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AN ECONOMETRIC STUDY OF THE EFFECTS AND MOTIVATION FOR CENTRAL BANK INTERVENTION IN TURKEY: 1993-2003

by

Pinar Ozbay

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ABSTRACT

AN ECONOMETRIC STUDY OF THE EFFECTS AND MOTIVATION FOR CENTRAL BANK INTERVENTION IN TURKEY: 1993-2003

by

Pinar Ozbay

This dissertation consists of four distinct chapters, all of which model and examine the effects and motivation of central bank intervention in Turkey during 1993-2003. Chapter one considers the effectiveness of central bank intervention in the Turkish Lira-US$ spot exchange rate market for different exchange rate policy regimes in Turkey. Forms of GARCH models are used to present the effect of intervention on both the mean and volatility process.

Chapter two is concerned with the motivations of the central bank intervention in the Turkish Lira-US$ spot exchange market. The central bank intervention reaction function is modeled using probit, tobit and censored least absolute deviation models.

Chapter three examines the intervention reaction function with a different approach. The Threshold model is used in the non-linear estimation of the reaction function in the Turkish Lira-US$ spot exchange market.

Chapter four is concerned with the relation between risk premium and central bank intervention. Forward rates are calculated for the Turkish Lira-US$ spot exchange market and then the effect of central bank intervention on risk premium is presented.

This dissertation is dedicated to my beloved husband, Gokce Ozlu, my mother, Hatice Ercan, my brother and my sister

For their love, encouragement and trust

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CHAPTER 1

Is Central Bank Intervention Effective?

1.1 Introduction

Exchange rate intervention in the foreign exchange market is defined as the buying and selling of foreign currency by a central bank or government in an attempt to influence the level of an exchange rate. There are two main motives of intervention. The first one is to influence the level of an exchange rate and the second one is to reduce its volatility or in other words to calm a disorderly market.

Intervention is generally sterilized such that purchase (sale) of foreign currency is offset by a corresponding sale(purchase) of domestic government debt to eliminate the effect on the money supply. Hence intervention is quite distinct from pure monetary policy. Sterilized intervention provides monetary authorities to aim an exchange rate target objective independent of their monetary policy.

Studies of intervention often distinguish between sterilized intervention, which does not affect the money supply, and non-sterilized intervention which does. Despite the agreement among economists about the effectiveness of non-sterilized intervention, the effect of sterilized intervention is much more controversial. Non-sterilized intervention is expected to directly affect the exchange rate because it changes the stock of base money and involves broader money aggregates, interest rates, real demands for goods and assets, and market expectations. Sterilized intervention leaves the monetary base unchanged. So it is not expected to affect the exchange rate through the monetary channel. In contrast to the direct effect, intervention, even if sterilized, can influence exchange rates through the portfolio and the signaling channels. Sterilized intervention will alter the relative supplies of domestic money and bonds. With risk averse investors who view domestic and foreign bonds as imperfect substitutes, the impact of intervention will make them trade bonds which, in turn, will lead to an adjustment of the relative rate of return by changing the exchange rate. A sterilized purchase of foreign exchange increases the amount of publicly held domestic bonds, relative to foreign bonds, and induces a depreciation of the domestic currency.

The portfolio balance theory implies there will be no impact of intervention on the exchange rate when there is perfect substitutability of bonds. To test this, theory requires information on the relative supplies of the assets. In the signaling channel, central banks try to influence exchange rates by conveying to the market a signal concerning current or future monetary or exchange rate policy. That is, sterilized purchases of foreign currency are expected to lead to a depreciation of the exchange rate if the foreign currency purchase is assumed to signal a more expansionary domestic monetary policy. This channel is largely acknowledged as the main path by which interventions affect foreign exchange markets.

There is an enormous amount of literature concerning the effects of intervention on currency markets and the motivations for intervention. While researchers have been able to document short-lived effects, the overwhelming conclusion after studying the literature is that foreign exchange intervention is not effective for influencing the level and the volatility of the exchange rate. See Edison (1993), Almekinders (1995), Baillie et al. (2000), Schwartz (2000), Sarno and Taylor (2001), King (2003) and Humpage (2003). Empirical studies of the 1980s are characterized by two major handicaps, a lack of data on intervention and also a lack of survey data on exchange rate expectations. Studies on intervention in the 1990s and early 2000's use high quality daily data on intervention.

Policy-makers seem to believe that it is possible for a central bank to significantly affect the supply and demand conditions in the foreign exchange market. In the 1980s and 1990s, attention focused on the effect of sterilized intervention on the level of the exchange rate and the channels through which intervention works. Humpage (1988) and Obstfeld (1989) note that the monetary amount of intervention is very small in comparison to the total market trading. Most empirical studies, such as Humpage (1988), Baillie and Osterberg (1997b) and Beine et al (2002) find a "leaning against the wind" phenomenon, which is regarded as economically unsatisfactory. Usually if any significant relationship is found, it is of the "leaning against the wind" type, with the Fed buying dollars associated with a subsequent dollar depreciation next period. This is almost certainly due to the policy endogeneity issue, with the bank buying dollars to support the already depreciating currency.

There is general consensus in the literature that intervention does not affect exchange rates through the portfolio channel. Lewis (1988) estimates outside bond demand equations from the portfolio balance model of exchange rate determination for five currencies. The portfolio balance model focuses upon bonds from outside the economic sector that arise from the government debt. Different from the previous studies, she decomposes the foreign asset by currency. Despite improved empirical techniques, estimates of the portfolio balance model remain imprecise. Ghosh (1992) tested the portfolio balance channel for sterilized intervention by examining the effects of changes in relative asset supplies on the dollar-deutschmark rate during the 1980s. A weak but significant portfolio balance influence is found. He concludes that substantial intervention is required to influence the exchange rate through portfolio balance effects. Dominquez and Frankel (1993b) estimate a portfolio balance equation that is consistent with mean-variance optimization. In this model, expected future exchange rates are represented by data from surveys of expectations among private exchange market expectations. Their main conclusion is that sterilized interventions are effective if they change the risk premium and that cumulative intervention has a statistically significant effect on the risk premium.

Edison (1993) provides a comprehensive review of literature that focuses on empirical work conducted in the 1980s. Most of the empirical evidence summarized in Edison`s survey suggests that intervention can affect the exchange rate through the signaling channel but not the portfolio-balance channel. Almekinders (1995) agrees with Edison (1993) that no systematic effect of sterilized intervention via the portfolio balance channel is found in empirical evidence. Data limitations and theoretical and econometric problems have made it impossible to estimate the portfolio balance model and measure the effects of sterilized intervention satisfactorily. Only official exchange market operations, which create expectations of changes in monetary policy, or which embody another sufficient 'news' content, appear to have a chance of affecting the exchange rate significantly. In their brief survey on recent literature, Sarno and Taylor (2001) focus on the empirical work conducted in 1990s. They suggest that the portfolio balance channel will diminish in importance over time, at least among the major industrialized countries, as capital markets become increasingly integrated and the degree of substitutability between financial assets increases.

Most monetary authorities and economists believe that if intervention works, then it must be through the signalling or expectations channel. See Sarno and Taylor (2001). The signaling channel assumes that intervention affects exchange rates by providing the market with new and relevant information to other market participants. In research on signaling, coordinated intervention is assumed to be more effective than unilateral intervention. Despite the consensus among economists about the effectiveness of coordinated intervention, there is still a debate on whether or not the transparency of monetary authorities` actions and objectives is necessary. While some studies provide that secrecy is desired, others recommend that intervention be made public and the objectiveness made transparent in order to increase the effectiveness through the signaling channel. In a 1990 study, Dominquez discusses credibility games involving signaling and concludes that credible intervention signals, will be effective as the non-sterilized intervention when the central bank invokes its promised monetary policy. The study also implies that coordinated intervention may differ from unilateral intervention in terms of its impact on foreign exchange markets. Coordinated intervention has a significantly different and longer-term influence on market expectations than does unilateral intervention. Weekly data on monetary surprises, exchange rates and intervention is used and the effectiveness of intervention to vary with the credibility of monetary policy is found. Similar to Dominquez (1990), Humpage (1999) found that coordinated intervention increases the probability of success in affecting market expectations. The size of an intervention also affects its probability of success, but coordinated is generally a better predictor. He tested the hypothesis that the Federal Reserve routinely has better information concerning exchange rate movements than the market following the Louvre Accord. The frequency of success was relatively low, implying that the US interventions generally possessed little forecast value. However, there was evidence of intervention as a predictor that recent exchange rate movements would moderate, but not reverse. Coordinated and possibly the amount of intervention increased the probability of success. Sarno and Taylor (2001) mention that official intervention can be effective through its role as a signal of policy intentions, especially when it is publicly announced and coordinated. Contrary to Dominquez (1990) and Humpage (1999), Vitale (1999) shows that when the uncertainty about the objective of foreign exchange intervention is particularly severe, the monetary authorities may target the exchange rate more successfully. The market is more efficient when this objective is secret than when it is common knowledge.

Baillie, Humpage and Osterberg (2000) surveyed the literature on informational issues. They suggest researchers should carefully consider whether intervention might provide information to the market or whether the authorities have a clearer understanding of market conditions than less informed private traders. Popper and Montgomery (2001) discuss that a central bank can affect the exchange rate by aggregating and disseminating agents` information. The intervention is a useful way to transmit this information.

Most of the empirical studies show that sterilized interventions have little impact on the exchange rate. Fatum and Hutchison (2003) used an event-study approach to assess the effectiveness of intervention operations. In contrast to other studies, they found that official intervention is effective when directed to short-run objectives.

An often stated objective of intervention policy is to calm disorderly markets. Bonser-Neal and Tanner (1996), Baillie and Osterberg (1997b), Hung (1997), Chang and Taylor (1998), Dominquez (1998), Beine et al (2002) all find evidence that intervention tends to increase spot exchange rate volatility.Dominquez (1998) mentions that while intervention policy often influences exchange rate volatility, it is not volatility that causes intervention. A more surprising result is that secret interventions were generally found to increase volatility. This result provides evidence that the more ambiguous are signals, the more likely they are to increase volatility. Galati and Melick (1999) focused on intervention that is perceived by market participants, different from the actual interventions. Their analysis suggests that, on average, perceived intervention in support of the dollar fails to strengthen the currency. They find that market perceived intervention may increase the uncertainty prevailing in the market regarding future movements in the spot market. Besides these two effect, perceived intervention does not change the balance of weights that market participants assign to future sharp appreciations and sharp depreciations.

There is empirical evidence which indicates that some types of intervention can affect the risk premia in forward markets. However, the risk premium is not necessarily the intended target of the intervention .Likewise, evidence that spot exchange rate volatility is frequently increased following intervention may be an unintentional externality of intervention. Baillie and Osterberg (1997a) find that purchases of US dollars by the Federal Reserve appear to have significantly increased dollar denominated returns over uncovered interest rate parity for both the DM-$ and the Yen-$. However the effect is not symmetric since the Fed`s actions has an impact, while the other central bank`s actions do not. They also find some evidence that intervention leads to increases in volatility of the risk premium, as well as affecting the conditional mean of the risk premium. The nature of the causality appears unidirectional since there is no evidence that volatility of the forward premium Granger causes intervention. Consistent with this study, Baillie and Osterberg (2000) find some support for the intervention variables affecting the risk premium in the analysis where the relationship between daily deviations from uncovered interest rate parity and intervention is investigated by using daily overnight euro-currency deposit rates.

Another area of investigation has been the relationship between central bank profits and intervention. Sweeney (1997) noted that if central banks have better information than the market, then they should consistently be able to earn profits on their intervention activity. Leahy (1995) and Neely (1998), Saacke(2002) had similar results. Kim and Sheen (2002) note that profitability is important in determining intervention like the other factors such as, overnight interest differentials, volatility smoothing and exchange rate trend correction.

Following Sarno and Taylor (2001), King (2003) and Humpage (2003) present a brief survey on the empirical work conducted post-1992. Similar to Sarno and Taylor (2001), Humpage (2003) mentions that if the transaction of the given intervention is large and coordinated, the probability to have the desired effect increases. He emphasizes the methodological problems of the estimation techniques and suggests that the timing issue with respect to the intervention data should be solved; otherwise empirical studies will give limited information about the efficacy of intervention. He suggests using high frequency and intra-day data, so that intervention appears to affect the exchange rate within minutes. Empirical studies using intra-day intervention data are available in the recent literature. See Dominquez (2003) and Chang and Taylor (1998). Dominquez (2003) used intra-day (5-minutes) intervention data on DM-USD and Yen-USD. She mentions that intervention operations, especially coordinated types, are consistently associated with increases in intra-day and daily volatility while there is little evidence that interventions influence longer-term volatility. Chang and Taylor (1998) also find similar results. King (2003) mentioned that empirical studies show that foreign exchange intervention has a transitory effect on the level or volatility of the exchange rate because foreign exchange intervention may be undertaken to meet a range of objectives and the studies do not adequately adress how these objectives may vary over time.

The results on the effectiveness of intervention are mixed and depend on which exchange rate regime is analyzed, what sample period is studied and on the intervention strategy that is followed. Empirical studies are often done for the developed and big economies, yet few studies are available for developing and small economies. Hutchison (2003) discusses that coordinated intervention is desirable in the short-run stabilization policies of developing countries. Data on the amounts of intervention used by countries with their currencies in target, or managed exchange rate regimes are usually impossible to obtain and are regarded as highly secret, unlike the data on free-floating regimes.

In this study, the effect of intervention is investigated in Turkey. It is a small economy that has had high inflation during the last 20 years. There is only one empirical study in recent literature with respect to FX intervention in Turkey. See Domac and Mendoza (2004). They find that interventions decreased the volatility of exchange rate during the free-float regime covering the period February 22, 2001 through May 30, 2002. This study used the data which covers the period November 1993 through December 2003. The Turkish economy had both managed and free float exchange rate regimes during this period. This enables us to make a comparison of the effect of intervention under different exchange rate regimes in a small-open economy with high inflation. Section 1.2 discusses the economic developments through the whole period covered in this study. Sections 1.3 and 1.4 discuss the data, model and the estimation results. Finally Section 1.5 gives a brief conclusion.

1.2 Economic Developments

Turkey adopted liberal economic policies in 1980s and financial liberalization brought important changes in the institutional arrangements of financial markets . Most trade liberalization was completed in the mid-1980s and Turkey entered into a customs union with the European Union in 1996. Similarly, the reforms in the financial area were also rapid and decisive. Interest rates were liberalized in the early 1980s, residents were permitted to hold foreign exchange (FX) deposits in 1984. New institutional arrangements helped to develop money and bond markets in the late 1980s, and capital movements and the exchange rate system were fully liberalized in August 1989. Despite the measures taken in the financial sector, public finance did not receive its proper share of reforms in the 1980s. The economic environment was very unstable throughout the 1990s contrary to the developments throughout the 1980s. The financial crises, external shocks, high inflation, lack of fiscal disipline, the difficulty in the rollover of the growing domestic debt and political uncertainty were the main problems that created the unstable environment. Stabilization programs targeting price stability did not have political support, so efforts to decrease inflation were not successful.

