	1.36	1.23	1.48	1.26
Median	1	0.57	0.73	0.78
Standard Deviation	1.63	1.62	1.96	1.5
Skewness	2.15	1.95	2.31	2.02
Kurtosis	5.19	3.21	6.25	3.8
Minimum	0	0	0	0
Maximum	7.95	6.43	9.82	6.52
Output-Capital Ratio	1983	1984	1985	1986
Mean	6.32	6.55	7.2	6.07
Median	4.45	4.39	3.61	3.09
Standard Deviation	5.89	6.11	7.96	7.65
Skewness	2.15	1.56	2.14	3.23
Kurtosis	5.31	2.28	5	13.05
Minimum	0.92	1.1	0.45	-0.16
Maximum	29.76	28.22	37.18	44.45

Table A4: Descriptive Statistics				
Manufacture of chemicals, and of chemical petroleum, coal, rubber, and plastic products (167 firms)				
Capital Stock (000 TL)	1983	1984	1985	1986
Mean	537,385	621,336	682,004	738,603
Median	75,178	85,639	100,818	108,298
Standard Deviation	1,529,307	1,782,561	2,018,374	2,079,894
Skewness	5.57	5.16	5.34	5.5
Kurtosis	37.6	29.8	31.35	35.03
Minimum	1,481	3,207	3,188	2,993
Maximum	13,620,350	13,671,889	14,851,031	17,358,818
Investment (000 TL)	1983	1984	1985	1986
Mean	65,981	137,689	122,802	124,800
Median	6,332	7,914	5,715	8,561
Standard Deviation	217,492	516,096	551,893	375,732
Skewness	7.37	7.06	9.08	7.39
Kurtosis	66.97	58.65	94.41	69.72
Minimum	-5,500	-94,251	-12,752	-76,088
Maximum	2,272,009	5,076,044	6,241,405	3,992,891
Investment-Capital Ratio	1983	1984	1985	1986
Mean	0.18	0.17	0.14	0.17
Median	0.1	0.11	0.07	0.1
Standard Deviation	0.25	0.21	0.17	0.2
Skewness	2.48	0.65	1.69	1.37
Kurtosis	7.45	1.73	3.16	1.77
Minimum	-0.04	-0.64	-0.13	-0.21
Maximum	1.4	0.86	0.86	0.94
Debt-Capital Ratio	1983	1984	1985	1986
Mean	1.87	1.7	1.88	1.67
Median	1.32	1.05	1.14	1.36
Standard Deviation	1.91	1.75	1.96	1.56
Skewness	1.75	1.38	1.47	1.43
Kurtosis	3.72	1.72	1.73	2.83
Minimum	0	0	0	0
Maximum	9.45	9.14	9.25	9.07
Output-Capital Ratio	1983	1984	1985	1986
Mean	9.44	8.06	8.01	7.68
Median	6.23	5.04	5.44	5.34
Standard Deviation	15.95	10.1	11.85	7.68
Skewness	7.81	3.96	7.28	2.19
Kurtosis	77.86	19.32	71.21	6.01
Minimum	0.08	0.23	0.57	-2.4
Maximum	178.73	73.15	131.23	43.6

Table A5: Descriptive Statistics				
Manufacture of non-metallic mineral products except products of petroleum and coal (51 firms)				
Capital Stock (000 TL)	1983	1984	1985	1986
Mean	871,724	881,702	927,228	1,153,028
Median	126,432	163,601	168,114	225,891
Standard Deviation	2,627,456	2,564,501	2,433,302	2,944,906
Skewness	5.69	5.61	5.11	4.98
Kurtosis	36.07	35.4	30.44	28.91
Minimum	2,096	1,886	1,698	1,528
Maximum	17,827,420	17,360,536	16,023,261	19,176,594
Investment (000 TL)	1983	1984	1985	1986
Mean	45,320	97,150	133,696	318,523
Median	6,943	12,256	10,061	14,035
Standard Deviation	141,844	264,325	428,396	1,165,170
Skewness	6	3.99	5.04	4.62
Kurtosis	39.2	16.21	27.92	22.03
Minimum	-38,070	-5,049	-6,251	-480,875
Maximum	978,423	1,315,858	2,712,826	6,707,129
Investment-Capital Ratio	1983	1984	1985	1986
Mean	0.16	0.12	0.12	0.17
Median	0.05	0.07	0.05	0.06
Standard Deviation	0.48	0.17	0.19	0.25
Skewness	5.94	2.11	1.92	1.77
Kurtosis	39.04	4.66	3.66	2.86
Minimum	-0.3	-0.03	-0.14	-0.19
Maximum	3.34	0.7	0.81	0.95
Debt-Capital Ratio	1983	1984	1985	1986
Mean	1.21	1.21	1.45	1.44
Median	0.87	0.9	0.89	1.21
Standard Deviation	1.1	1.42	1.77	1.66
Skewness	1.9	2.63	2.04	2.24
Kurtosis	4.28	8.12	3.67	5.93
Minimum	0	0	0	0
Maximum	5.18	6.79	7.37	8
Output-Capital Ratio	1983	1984	1985	1986
Mean	5.15	4.92	4.84	5.14
Median	2.95	2.79	2.4	2.5
Standard Deviation	7.72	8.18	7.81	7.79
Skewness	4.08	4.4	3.69	3.08
Kurtosis	20.59	22.6	15.44	10.42
Minimum	0.08	0.07	0.06	0.11
Maximum	48.73	51.84	44.71	40.04