The economic growth rate has been quite high except the crisis periods in 1990s. Both the nominal rates of interest and inflation were very high almost throughout the decade of the 1990s. See Table 1.1, Figure 1.1 and Figure 1.2.

TABLE 1.1: Main Economic Indicators (% of GNP)

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
GNP(*)	0.4	6.4	8.1	-6.1	8.1	7.1	8.3	3.9	-6.1	6.3	-9.5	7.8	5.0[(a)]
Inflation(**)	66.1	70.1	66.4	106.0	93.2	79.4	85.3	83.6	63.6	53.9	53.9	44.8	25.2
Interest Rate(***)	87.5	93.0	86.1	158.0	124.2	132.2	107.0	115.5	104.6	38.2	99.6	63.5	54.8
Current Account Balance	0.2	-0.6	-3.5	2.0	-1.4	-1.3	-1.4	0.9	0.7	-3.4	1.9		
Central Bank Reserves	3.2	3.8	3.4	5.4	7.2	8.8	9.5	9.7	12.1	12.0			
PSBR(****)	10.2	10.6	12.0	7.9	5.0	8.6	7.7	9.4	15.6	12.5	16.5	12.6	8.5[(b)]

Source: Central Bank of The Republic of Turkey, State Planing Organization, State Institute of Statistics

(*) Gross National Product (GNP) Growth Rate

(**) Change in Average CPI (1987 = 100)

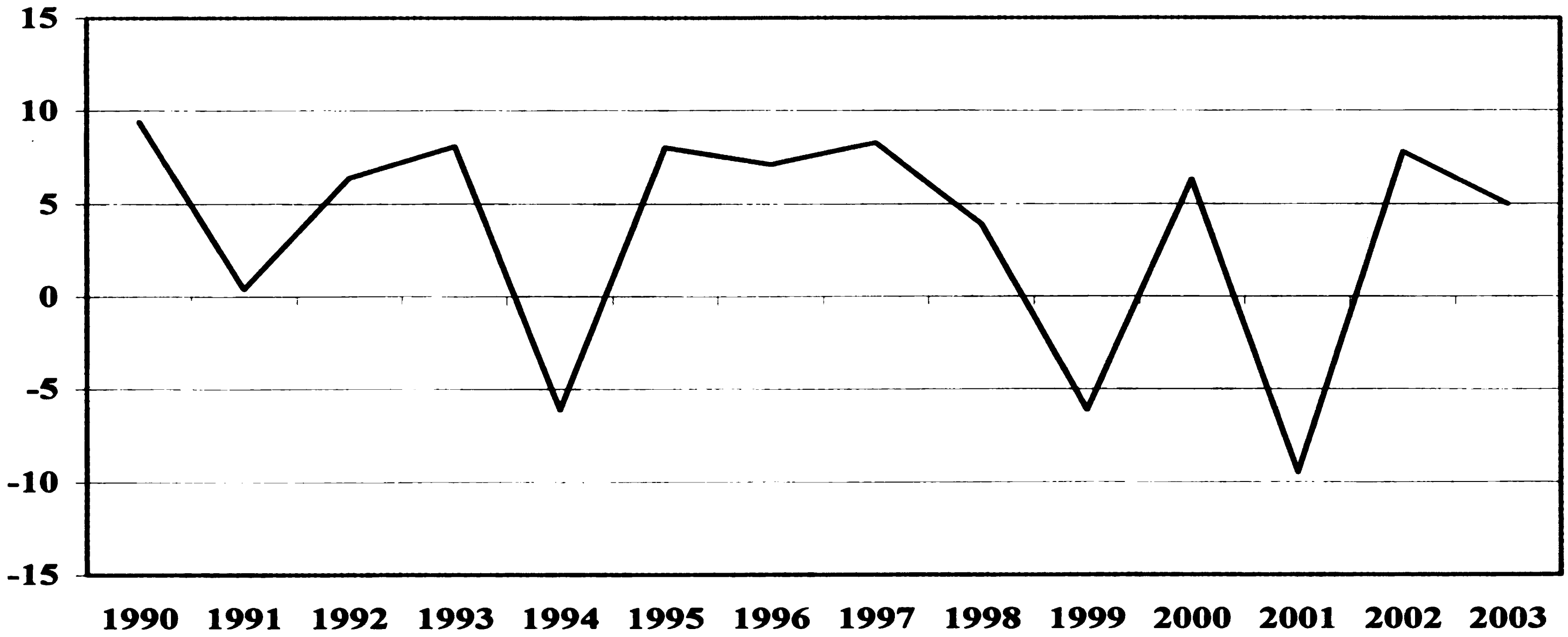
(***) Treasury Auction Average Borrowing Rate

(****) Public Sector Borrowing Requirement

(a) Forecast

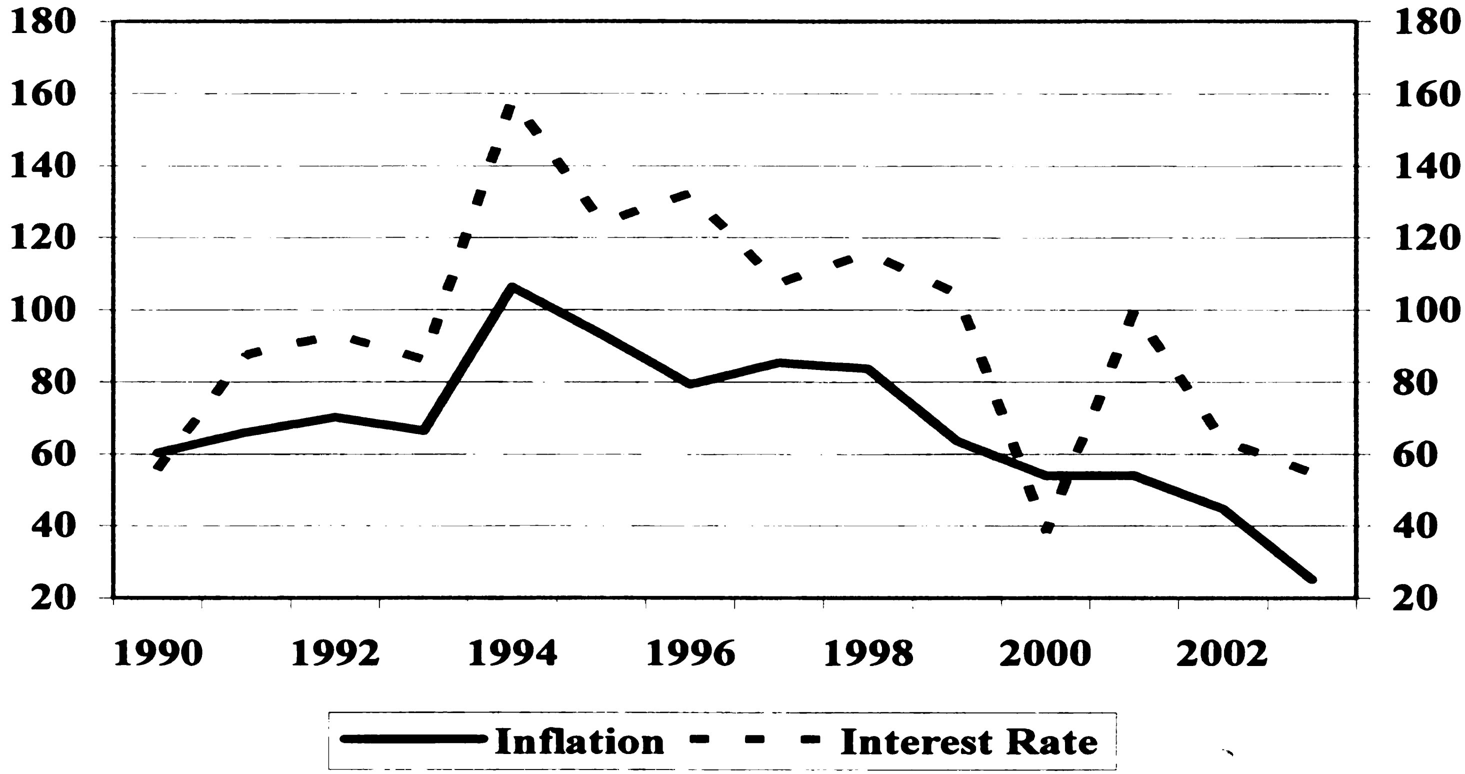
(b) Forecast

Figure 1.1: Percentage Change in Annual GNP(*)



(*) Gross National Product (GNP) In Current Prices

Figure 1.2: Inflation and Interest Rate(*)



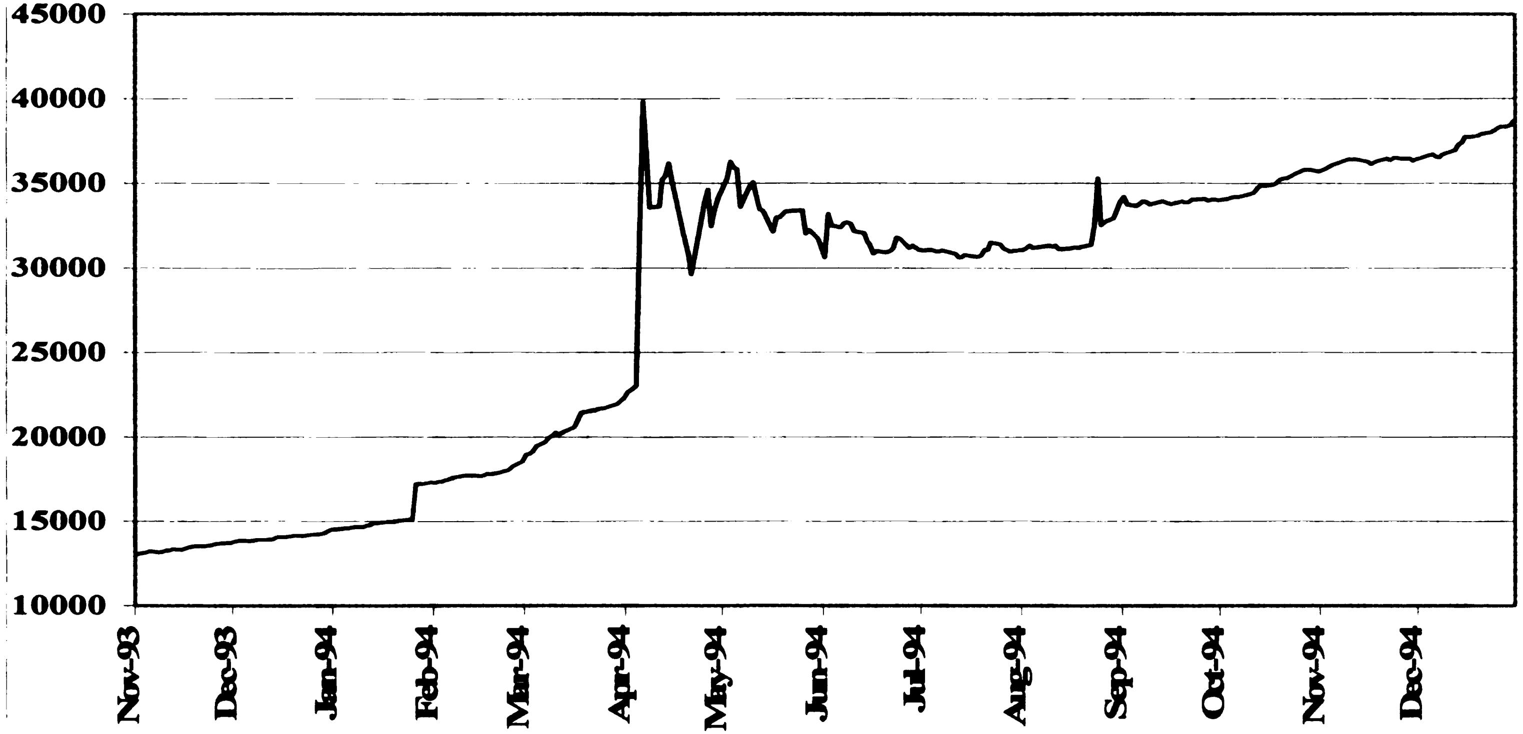
(*) Change in Average Consumer Price Index (1987 = 100) and Average Treasury - Auction Borrowing Rate

The first half of the 1990s' were marked by the liberalization of capital movements in August 1989. Thereafter Turkish Lira (TL) appreciated continously in real terms except the two main depreciations. The first one occured in 1991, the year of the Gulf crisis, and the second one in 1994, the year Turkey experienced a severe financial crisis. Before the financial crisis, Turkey promoted exports by means of a real depreciation of TL . This policy changed after the crisis and Turkey promoted capital inflows by means of a real appreciation of TL.

Public finances deteriorated markedly in 1992-1993 and political uncertainty intensified. Combined with an open capital account, this led to a financial crisis. The main factors were unsustainable fiscal policy, the strong desire to keep domestic interest rates below the market clearing levels, minimizing domestic debt finance and instead relying upon monetization. See Ozatay, (1994).

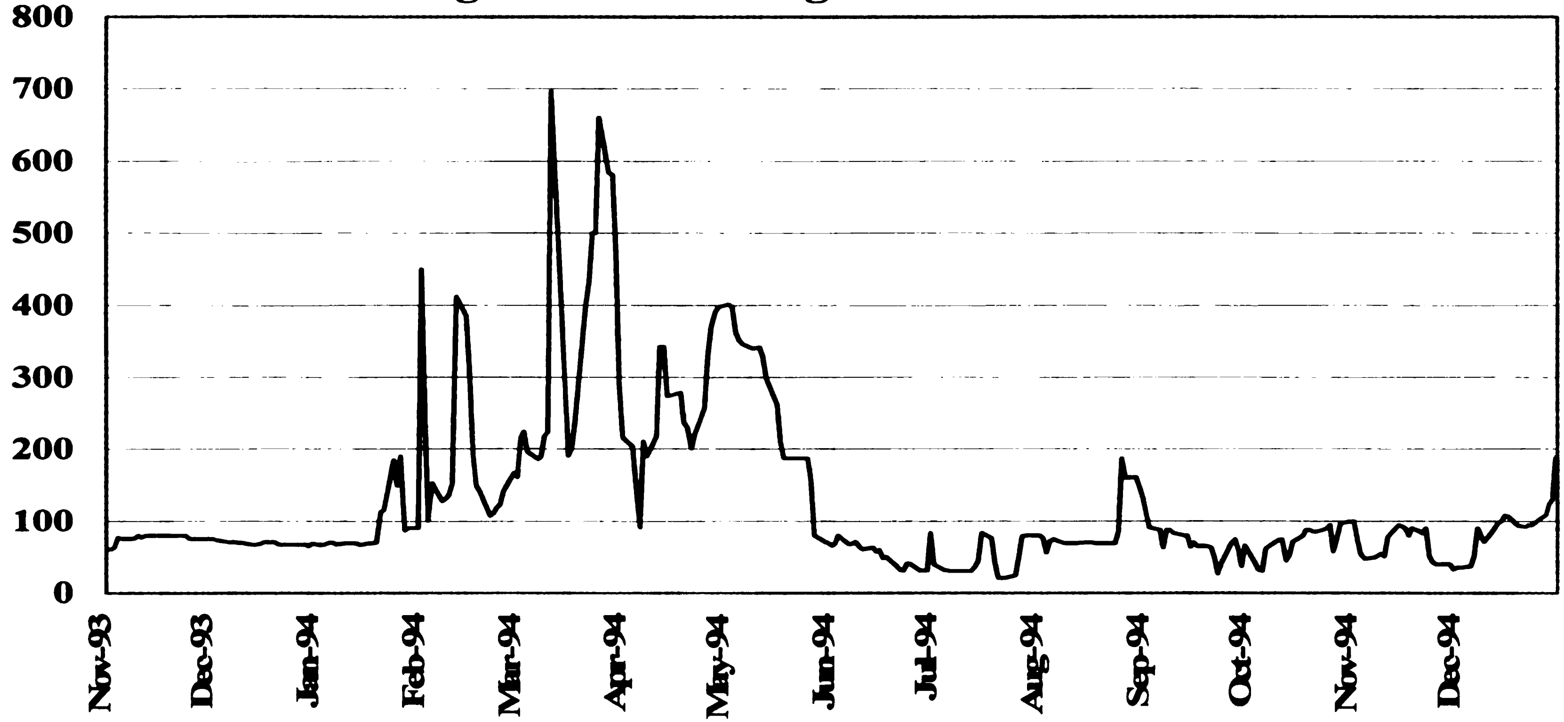
Deterioration in fiscal balances and increased recourse to central bank financing, lack of fiscal discipline, and expansion of the credits extended to the public sector made it impossible for the Central Bank of the Republic of Turkey (CBRT) to comply with the monetary program in 1993. Reliance on foreign debt and the CBRT advances increased by the end of 1993. The unsuitable environment for external borrowing necessitated financing of the deficit through central bank resources. At the same time domestic interest rates were administered such that the Treasury tried to pay less than the equilibrium interest rate on government securities and several Treasury auctions were cancelled. Moreover, an income tax on the holders of government bonds and bills was introduced. The response of the private sector was not to purchase government securities and, therefore, a funding crisis started. Excess liquidity and bank's high foreign exchange (FX) demand put upward pressure on the FX market. The turmoil in financial markets started in January 1994 and continued unabated through April, with the TL depreciating sharply on a daily basis, despite high interest rates and frequent interventions by the CBRT in the FX market. The US dollar appreciated by almost 70 percent in the first three months of 1994 against the TL. To prevent a further depreciation of the domestic currency, the CBRT increased the overnight interest rates and intervened both in the interbank money market and foreign exchange market. CBRT lost more than half of its international reserves whereas the interbank money market rates increased to record levels. The actions of the CBRT to stabilize the markets through open market operations proved insufficient and the rapid loss of reserves on a continuous basis called for more radical and widespread measures. The first devaluation was in January and the second one was in April. See Figures 1.3 and 1.4. On April 5, when the CBRT stopped intervening, the TL was devalued and the foreign exchange market was unstable until May 1994. International agencies decreased the rating of Turkey's government debt and three small banks went bankrupt. Hence, the Turkish economy found itself in a very severe financial crisis.

Figure 1.3: Spot Rate (TL/USD)(*)



(*) Daily Spot Rate of TL/USD including full period of 1 November, 1993 through 30 December, 1994

Figure 1.4: Overnight Interest Rates (*)



(*) Daily Overnight Interest Rates including full period of 1 November, 1993 through 30 December, 1994

The CBRT promulgated several new regulations regarding financial markets, and a new monetary framework was prepared in line with the IMF stand-by agreement after the crisis. In the medium term, in order to achieve price stability, a tight monetary policy was put into effect. As stability reemerged in the markets, the treasury started to borrow from the domestic markets. Foreign reserves rose strongly in the second half of 1994.

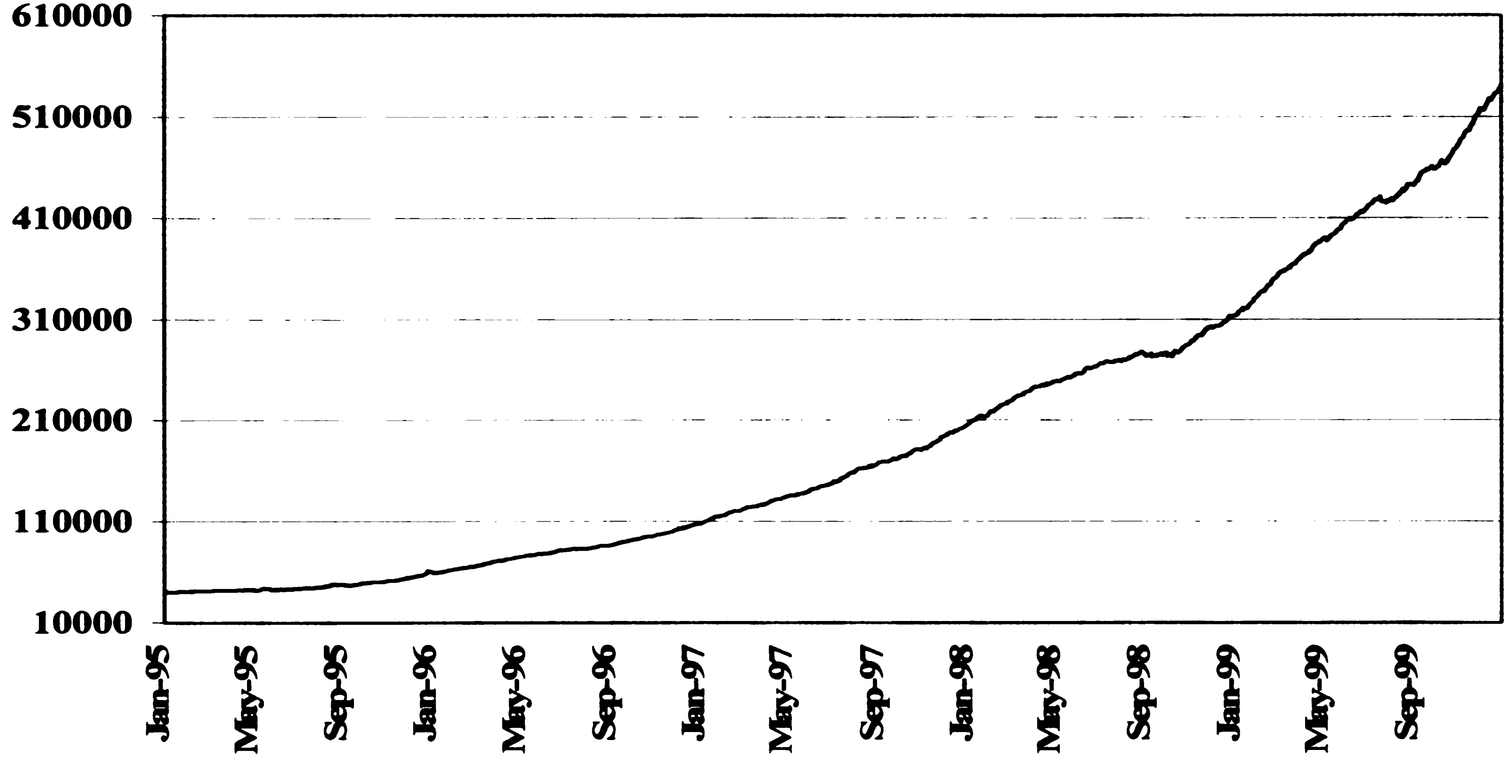
The second half of the 1990s was marked by monetary programs aiming at achieving stability in the financial markets. High inflation and an increase in the Public Sector Borrowing Requirement (PSBR) kept the interest rates high during 1995-1999. Economic growth was very strong except in 1999. The economy was characterized by high growth rates and high inflation in this period. Following this strong demand-led growth, a sharp decline was seen in 1999 due to the adverse effects of the earthquake in Turkey and the Russian banking crisis. See Table 1.1.

The CBRT followed a monetary policy which focused on stabilizing the financial markets during 1995-1999. The CBRT announced publicly that its aim was to keep real exchange rates stable. This aimed both at affecting agents` inflationary expectations and to reducing the degree of uncertainty about the future of the economy. Under the constraints of an open capital account, large fiscal deficits and inertial inflation, CBRT aimed at maintaining financial market stability, which meant safeguarding competitiveness and minimizing the burden imposed by high fiscal borrowing requirements on the financial system. CBRT has prepared a monetary program every year since 1996. Although the programs were formulated with a certain inflation target in mind, this did not quite mean that reducing inflation was the key objective. Instead the overriding objective was real exchange rate stability and, ultimately, FX reserve strength.

According to the standby agreement signed by IMF in early 1995, the exchange rate policy was based on the idea of utilizing exchange rates as a nominal anchor in curbing inflation. The increase in the foreign exchange basket, defined as 1.5 German marks and 1 US dollar, was targeted to increase by as much as the targeted monthly inflation rates. The basket was revised as 1 US dollar and 0.77 Euro by the introduction of Euro in 1999. Deviations from the targeted inflation rate were seen in certain periods and the targets for the basket were adjusted accordingly.

During the managed float exchange rate policy, most of the sales of US dollar were seen in the last quarter of the year. The bank's demand for foreign currency to close FX open positions put upward pressure on FX markets. CBRT sold US dollars usually when the German mark/US dollar parity rose, to achieve targets for the foreign exchange basket, excess liquidity, speculative increase in FX demand due to adverse effects of external crises like Russian and Argentine crises, an earthquake, and deterioration of expectations about Treasury's domestic debt finance. When there was stability in the markets and capital inflow, or when the inflationary expectations decreased, CBRT usually bought US dollars and the reserves increased.

Figure 1.5: Spot Rate (TL/USD)(*)



(*) Daily Spot Rate of TL/USD including the full period of 2 January, 1995 through 31 December, 1999.

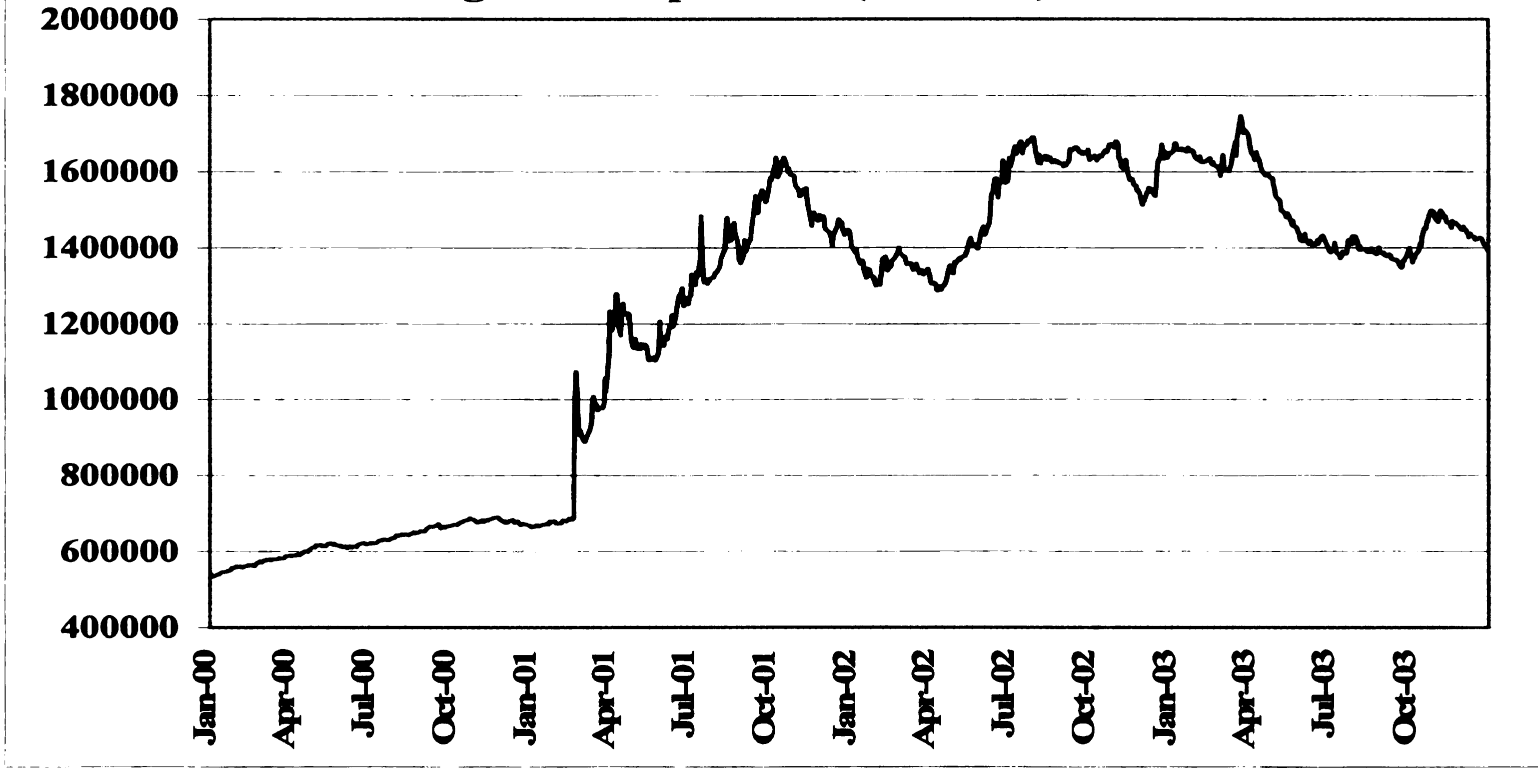
The economic environment was not good despite the stabilization efforts. Towards the end of the 1990s, deterioration in public finances, high levels of real interest rates and inflation and the economic contraction necessiated the government to put a new medium term program into affect in 2000. The Turkish government adopted a disinflation program backed by the International Monetary Fund (IMF) at the beginning of 2000. This program aimed at decreasing the inflation rate to single digits by the end of 2002 and had three main specific targets. First, it imposed limits on CBRT's balance sheet items such that it limited monetary expansion only to changes in its net foreign asset position in the balance sheet. The CBRT committed itself to a policy of no sterilization. Changes in monetary base would be directly reflected changes in the net foreign assets of its balance sheet. CBRT`s liquidity creation was tied to foreign capital inflows. Within this framework, the banks were sellers or buyers in the foreign exchange markets by considering increases in the short-term interest rates. Second, pre-announced target values of the currency basket, in other words a pre-announced calendar for the depreciation rate in line with the targeted inflation, were applied. Third, there were specific targets for primary surplus to ease the domestic debt finance. The CBRT confirmed that the exchange rate targets had been met by the end of 2000.