Table A6: Descriptive Statistics				
Basic metal industries (70 firms)				
Capital Stock (000 TL)	1983	1984	1985	1986
Mean	437,567	521,375	537,729	647,217
Median	100,584	110,482	108,755	129,230
Standard Deviation	953,703	1,195,976	1,179,729	1,681,842
Skewness	3.89	4.18	3.77	4.9
Kurtosis	16.6	19.55	15.3	26.91
Minimum	9,518	8,566	7,710	6,939
Maximum	5,581,833	7,399,476	6,659,528	11,338,010
Investment (000 TL)	1983	1984	1985	1986
Mean	75,910	127,565	68,491	163,261
Median	9,698	8,224	2,053	14,064
Standard Deviation	269,692	385,196	189,789	688,725
Skewness	6.28	4.44	4.9	6.73
Kurtosis	42.25	20.88	27.7	48.7
Minimum	-902	-825	-748	-1,063
Maximum	2,020,366	2,375,826	1,296,416	5,344,435
Investment-Capital Ratio	1983	1984	1985	1986
Mean	0.24	0.16	0.09	0.14
Median	0.09	0.1	0.03	0.1
Standard Deviation	0.38	0.19	0.12	0.16
Skewness	2.74	1.55	1.18	1.34
Kurtosis	8.41	1.85	0.12	1.34
Minimum	0	0	-0.01	-0.03
Maximum	1.91	0.73	0.41	0.69
Debt-Capital Ratio	1983	1984	1985	1986
Mean	1.32	1.24	1.26	1.31
Median	1.05	0.83	0.72	0.9
Standard Deviation	1.23	1.36	1.36	1.64
Skewness	1.27	1.65	1.46	2.79
Kurtosis	1	2.21	1.58	9.67
Minimum	0	0	0	0
Maximum	4.9	5.86	5.8	9.21
Output-Capital Ratio	1983	1984	1985	1986
Mean	7.03	8.23	9.71	9.54
Median	6.13	6.23	6.26	5.43
Standard Deviation	5.37	6.94	9.23	9.49
Skewness	1.44	1.52	1.73	1.79
Kurtosis	2.08	2.19	2.9	3.39
Minimum	0.28	0.2	1.03	0.4
Maximum	24.89	31.47	44.71	45.85

Table A7: Descriptive Statistics				
Other manufacturing industries (25 firms)				
Capital Stock (000 TL)	1983	1984	1985	1986
Mean	200,933	208,288	222,913	216,988
Median	52,723	71,533	84,930	82,511
Standard Deviation	513,953	518,824	557,079	504,168
Skewness	4.64	4.66	4.65	4.6
Kurtosis	22.41	22.51	22.48	22.1
Minimum	9,517	8,565	7,709	6,938
Maximum	2,609,393	2,641,838	2,835,300	2,572,430
Investment (000 TL)	1983	1984	1985	1986
Mean	25,269	27,448	35,455	16,366
Median	750	11,754	4,753	7,041
Standard Deviation	63,478	59,865	92,439	19,543
Skewness	3.86	3.98	4.3	0.88
Kurtosis	16.28	17.52	19.91	-0.82
Minimum	-2,389	0	0	0
Maximum	302,600	293,384	457,645	53,516
Investment-Capital Ratio	1983	1984	1985	1986
Mean	0.22	0.16	0.11	0.13
Median	0.03	0.04	0.05	0.06
Standard Deviation	0.37	0.23	0.13	0.16
Skewness	2.01	1.7	1.36	1.63
Kurtosis	3.75	2.45	1.29	2.71
Minimum	0	0	0	0
Maximum	1.44	0.78	0.48	0.64
Debt-Capital Ratio	1983	1984	1985	1986
Mean	1	0.93	1.16	1.63
Median	0.71	0.86	0.91	1.35
Standard Deviation	0.87	0.66	1.07	1.54
Skewness	1.15	0.56	1.31	1.19
Kurtosis	0.74	-0.02	2.1	0.84
Minimum	0	0	0	0
Maximum	3.19	2.58	4.36	5.55
Output-Capital Ratio	1983	1984	1985	1986
Mean	4.91	3.47	4.06	4.37
Median	3.38	2.73	2.84	2.61
Standard Deviation	3.96	1.99	3.47	3.84
Skewness	1.74	0.67	1.25	1.5
Kurtosis	3.96	-0.72	0.9	1.8
Minimum	1.2	1.01	0.39	0.73
Maximum	18.11	7.9	12.78	15.64

Chart A1
Histogram of 1983 Capital Stock
Total Manufacturing Sector
(1036 Firms)

Chart A2
Histogram of 1983 Capital Stock
Food, beverages, and tobacco
(64 firms)

Chart A3
Histogram of 1983 Capital Stock
Textile, wearing apparel, and leather
(268 Firms)

Chart A4
Histogram of 1983 Capital Stock
Wood and wood products including furniture
(23 Firms)

Chart A5
Histogram of 1983 Capital Stock
Paper and paper products, prints, and publishing
(50 Firms)

Chart A6
Histogram of 1983 Capital Stock
Chemicals, chemical petroleum, coal, rubber,
and plastic (167 Firms)

Chart A7
Histogram of 1983 Capital Stock
Non-metallic mineral products except products of
petroleum and coal (51 Firms)

Chart A8
Histogram of 1983 Capital Stock
Basic metal industries
(70 Firms)

Chart A9
Histogram of 1983 Capital Stock
Fabricated metal products, machinery and equipment
(318 Firms)

Chart A10
Histogram of 1983 Capital Stock
Other manufacturing industries
(25 Firms)