The disappearance of the foreign exchange risk caused nominal interest rates to decline sharply. These developments in foreign exchange and interest rates led the consumption of durable goods, production, investment expenditures, credits and imports to rise and the Turkish economy, which had slowed down in 1998 and contracted in

1999, to enter a new period of growth in 2000. The monetary policy within the framework of the "Disinflation Program" was carried out until February 2001.

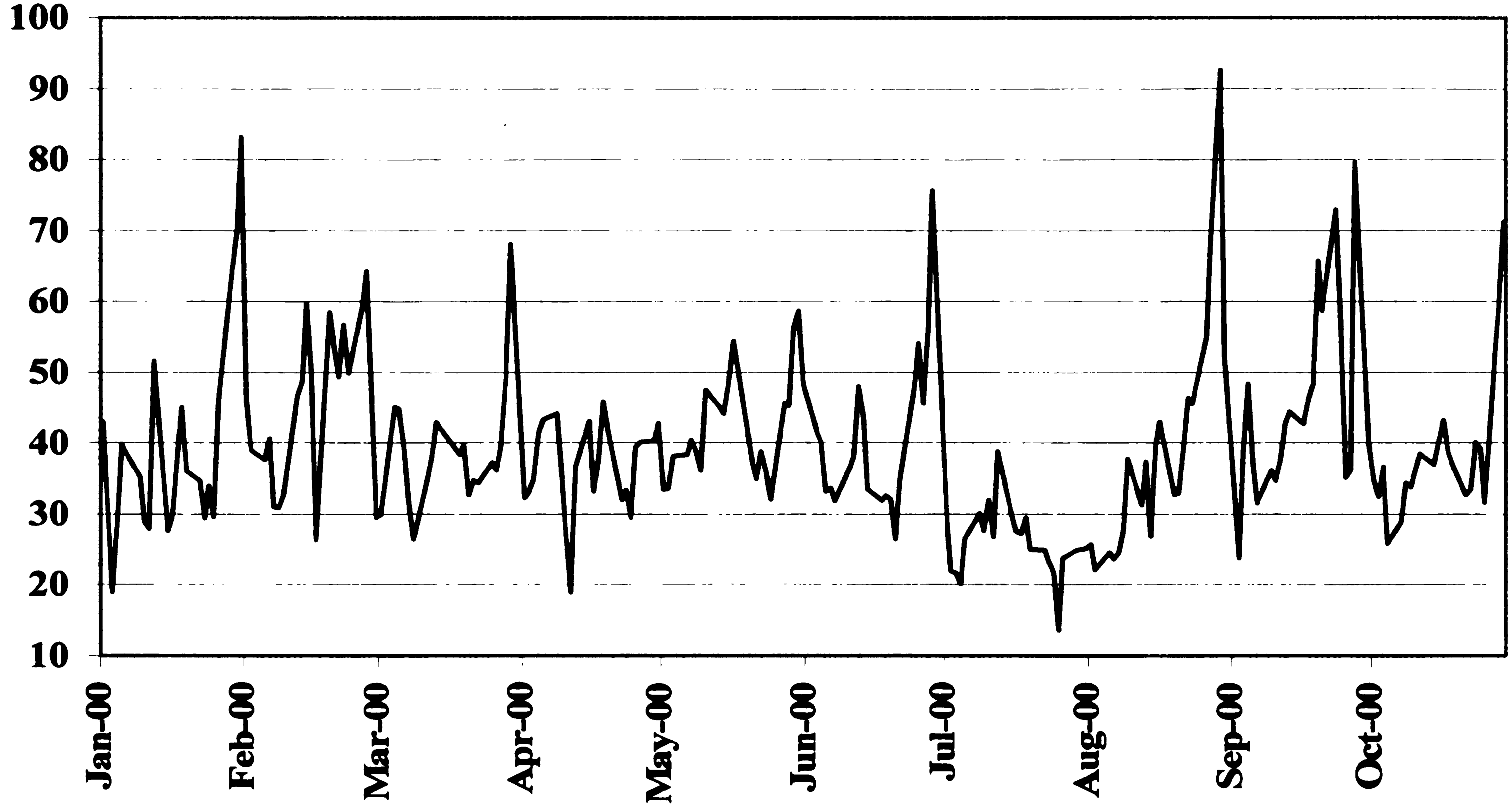
The announced increases in the basket at the beginning of the program were according to the targeted but below the realized inflation rates. The decreases in nominal interest rates were very sharp. This structure caused a deep deterioration in comparative advantage and so the current account balance. Delays in the implementation of structural reforms in the second half of 2000, and deviations from the privatization targets caused loss of credibility of the program enhancing devaluation expectations. In line with the monetary policy framework in which the CBRT's liquidity creation was tied to foreign capital inflows, the increasing capital outflows, due to devaluation expectations, resulted in a rise in interbank money market interest rates in November 2000. Rising interest rates caused deterioration in the financial situation of banks with maturity mismatches in their balance sheets, causing a lack of confidence in the banking system. The financial system's increasingly growing liquidity needs turned into financial crisis and the CBRT was left with no choice but to raise the liquidity it provided to the market. This situation brought about a departure from the targets determined for the CBRT's balance sheet aggregates. Despite the fact that the crisis environment had been relatively subdued, the maturity of both domestic and external funds lessened because of the rapid rise in the risk premium, while the interest rates continued to stay at high levels relative to the currency basket's rate of crawl. Following the political turmoil on February 19, 2001, prior to the Treasury's auction, a great demand for foreign exchange emerged in the financial markets, but the CBRT tried to avoid the realization of the foreign exchange demand by constraining the liquidity. This situation, however, resulted in a breakdown of the payments system due to the need of state banks for excessive overnight liquidity. The floating exchange rate regime was adopted on February 22, 2001 when the exchange rate policy had become unsustainable under existing circumstances. A sudden capital outflow caused a speculative attack on the foreign exchange market and, following the 22nd of February, a new exchange rate system was put into effect. See Figures 1.6 and 1.7 and 1.8.

Figure 1.6:Spot Rate (TL/USD)(*)



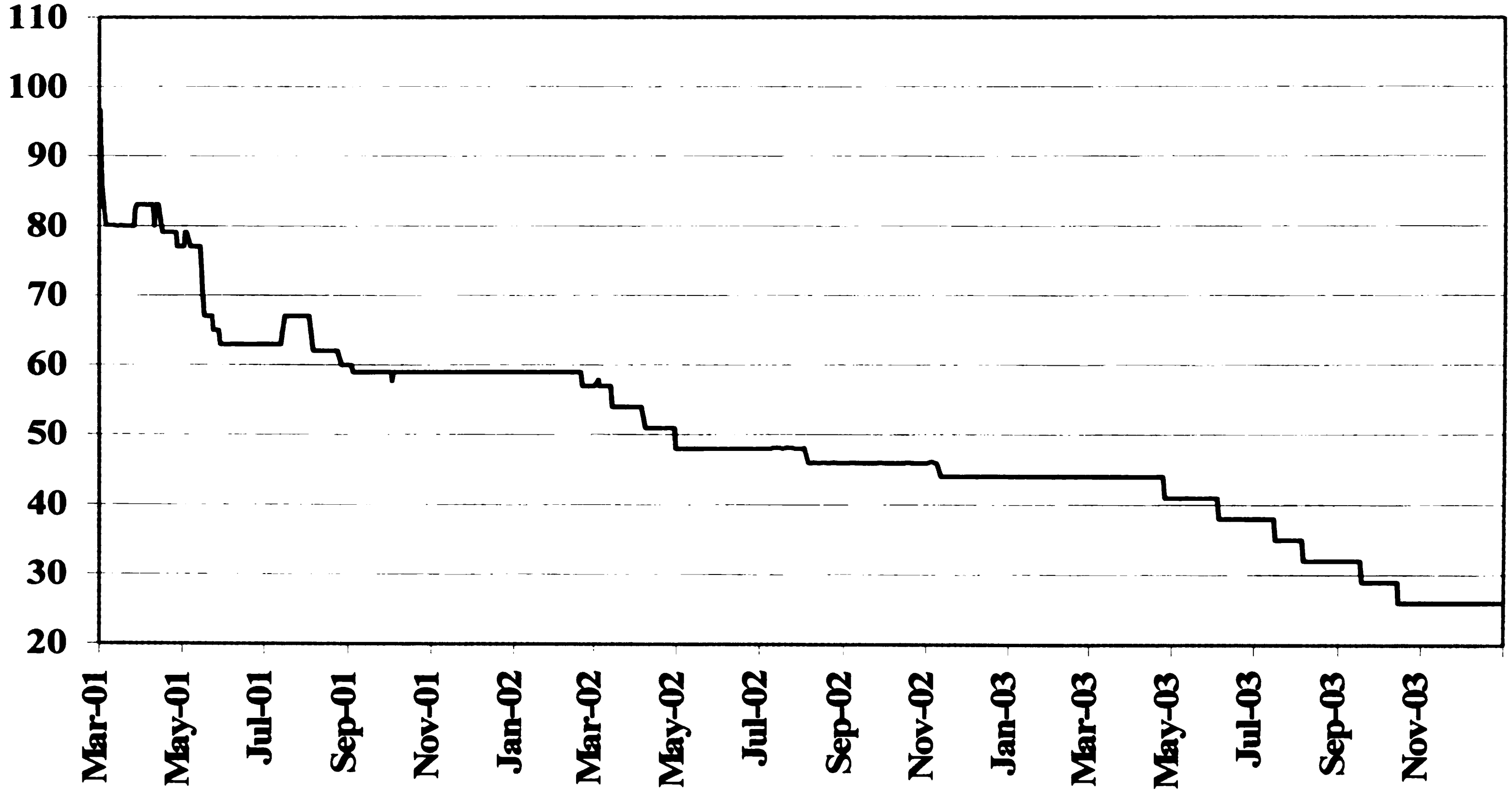
(*) Daily Spot Rate of TL/USD including the full period of 3 January, 2000 through 31 December, 2003.

Figure 1.7: Overnight Interest Rates(*)



(*) Daily Overnight Interest Rates including the full period of 3 January, 2000 through 31 October, 2000.

Figure 1.8 :Overnight Interest Rates(*)



(*) Daily Overnight Interest Rates including the full period of 1 March, 2001 through 31 December, 2003.

The banking sector problem in Turkey was basically a result of the mechanism chosen to finance the very high public sector borrowing requirement. Firstly this led to an increase in government debt instruments in the balance sheets of private banks and caused a significant deterioration in state-owned banks because of their accumulating duty losses. There are two major interest-earning assets in the Turkish banking system-commercial loans and government debt instruments. The share of the government debt instruments portfolio in private commercial bank balance sheets was greater than the loan portfolio. See Ozatay and Sak (2001). The quality of the government instruments portfolio is directly related with the expectations regarding debt sustainability. This feature increased the vulnerability of the banking system to concerns about the rollover of the outstanding government debt instruments.

Yeldan (2001) argues the Turkish currency crisis did not originate due to the failure of fiscal and monetary authorities in following the main targets of the program. The crisis conditions emerged as a result of the increased fragility in the financial system. Factors such as weak prudential regulation over the banking sector and finance of the large persistent fiscal deficits were instrumental in the burst of the crisis. Ozatay and Sak (2002) agree with him that a fragile banking system was the root cause of the crisis. The banking system was highly vulnerable to capital outflows. The foreign exchange risk was high in the period preceding the crisis. While the total open foreign exchange position of the banking system was increasing, the ratio of liquid foreign exchange denominated assets to total foreign exchange denominated liabilities was decreasing. Maturity mismatch was an other problem. The liabilities were more of a short-term nature while the maturities of assets were longer. Also the share of the bad loans to total loans was very high.

The new program put into effect after the crisis aimed mainly at arranging the role of the state banks and reducing their extensive short-term liabilities. The CBRT played a key role in the operation of restructuring the state banks. The CBRT set its short-term priorities so as to remove defects in the payments system, to make the financial system function again and to provide stability in financial markets. To avoid the inflationary effects, CBRT controlled base money by the implementation of monetary targeting. Moreover, considering the absence of a nominal anchor due to the abandoning of the exchange rate regime, money base targets were set to help the economic agents shape their expectations after switch to a free float regime. Short-term interest rates became the most important monetary policy tool in dealing with liquidity control and inflationary pressures during this period.

The exchange rate depreciated substantially and was volatile after the switch to the floating rate regime. In the beginning of the floating exchange rate regime, the CBRT declared that the exchange rate would be determined by market dynamics. The FX interventions of the CBRT after the switch to the floating exchange rate regime was directed towards damping the excessive volatility in the FX level without affecting its long-run value. Moreover, a programmed auction system for FX sales was implemented as of March 29, 2001. FX sales auctions were conducted daily until May 17, 2001. Between May 17, 2001 and July 11, 2001, FX sales auctions conducted whenever required without pre-announcing the amount. After July 11, 2001 the monthly program of FX sales auctions was pre-announced. These auctions were conducted in order to sterilize the excess liquidity in the market caused by the use of the external financing which was provided by the IMF to make the Treasury's domestic debt payments. The CBRT sometimes intervened in the exchange rate markets in order to smooth the fluctuations which emerged in the case of negative external developments and domestic political problems. However, beginning in August, non-programmed interventions were reduced to negligible levels, and as of September, program based auctions were carried out on the daily basis. After November 30, 2001, FX sales auctions were conducted when they are required.

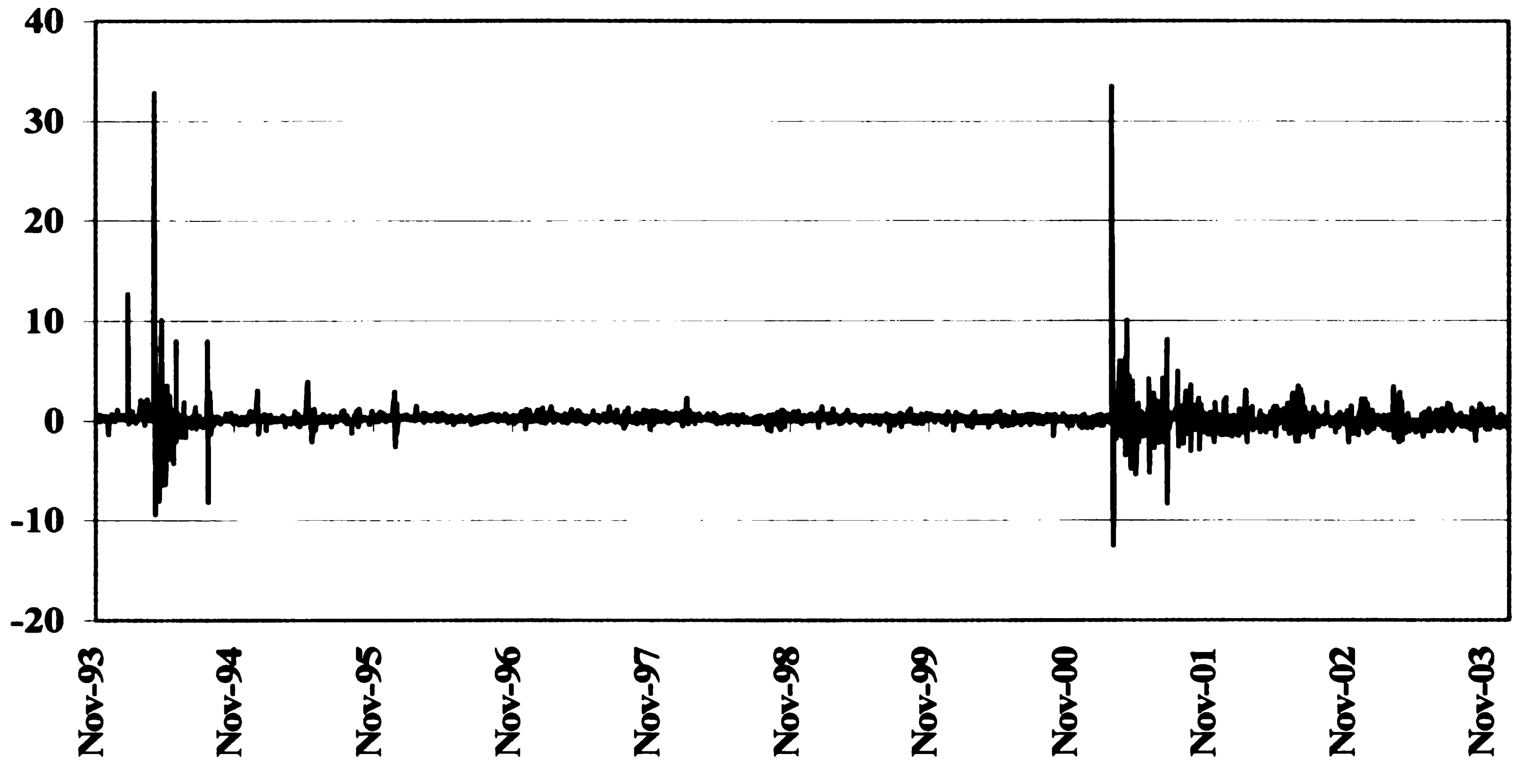
The CBRT pursued foreign exchange buying auctions in order to absorb the excess supply of foreign exchange that was accumulated by reverse currency substitution and the surplus in the balance of payments in the first half of the 2002. These operations did not aim at distorting the long-run trend in exchange rates. Moreover, the CBRT did not try to establish any specific exchange rate level. Foreign exchange auctions were temporarily suspended as of July due to the volatilities of exchange rates, which occurred as a result of an increase in the perception of political uncertainty. Similar to 2002, in 2003 the CBRT intervened in the foreign exchange markets when there was high volatility and the operations did not aim to distort the long-run trend in exchange rates.

Turkish economy was quite unstable through 1990s. Because of the two financial crisis in 1990s, it was realized that, without structural reforms, disinflation programs have no chance to decrease the inflation so priority was given to structural reforms regarding the arrangements of economic institutions at the beginnings of 2000s and disinflation program has found more support after the crisis. Tight monetary and fiscal policies helped to achieve financial stability, which created a suitable environment for economic growth.

1.3 Data

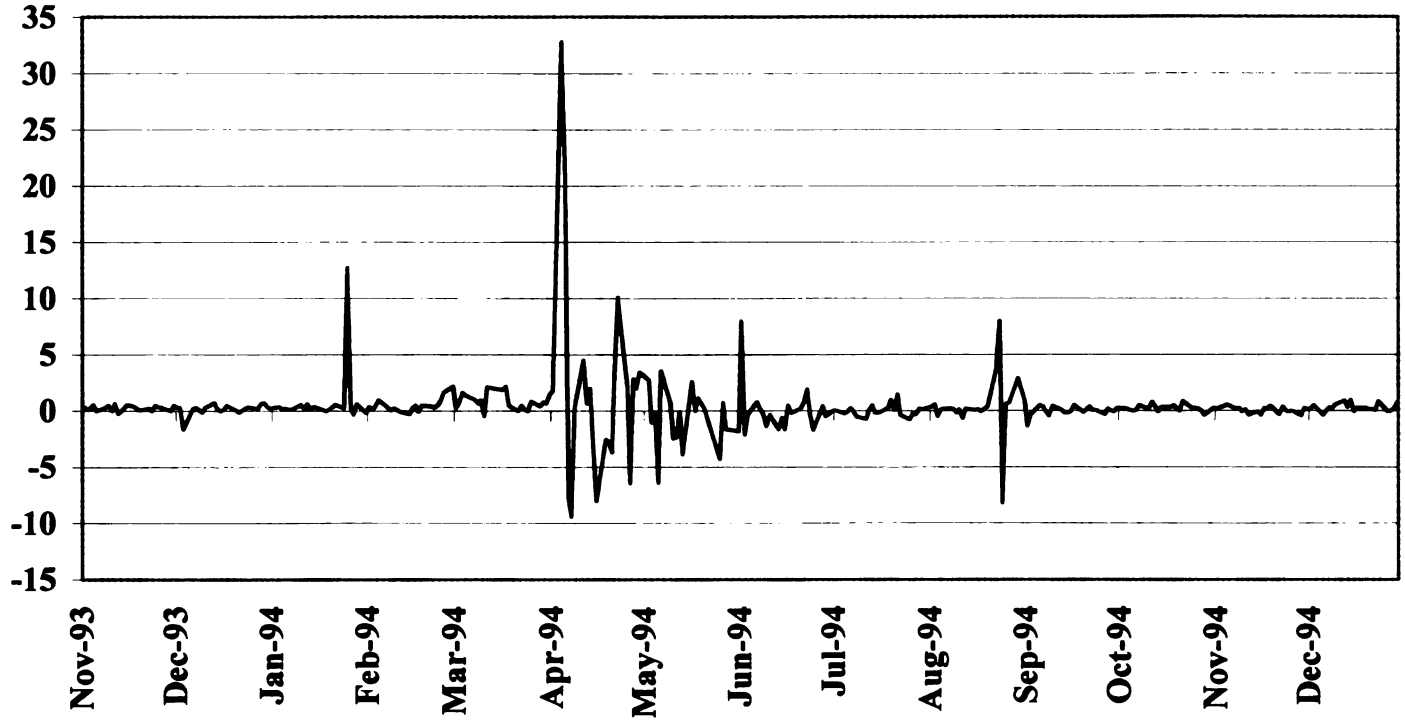
In this study, the data is provided by the CBRT. The data sample consists of both daily spot bid rates, interbank overnight interest rates and daily intervention variables from November 1993 through December 2003. Intervention values are in millions of US dollars. Exchange rate policies are different throughout the period. The analysis has been done separately for managed float and free float exchange rate policy regimes, respectively, including and excluding the crisis periods. So we take several sub-samples of the data. The first sub-sample has the daily amount of net dollar purchases (sales), daily spot bid rates and interest rates date from November 1993 through December 1999. This sub-sample covers the first financial crisis in April 1994 and exchange rate policy was managed float. Then the crisis period is excluded and only the period 1995-1999 is analyzed. This enables us to investigate the effect of intervention in both a crisis environment and without it. The third sub-sample dates from 2000 through December 2003. This period covers both crawling peg and free float regimes and include the second financial crisis. Then we exclude the financial crisis and estimate only the free float regime from February 27, 2001 through 2003. The daily spot returns for whole period is shown in Figure 1.9. The graphs of the spot returns and interest rates are drawn for certain sub-samples in order to show the data better. The first sub-period consists of November 1993-1994 at which time exchange rate policy was managed float. In this period the first financial crisis happened. Daily spot returns and short-term interest rates are seen in Figures 1.10 and 1.11. The period 1995-1999 is marked by IMF- standby agreements. Exchange rate policy was managed float and the exchange rate basket was pegged to forecast inflation. Daily spot returns and short-term interest rates are seen in Figures 1.12 and 1.13.

Figure 1.9: Spot Return (TL/USD)



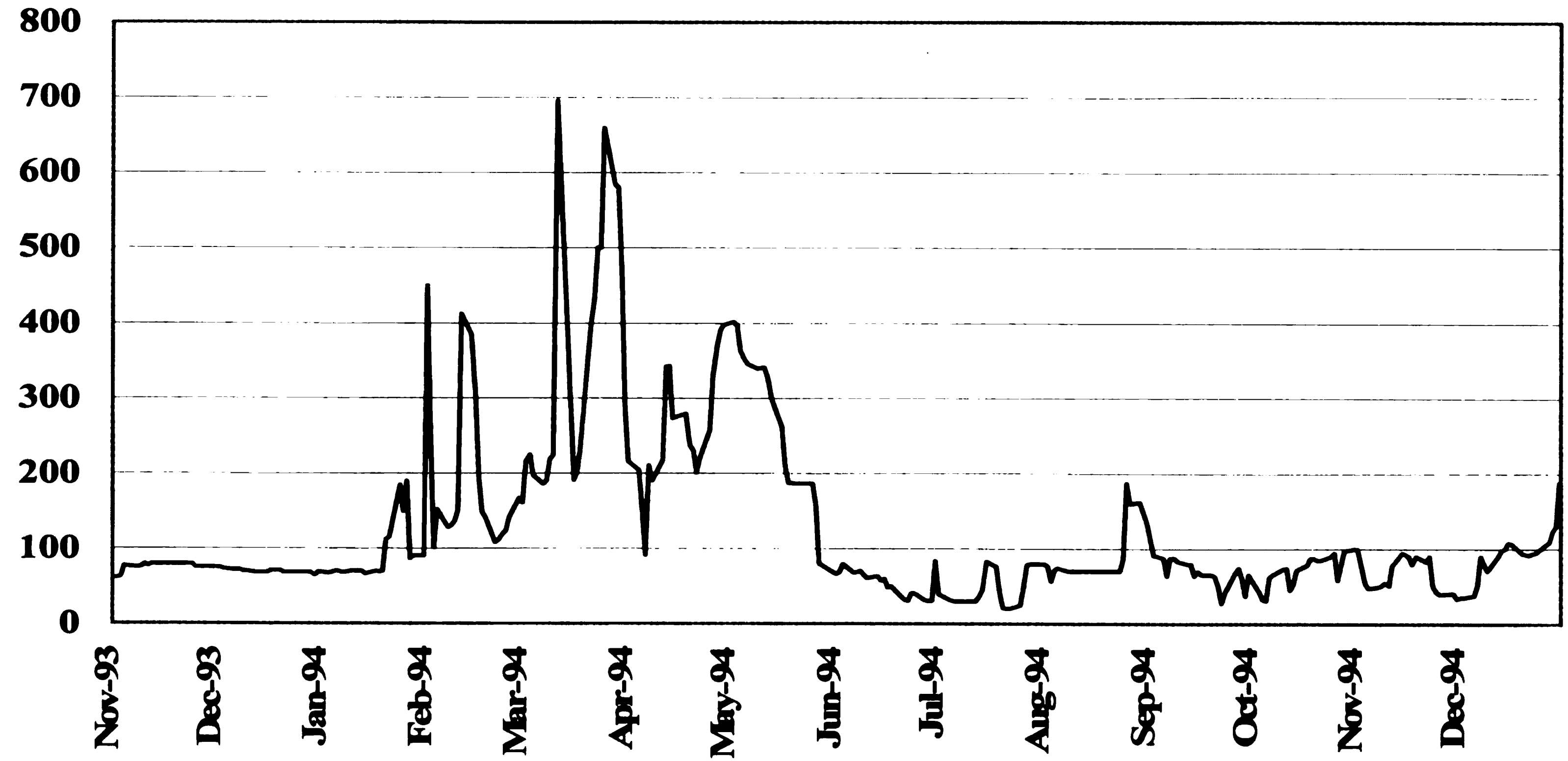
(*) Daily Spot Return of TL/USD including the full period of 2 November, 1993 through 31 December, 2003.

Figure 1.10: Spot Returns (TL/USD)(*)



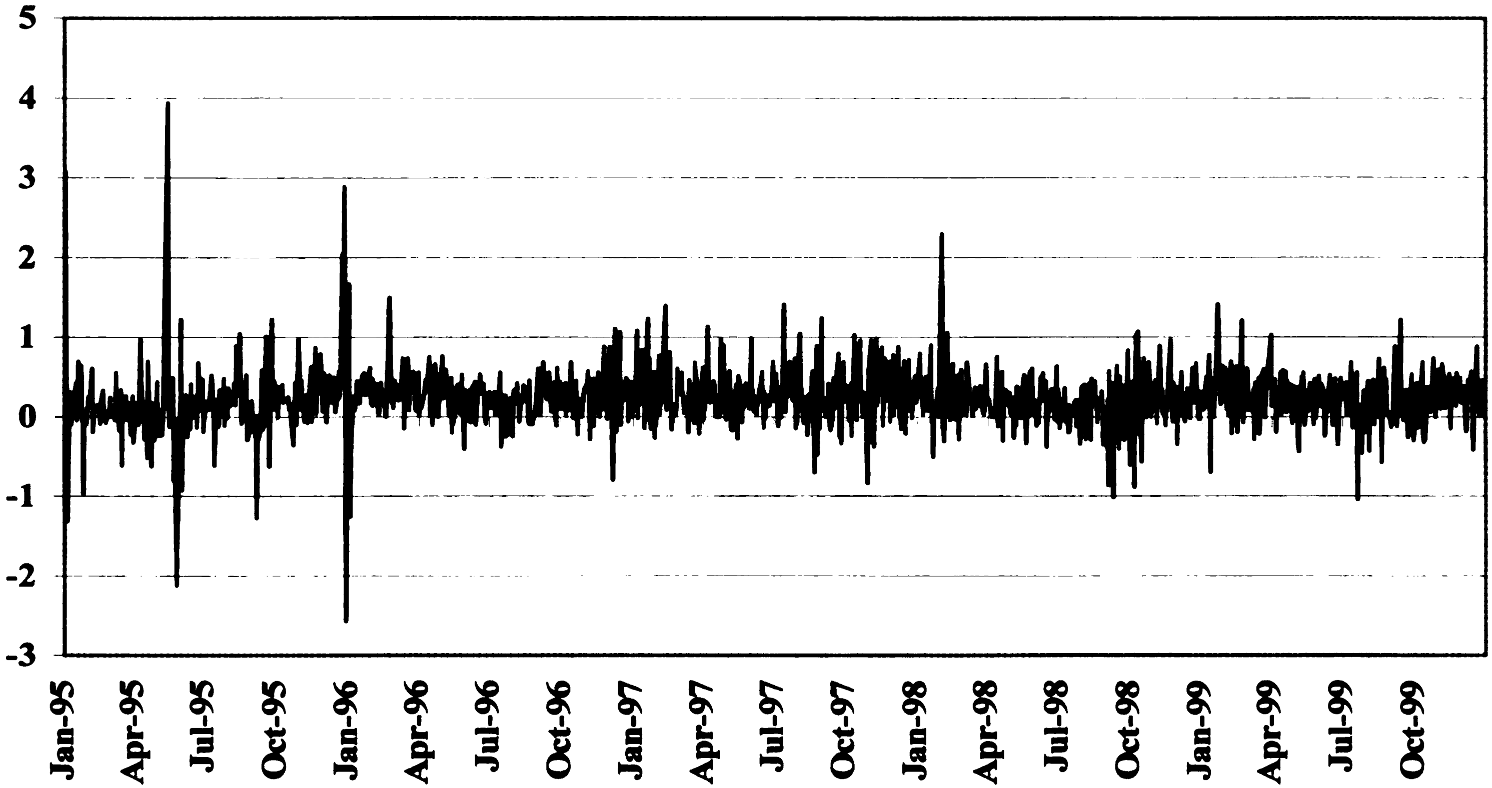
(*) Daily Spot Return of TL/USD including the full period of 2 November, 1993 through 30 December, 1994.

Figure 1.11: Overnight Interest Rates (*)



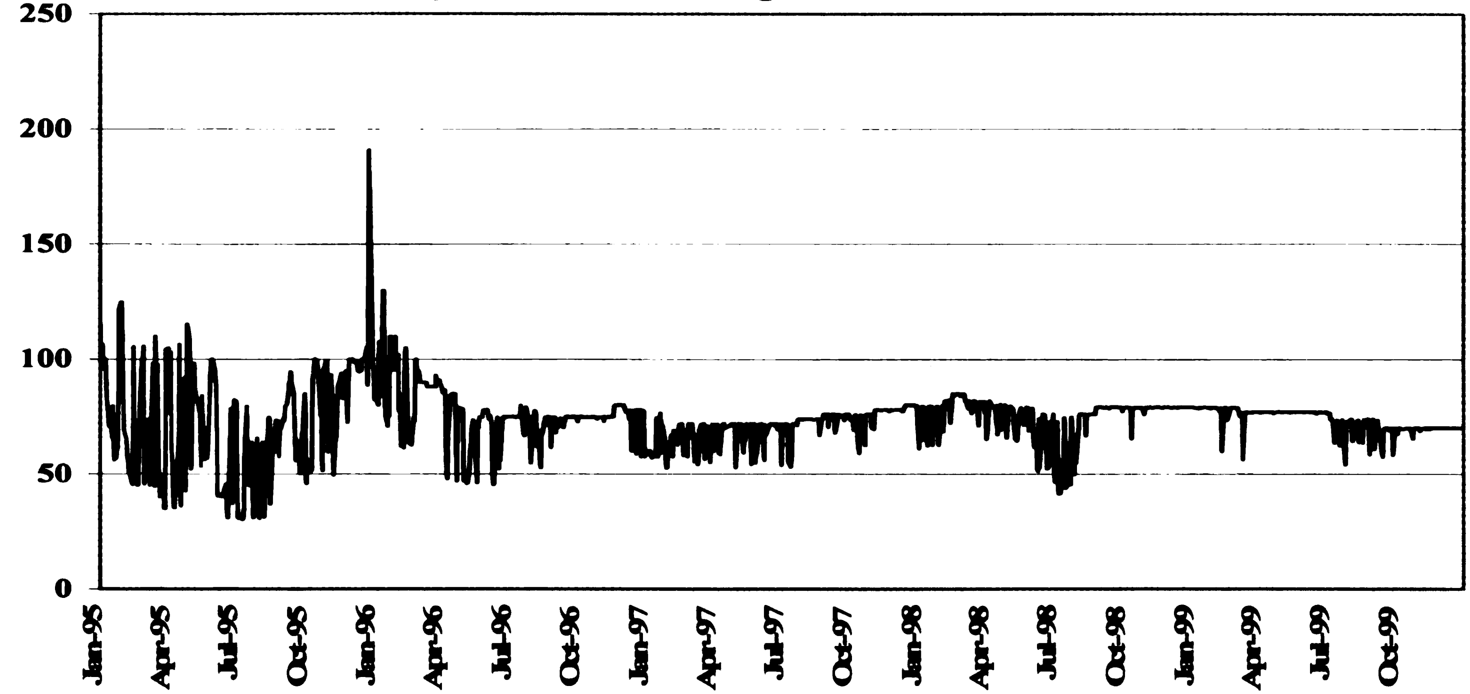
(*) Daily Overnight Interest Rates including full period of 1 November, 1993 through 30 December, 1994

Figure 1.12: Spot Returns (TL/USD)(*)



(*) Daily Spot Return of TL/USD including the full period of 2 January, 1995 through 31 December, 1999.

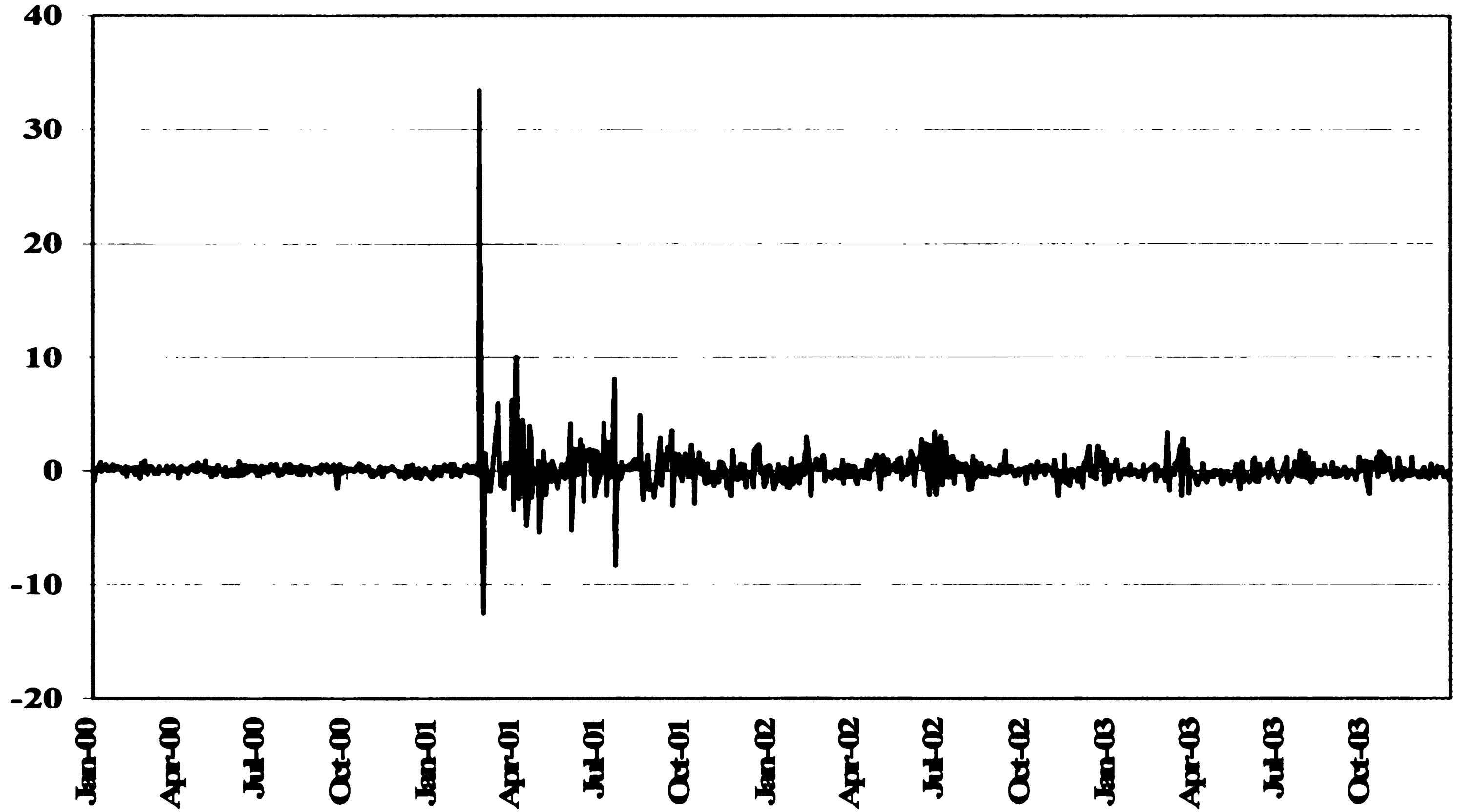
Figure 1.13: Overnight Interest Rates(*)



(*)Daily Overnight Interest Rates including the full period of 2 January, 1995 through 31 December, 1999.

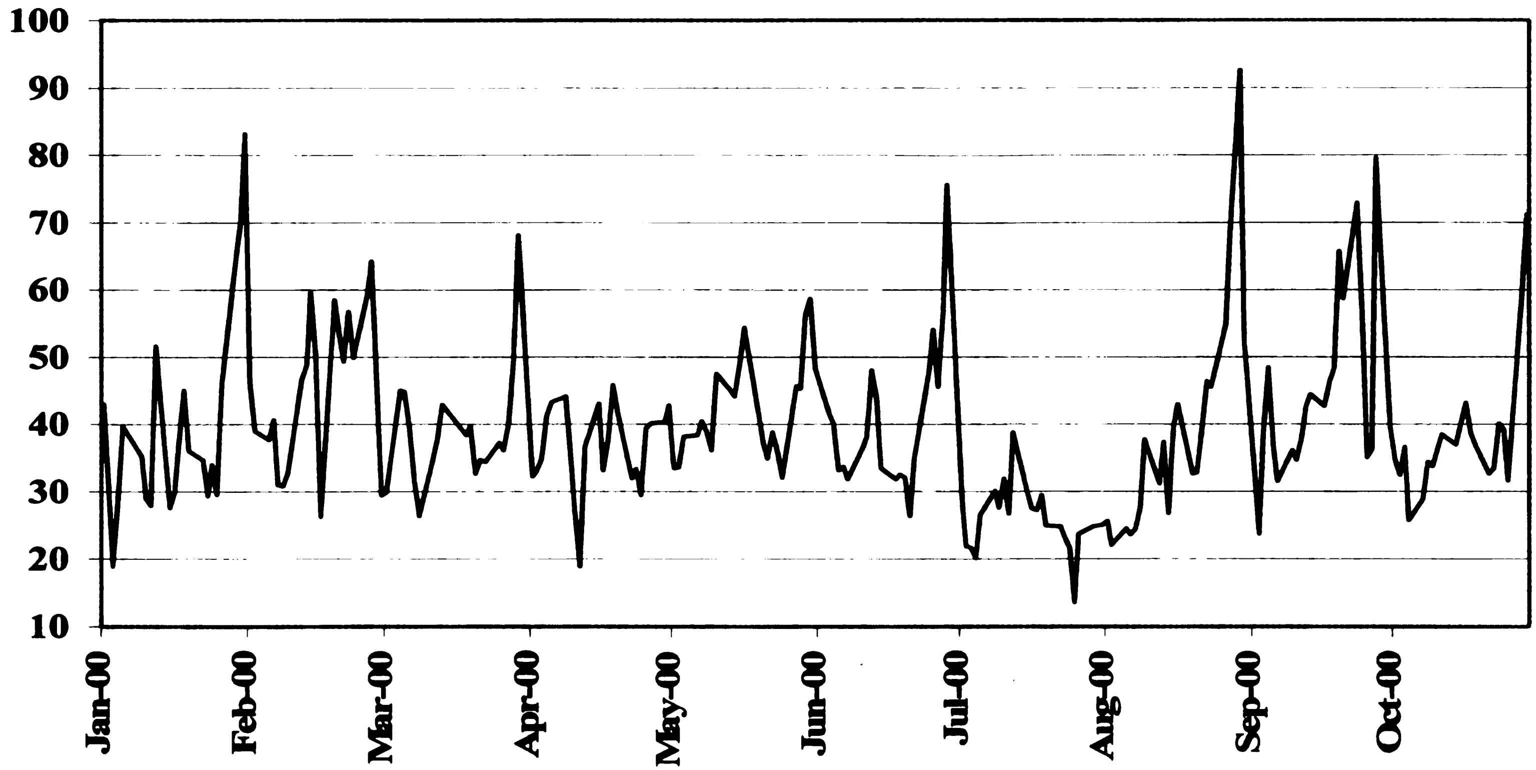
The CBRT changed the exchange rate policy and adopted crawling peg regime in 2000. However, this policy was not sustainable after the second financial crisis and free float regime is adopted in 2001. Daily spot returns, and short-term interest rates are seen in Figures 1.14 and 1.15, 1.16. During the crisis period interest rates increased to very high levels. It is difficult to show interest rates in one graph so we separate the period and graph the interest rates as before and after crisis.

Figure 1.14: Spot Return (TL/USD)(*)



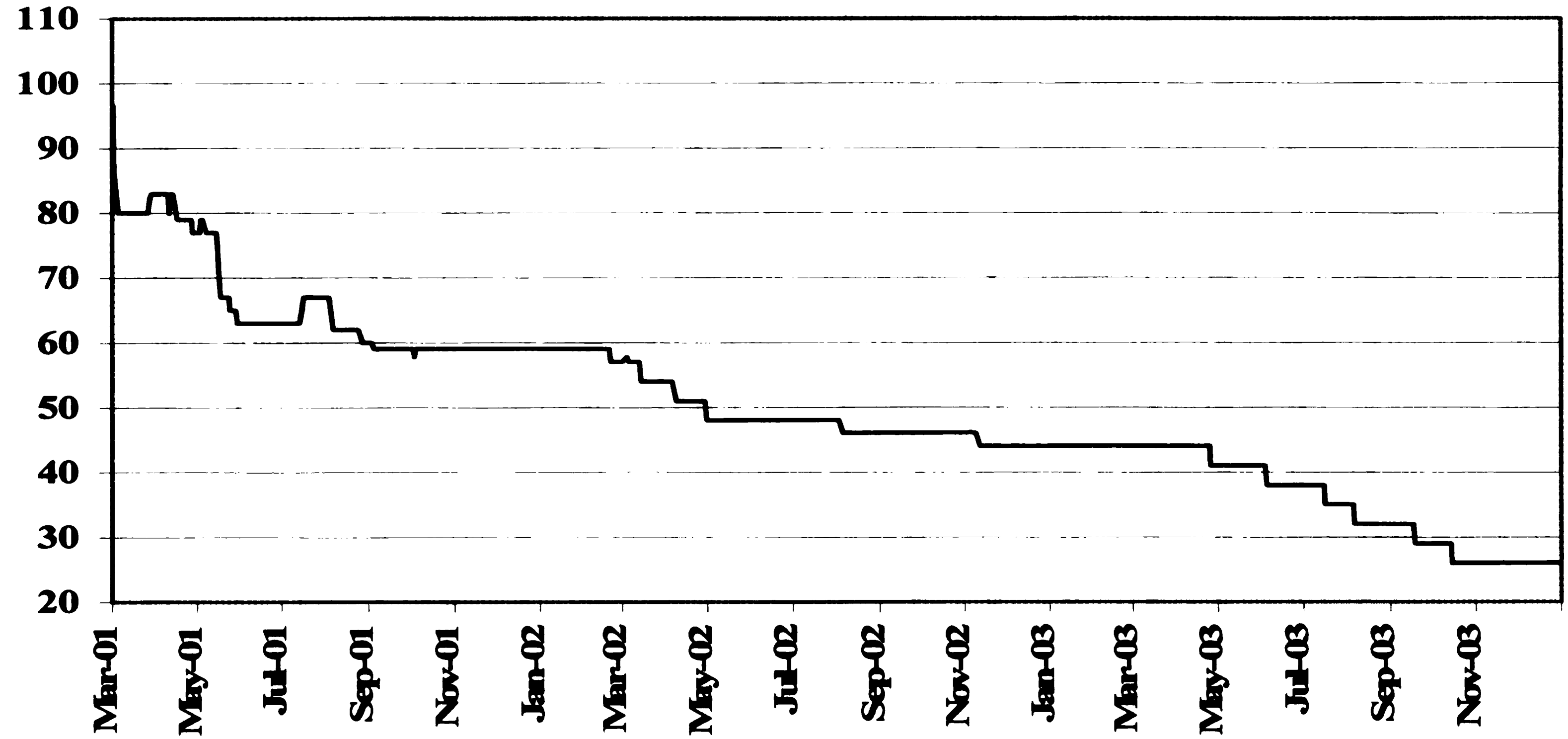
(*) Daily Spot Return of TL/USD including the full period of 3 January, 2000 through 31 December, 2003.

Figure 1.15: Overnight Interest Rates(*)



(*) Daily Overnight Interest Rates including the full period of 3 January, 2000 through 31 October, 2000.

Figure 1.16:Overnight Interest Rates(*)



(*)Daily Overnight Interest Rates including the full period of 1 March, 2001 through 31 December, 2003.

1.4 Model and Estimation Output

In this section, we aim to test the direct effect of intervention on the level and volatility of spot returns. In the literature, there is mixed evidence about the effectiveness of intervention. So this analysis is a contribution to the literature such that we are able to analyse the effect of intervention in Turkey. Turkish economy is a small economy where the central bank is an important player in the foreign exchange market. So we expect the foreign exchange intervention to be effective. Also, this study enables us to investigate the effect of intervention under different exchange rate policy regimes and crisis environment. Intervention is proposed to affect the mean and volatility of the spot rate.

The model in this study is built around the standard Martingale model with time dependent conditional heteroscedasticity. Following Bollerslev (1986) and Baillie and Bollerslev (1989), the conditional variance is modeled as a linear Generalized Autoregressive Conditional Heteroscedasticity (GARCH) process (see equation 1.3). Bollerslev (1986) introduced the GARCH (1,1) process, which extends the ARCH model to make σ_t^2 a function of lagged values of σ_t^2 as well as the lagged values of ε_t^2. Bollerslev (1986) required all the coefficients to be positive to ensure that the conditional variance is never negative. The quasi- maximum likelihood estimation is used. In this study, the aim is to investigate the effect of central bank intervention on the foreign exchange markets. We used a linear GARCH (1,1) model following Baillie and Osterberg (1997b) .

$$\Delta \ln S_t = b_0 + b_1 US_{t-2}{}^b + b_2 US_{t-2}{}^s + b_3 i_{t-2} + \sum_{i=1}^{4} d_i + \sum_{i=1}^{n} j_i + \varepsilon_t \qquad (1.1)$$

where $\Delta \ln S_t = 100\,[In(S_t) - In(S_{t-1})]$

$$\varepsilon_t = z_t \sigma_t \quad \text{with } z_t \text{ is } iid\ (0,1) \qquad (1.2)$$

$$\sigma_t{}^2 = \omega + \alpha \varepsilon_{t-1}{}^2 + \beta \sigma_{t-1}{}^2 + \gamma_1 US_{t-2}{}^b + \gamma_2 US_{t-2}{}^s \qquad (1.3)$$

S_t is the level of the spot exchange rate in terms of the number of TL per one US$. The variable $\Delta \ln S_t$ is the return on the exchange rate between 15.30 pm on day t-1 and 15.30 pm on day t. The explanatory variables includes the intervention variables and short term interest rates, d_i corresponds to the daily dummies and j_i corresponds to the crisis dummies. Crisis dummies are used in the conditional mean to take control of the devaluations during the crisis period. j_1 and j_2 corresponds to the dummies to take control for the devaluations in January 1994 and April 1994, respectively, while j_3 and j_4 corresponds to the dummies to take control for the following two days after the devaluation on April,5 1994.

The intervention variables US^b and US^s are purchases and sales of US dollars. Empirical results of estimating this model have generally been poor, probably because of the policy endogeneity issue, where a purchase of $ is found to be associated with a $ depreciation due to "leaning against the wind" phenomenon. See Baillie and Osterberg (1997) and Humpage (1988). The intervention variables are lagged to ensure they are pre-determined to a avoid the possible simultaneity bias. The intervention variables are the logarithms of net purchases or sales of intervention ending at the close of the markets on day t-2. If no intervention occurs, then the intervention variable is set to zero. The short-term interest rate (i) is also lagged as t-2 and is the logarithm of $(1+\frac{on_t}{100})$ where on_t is the overnight interest rate. The empirical results of the estimated models are given in Table 1.2 and Table 1.5. Asymptotic standard errors are in the second column with the corresponding parameter estimates. The statistics m_3 and m_4 are the sample skewness and kurtosis of the standardized residuals. Q_{20} and $Q_{20}{}^2$ are the Ljung-Box test statistics for autocorrelation and ARCH effects, and T is the sample size.

The model is estimated for different sub-periods. First, the managed float period including the financial crisis, covers November 1993 through December 1999. The estimation output is shown in the Table 1.2.During the managed float period, intervention is sterilized and Emir et al (2000) showed that there was a low degree of sterilization before the 1994 financial crisis and a high degree of sterilization during 1995-1999.

The crisis dummy variables in the mean equation are statistically significant and their magnitude is large. There is also a significant Monday effect and this is most likely due to the calculation of daily target values for the basket according to the projected inflation in a managed float regime. The projected monthly increase in the basket is linearized through the whole month, including the weekends, so the change between Friday and Monday includes target values for Saturday and Sunday as well. Also, most of the announcements were done towards or on the weekends when the markets are closed.

Most of the responses to the news are reflected on Monday when the markets are open. The most important finding regarding to results for managed float period is that intervention has been unable to influence the change in the exchange rate. During the managed float regime, the aim is to achieve the targets for the basket which consists of US dollar and German mark (euro after 1999). After the crisis, the turmoil in financial markets continued unabated through several months, with the TL depreciating sharply on a daily basis, despite high interest rates and frequent interventions by the CBRT in the FX market. The empirical results suggests that the short term interest rate has been able to influence the exchange rate such that increase in interest rates appreciates the US dollar. A 2002 study by Gumus supports our findings as it reports that raising interest rates had a significant effect on depreciating the nominal exchange rates. There is persistent volatility in the conditional variance. The sum of the coefficients of squared residual and the lagged value of variance is close to 1. The kurtosis of the standardized residuals is high. Skewness is also high and positive. There is also evidence that intervention have no effect on the volatility of the daily spot returns. During this period CBRT aimed at reducing the volatility in real exchange rates.

Table 1.2: Estimation of Intervention Model [a]

Conditional Mean Parameters		
	Coefficient	**Standard Error**
b_0	-0.0049	0.0842
b_1	-0.0003	0.0070
b_2	-0.0062	0.0070
b_3	0.2877 *	0.1630
d_1	0.3249 ***	0.0386
d_2	0.0198	0.0291
d_3	0.0220	0.0346
d_4	0.0327	0.0310
j_1	12.2960 ***	0.2430
j_2	35.8032 ***	2.6724
j_3	25.2516 ***	2.6118
j_4	-13.3175 ***	2.8799
Conditional Variance Parameters		
ω	0.0208 **	0.0092
α	0.2192 ***	0.0687
β	0.7214 ***	0.0865
γ_1	-0.0021	0.0019
γ_2	-0.0019	0.0019
Skewness	1.34	
Kurtosis	17.55	
Q_{20}	30.76	
Q_{20}^2	15.28	
T	1558	

(a) Full period of 1 November, 1993 through 31 December, 1999.
(*) denotes 10% significance level
(**) denotes 5% significance level
(***) denotes 1% significance level

$$\Delta \ln S_t = b_0 + b_1 US_{t-2}^{\,b} + b_2 US_{t-2}^{\,s} + b_3 i_{t-2} + \sum_{i=1}^{4} d_i + \sum_{i=1}^{n} j_i + \varepsilon_t$$

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 + \gamma_1 US_{t-2}^{\,b} + \gamma_2 US_{t-2}^{\,s}$$

$$\varepsilon_t = z_t\sigma_t \quad \text{with } z_t \text{ is } iid\ (0,1)$$

Table 1.3: Estimation of Intervention Model [a]

Conditional Mean Parameters		
	Coefficent	**Standard Error**
b_0	-0.0555	0.0753
b_1	0.0007	0.0061
b_2	-0.0035	0.0063
b_3	0.3884 ***	0.1375
d_1	0.3267 ***	0.0332
d_2	0.0022	0.0257
d_3	0.0039	0.0278
d_4	0.0028	0.0274
Conditional Variance Parameters		
ω	0.0134 ***	0.0045
α	0.1641 **	0.0675
β	0.7267 ***	0.0635
γ_1	0.0002	0.0012
γ_2	0.0001	0.0013
Skewness	0.48	
Kurtosis	9.92	
Q_{20}	31.86	
Q_{20}^2	15.02	
T	1259	

(a) **Full period of 1 November, 1993 through 31 December, 1999.**
(*) **denotes 10% significance level**
(**) **denotes 5% significance level**
(***) **denotes 1% significance level**

$$\Delta \ln S_t = b_0 + b_1 US_{t-2}^{b} + b_2 US_{t-2}^{s} + b_3 i_{t-2} + \sum_{i=1}^{4} d_i + \sum_{i=1}^{n} j_i + \varepsilon_t$$

$$\sigma_t^2 = \omega + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2 + \gamma_1 US_{t-2}^{b} + \gamma_2 US_{t-2}^{s}$$

$\varepsilon_t = z_t \sigma_t$ with z_t *is* *iid* (0,1)

The intervention models were also estimated for the period 1995-1999, which excludes the crisis period. The empirical findings shown in Table 1.3 for period 1995-1999 are similar to the results for 1993-1999.

Intervention has been unable to influence the change in the exchange rate. The signs are as expected but not significant and there is a significant Monday effect. Overnight interest rates are significant but not of the expected sign. There is a tendency that the increase in overnight rates is associated with a subsequent dollar appreciation. During this period inflation is high and agents have inflationary expectations. They already know that the US dollar will appreciate as long as inflation is high. The basket which consists of the US dollar and TL is pegged to inflation. High interest rates indicate high inflation and result in a strong FX demand. The intervention variables have no effect on the volatility during this period.

The empirical results of the models estimated for the period 2000 through 2003 are quite different from the models for the managed float regime. During the Disinflation Program covering the period January 1, 2000-February 21, 2001, intervention is not sterilized but after a switch to a free float regime, intervention is fully sterilized. This period includes the second financial crisis. The empirical results are shown in Table 1.4. Linear integrated GARCH (1,1) model is estimated. The coefficients of intervention are significant. Purchases of US dollars are associated with subsequent dollar appreciation. This is most probably due to that the central bank intervenes (purchases) with the wind during the crawling peg period. Sales of US dollars is followed by the appreciation of the US dollar. This effect is sometimes known as the leaning against the wind phenomenon and suggests the possibility of policy endogeneity with central banks selling dollars because the dollar is appreciating. The TL depreciated substantially and displayed a highly volatile pattern in the first months after the switch to the free float regime. The CBRT conducted regular FX sales auctions to smooth excessive short-run exchange rate fluctuations without affecting the long-run equilibrium level of exchange rates and to perform FX sales in a more transparent manner in the first half of 2001. Contrary to a managed float period, increase in interest rates decrease the spot returns as expected. The crisis dummies are also statistically significant. j_1 corresponds to the devaluation day, February 22, 2001 and j_2 and j_3 corresponds to the following two days after the crisis, respectively.

We exclude the crisis period and estimate the same models for the free float period for February 27, 2001 through December 31, 2003. The empirical findings are shown in Table 1.5. After the switch to a free float regime, CBRT declared that the exchange rate would be determined by market dynamics and it would not intervene in the exchange rate markets except in cases where the exchange rate displayed an instantaneous and highly volatile pattern. Intervention is fully sterilized and, more importantly, announced to the market. The empirical findings for the free float regime have similarities with the ones for managed float regime. Intervention has been unable to influence the change in exchange returns. Contrary to Domac and Mendoza (2004), although the central bank advocated the use of intervention to reduce exchange rate volatility, sales of US dollars may have actually Granger caused an increase in volatility and this result may reflect that intervention, by providing more information to market participants, which can induce increased volatility as agents adjust their positions. Similar to intervention, overnight interest rates are also not effective during this period. The sign is as expected but not significant.

Table 1.4: Estimation of Intervention Model [a]

Conditional Mean Parameters		
	Coefficient	**Standard Error**
b_0	-0.0694	0.0723
b_1	0.0390 ***	0.0112
b_2	0.0306 ***	0.0111
b_3	-0.2900 **	0.1238
d_1	0.1804 ***	0.0544
d_2	0.0940	0.0603
d_3	0.1400 **	0.0573
d_4	0.0990 *	0.0569
j_1	33.0800 ***	0.8556
j_2	10.9346 ***	1.0750
j_3	-13.9610 ***	1.1828
Conditional Variance Parameters		
ω	0.0288 **	0.0183
β	0.2115 *	0.0954
γ_1	-0.0055	0.0034
γ_2	-0.0031	0.0028
Skewness	0.608	
Kurtosis	5.538	
Q_{20}	32.68	
Q_{20}^2	26.98	
T	1004	

(a) **Full period of 1 November, 1993 through 31 December, 1999.**
(*) **denotes 10% significance level**
(**) **denotes 5% significance level**
(***) **denotes 1% significance level**

$$\Delta \ln S_t = b_0 + b_1 US_{t-2}{}^b + b_2 US_{t-2}{}^s + b_3 i_{t-2} + \sum_{i=1}^{4} d_i + \sum_{i=1}^{n} j_i + \varepsilon_t$$

$$\sigma_t{}^2 = \omega + \alpha\varepsilon_{t-1}{}^2 + \beta\sigma_{t-1}{}^2 + \gamma_1 US_{t-2}{}^b + \gamma_2 US_{t-2}{}^s$$

$\varepsilon_t = z_t \sigma_t$ with z_t *is* iid (0,1)

Table 1.5: Estimation of Intervention Model [a]

	Coefficent	Standard Error
Conditional Mean Parameters		
b_0	-0.2198	0.1987
b_1	0.0202	0.0203
b_2	0.0295	0.0497
b_3	0.0998	0.5049
d_1	0.1878**	0.0871
d_2	0.104	0.1071
d_3	0.2094**	0.104
d_4	0.0768	0.0962
Conditional Variance Parameters		
ω	0.0834*	0.0397
α	0.2954**	0.1133
β	0.6105***	0.1129
γ_1	0.0019	0.0097
γ_2	0.192**	0.0838
Skewness	0.9	
Kurtosis	5.26	
Q_{20}	29.4	
Q_{20}^2	15.11	
T	712	

(a) Full period of 1 November, 1993 through 31 December, 1999.
(*) denotes 10% significance level
(**) denotes 5% significance level
(***) denotes 1% significance level

$$\Delta \ln S_t = b_0 + b_1 US_{t-2}^{\,b} + b_2 US_{t-2}^{\,s} + b_3 i_{t-2} + \sum_{i=1}^{4} d_i + \sum_{i=1}^{n} j_i + \varepsilon_t$$

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 + \gamma_1 US_{t-2}^{\,b} + \gamma_2 US_{t-2}^{\,s}$$

$\varepsilon_t = z_t \sigma_t$ with z_t *is iid* (0,1)

1.5 Conclusion

In this section we investigated the effect of intervention on both the level and volatility of spot returns in Turkey. The analysis covers the period November 1, 1993-December 31, 2003. It is a common belief among policy-makers that central bank intervention is effective. However, the evidence on the effectiveness of intervention is mixed. In general, the evidence is disposed towards ineffectiveness. We also find evidence that central bank intervention was not effective in Turkish foreign exchange market during the period November 1, 1993-December 31, 2003. We estimate a linear GARCH (1,1) model for different sub-periods including and excluding the crisis periods. The results show that intervention has been unable to affect the level of spot returns both in managed and free float regimes except during the sub-period January 1, 2000-February 21, 2001. While intervention has no effect on volatility in managed float regime, it increases the volatility in a free float regime. With respect to effect of short-term interest rate, an increase in overnight interest rates appreciates US dollar in a managed float regime but has no effect in a free float regime.

CHAPTER 2

What Motivates Central Bank Intervention?

2.1. Introduction

In the first chapter, we find evidence that central bank intervention was not effective in Turkish foreign exchange market during the period November 1993-December 2003. In this chapter we ask the question what motivates central bank intervention and analyze the estimation of intervention reaction function.

A proposed relationship between the amounts of intervention and the various characteristics of a disorderly foreign exchange market is called a reaction function. Since no specific measures of the disorderly market conditions are given by either the central banks or by economic theories, economists often rely on econometric methodologies to test if certain characteristics of the market are closely related to the interventions. One of the main challenges in specifying a reaction function is the fact that the intervention variable has a zero value for the majority of the observations in a sample while the explanatory variables are not zero. This implies a non-linear relationship because the observed quantities of intervention do not increase or decrease approximately in proportion to the level of the explanatory variables. One way to proceed is to approximate this potential non-linear relationship with a linear model. Eijffinger and

Gruijters (1991), Ito (2002), Rogers and Siklos (2003) used simple OLS models. An other way is to model the probability, rather than the quantity of intervention, uses a probit approach, as in Baillie and Osterberg (1997), Dominquez (1998), Kim and Sheen (2002) and McKenzie (2004). Recent studies use ordered probit as in Frenkel, Pierdzioch and Stadtmann (2003), and Ito and Yabu (2004). Different from the probit model, Frenkel and Stadtmann (2001) use the logit model. If one is interested in the quantity, rather than the probability of intervention, an appropriate model may be a Tobit model. Almekinders and Eijffinger (1994) and Humpage (1999) follow this approach. However, a Tobit approach takes either a buying intervention or a selling intervention one at a time but not both as the dependent variable. If one wants to explain both types of intervention simultaneously , then the friction model may be an appropriate specification for the reaction function as in Almekinders and Eijffinger (1996), Kim and Sheen (2002) and Sheen (2002).

In the first chapter we estimate the effect of intervention on the spot returns using linear GARCH(1,1) model for different sub-samples including and excluding the crisis period. In this chapter, we only take the sub-samples of managed float and free float period excluding the crisis period. During the crisis period, the motivations for intervention may be quite different from normal times. We first used the probit model to assess the probability of intervention. We then use a tobit model and compared the results and found that the main assumptions of the tobit model of homoscedasticity and normality are likely to be invalid. Hence we used the censored least absolute deviation method, as suggested by Powell (1984) to get asymtotically consistent estimators. Section

2.2 gives a description of the measures of market disorder and the data. Section 2.3 briefly mentions the probit model and gives the estimation output with respect to probit model. Then Section 2.4 gives a description of the tobit model and the censored least absolute deviation method in the context of intervention . The empirical results with respect to these models, are also given in section 2.4. Finally, section 2.5 gives a brief conclusion.

2.2. Modeling Intervention Behaviour

We propose that a central bank intervenes with the objective of minimizing disorderliness over time in the foreign exchange market for its currency, depending on its perception of the effectiveness of intervention. First, they might wish to reduce disorderliness by returning the exchange rate to what they perceive to be the appropriate trend to be. With a very long horizon, purchasing power parity considerations might drive intervention behaviour. See Dominquez and Frankel (1993) and Frenkel and Stadtmann (2001). Secondly a central bank may be concerned about disorderly conditions in foreign exchange markets that might show up as excessive fluctuations in exchange rates through higher volatility, due to higher levels of uncertainty and trading. They may intervene to calm the market by trying to reduce uncertainty. This uncertainty may be measured by the conditional volatility of the daily change in the exchange rate.

Most empirical studies include the deviation of exchange rate from some targets levels and a measure of volatility of the exchange rates. There is no clear answer to the appropriate measures of the disorderly market conditions and it is rather difficult to reach this information. The target level for the exchange rate is thought to present past levels of the exchange rate. This is not to say that the exchange is considered to be at a desirable level in previous days. It merely allows one to test whether the central bank systematically 'leaned against the wind' and tried to smooth deviations from the m-days moving average of the exchange rate. Central banks appear to intervene whenever current exchange rate movements deviate significantly from a trend.

The deviation measure (dev_t) is modeled in (2.1) as the deviation of the current exchange rate from a moving average exchange rate.

$$dev_t{}^m = 100[In(S_t) - In(\frac{1}{m}\sum_{i=1}^{m} S_{t-i})] \tag{2.1}$$

Different studies include different length of a representative moving average. Almekinders and Eijffinger (1994,1996) include the deviation of DM/USD rate from the seven-day moving average . Humpage (1999) uses ten-day moving average. Frenkel and Stadtmann (2001) and Frenkel, Pierdzioch and Stadtmann (2003) use a 25- day moving average as a short run target level of exchange rate, and purchasing power parity as a long run target. Kim and Sheen (2002), Neely (1998) and Le Baron (1999) use a 150-day moving average rate and claim it is the common choice among market traders.

As for the volatility measure, the dominant choice seems to be the conditional variance of the log return of the exchange rate estimated with a GARCH(1,1) model. The conditional variance is estimated using the following model:

$$100[In(S_t) - In(S_{t-1})] = \mu + \varepsilon_t \qquad (2.2a)$$

$$\varepsilon_t = z_t \sigma_t \qquad (2.2b)$$

$$\sigma_t{}^2 = \omega + \alpha \varepsilon_{t-1}{}^2 + \beta \sigma_{t-1}{}^2 \qquad (2.2c)$$

where z_t is i.i.d (0,1). There is considerable evidence that shows central banks respond to deviations of the spot rate from some target level by leaning against the wind, and to exchange rate volatility, by market calming down. Almekinders and Eijffinger (1994,1996), Frenkel and Stadtmann (2001), and Kim and Sheen (2002) find evidence of leaning against the wind and of market calming. They show that both target deviations and volatility matter. Baillie and Osterberg (1997), find that while a GARCH measure of the deviations of conditional volatility from unconditional volatility has no effect on intervention, deviations of the spot rates from the targets do matter. As in Baillie and Osterberg (1997), Ito and Yabu (2004) show that deviations from the target motivates intervention. Dominquez (1998) and McKenzie (2004) find no significant intervention response to volatility of exchange rate movements.

It is difficult to reach the appropriate measures for disorderly market conditions. According to the standby agreement signed by the IMF in early 1995, the exchange rate policy was based on the idea of utilizing exchange rates as a nominal anchor in curbing inflation. The increase in the foreign exchange basket, defined as 1.5 German marks and 1 US dollar, was targeted to increase by as much as the targeted monthly inflation rates. The basket was revised as 1 US dollar and 0.77 Euro by the introduction of the Euro in 1999. Deviations from the targeted inflation rate were seen in certain periods and the targets for the basket were adjusted accordingly. Target values of the data for this period are unavailable. The FX interventions of the CBRT, after the switch to the floating exchange rate regime, were directed towards damping the excessive volatility in the FX level without affecting its long-run value. In this analysis, we use several lengths of a representative moving average values such as 5, 25, 50, 125 days for both the managed and free float periods. This enables us to see the response of central bank to short and long-term deviations.

2.3.1. Probit Model

Econometric modeling of the daily intervention series has some practical challenges. The dependent variable, e.g. the intervention series, is discontinous and so modeling it using standard regression techniques is inappropriate. The intervention variable takes zero values for the majority of the observations in a sample while the explanatory variables are not zero. This implies a non-linear relationship because the observed quantities do not increase or decrease approximately in proportion to the levels of the explanatory variables. We generate a binary choice dependent variable corresponding to intervention/no intervention outcomes for each of the two types of interventions and model the probability of each type of intervention. As an initial approach, we follow

Baillie and Osterberg (1997), Dominquez (1998), and Kim and Sheen (2002) and adopt a probit model and estimate the probability of positive and negative interventions of the CBRT`s foreign exchange market interventions.

In a binary response model, the aim is to find the response probability

$$P(y=1 \mid x) = P(y=1 \mid x_1, x_2, \ldots . x_k) \tag{2.3}$$

where x denotes the full set of explanatory variables. Wooldridge (2000) mentions that the linear probability model is simple to estimate but has some important disadvantages- the fitted probabilities can be less than zero or greater than one and the partial effect of any explanatory variable is constant. To avoid these limitations, a class of binary response models is proposed and, among the nonlinear functions suggested, probit is the most commonly used model. Because of the nonlinear nature of $E(y \mid x)$, a maximum likelihood estimation is used (MLE). The MLE is consistent , asymptotically normal and efficient. Likelihood ratio statistics (LR) commonly are used to test multiple restrictions in probit models.

We define US_t^b as the amount of dollar purchases vis-a-vis TL by the CBRT in time period t. Similarly we define US_t^s as the amount of dollar sales vis a vis TL in time period t.

$$I_t^b = 1, \quad US_t^b \rangle 0 \text{ and } I_t^b = 0, otherwise \tag{2.4a}$$

$$I_t^s = 1, \quad US_t^s \rangle 0 \text{ and } I_t^s = 0, otherwise \tag{2.4b}$$

Then the following two equations are estimated separately by using a Maximum Likelihood Estimation

$$I_t{}^b = \gamma_1{}^b + \gamma_2{}^b dev_{t-1}{}^{(m)} + \gamma_3{}^b \sigma_{t-1}{}^2 + \varepsilon_t{}^b \tag{2.5a}$$

and

$$I_t{}^s = \gamma_1{}^s + \gamma_2{}^s dev_{t-1}{}^{(m)} + \gamma_3{}^s \sigma_{t-1}{}^2 + \varepsilon_t{}^s \tag{2.5b}$$

It is important to mention that we also include the lagged value of the dependent variable among the regressors. A 2004 study by De Jong and Woutersen considers dynamic time series binary choice model in detail.

In this study, the data is provided by the Central Bank of Turkey. The data sample consists of both daily spot bid rates, and daily intervention variables from November 1, 1993 through December 31, 2003. Intervention values are in millions of US dollars. Exchange rate policies are different through out the period. The analysis has been done separately for managed float and free float regimes excluding the crisis periods. So two subsamples of the data are taken and the first has the daily amount of net dollar purchases (sales) and daily spot bid rates date from January 2, 1995 through December 31, 1999 when the exchange rate policy was managed float. We have the estimations for only the free float regime which dates from February 27, 2001 through December 31, 2003. The data used in the estimations will have different starting values because the $dev_{t-1}{}^m$ are calculated starting from January 2, 1995 (for managed float) and from February 27, 2001 (for free float). For example, when we estimate the reaction function using $dev_{t-1}{}^{25}$ and volatility, the estimation sample dates from February, 7 1995 to December 31, 1999 for the managed float period and dates from April, 10 2001 to December 31, 2003 for the free float period. When we use $dev_{t-1}{}^{50}$ and volatility, the estimation sample dates from March 15, 1995 to December 31, 1999 for the managed float, and May, 16 2001 to December 31, 2003 for the free float period.

2.3.2 Estimation Results

The estimation output for the managed float regime is shown in table 2.1. We take all the representative values of deviation from the m-day moving average and estimate the reaction function and include only the significant ones. For the managed float period, we find that deviation from both five and 25 day moving average increases the probability of sale while deviation from the 50 day moving average and volatility decreases the probability of sale. The probability of purchase of US dollars is increased by the deviation from a 50 day moving average and is decreased by the deviation from a 25 day moving average. The probability of purchase is not determined by the conditional volatility. Lagged values of intervention increase the probability of intervention next day. The empirical finding is consistent with the monetary policy of the central bank during this period. The bank aims to achieve stability in real exchange rates.

Table 2.1: Estimation of Probit Intervention Model [a]

	Purchases of US Dollars		Sales of US Dollars	
	Coefficient	Standard Error	Coefficient	Standard Error
C	-0.75 ***	0.120	-0.90 ***	0.12
DEV_{t-1}^{5}	-0.11	0.09	0.19 *	0.11
DEV_{t-1}^{25}	-0.28 ***	0.100	0.28 ***	0.11
DEV_{t-1}^{50}	0.16 ***	0.060	-0.13 **	0.06
σ_{t-1}^{2}	0.27	0.26	-0.56 *	0.32
I_{t-1}^{b}	0.980 ***	0.080		
I_{t-1}^{s}			0.94 ***	0.08
McFadden R^2	0.12		0.13	
LR statistic(5 df)	199		203	
$T^{(b)}$	1209		1209	

(a) Full period of 15 March, 1995 through 31 December, 1999.
(b) T denotes sample size
(*) denotes 10% significance level
(**) denotes 5% significance level
(***) denotes 1% significance level

$$I_t^b = \gamma_1^b + \gamma_2^b dev_{t-1}^{(m)} + \gamma_3^b \sigma_{t-1}^2 + \varepsilon_t^b$$

where $I_t^b = 1,\ US_t^b \rangle 0$ with $I_t^b = 0, otherwise$

and

$$I_t^s = \gamma_1^s + \gamma_2^s dev_{t-1}^{(m)} + \gamma_3^s \sigma_{t-1}^2 + \varepsilon_t^s$$

where $I_t^s = 1,\ US_t^s \rangle 0$ and $I_t^s = 0, otherwise$

The estimation output for the free float regime has differences from the managed float. During the free float regime, the CBRT announced that the aim is not to affect the level of the exchange rate. The aim is to smooth the excess volatility. Interventions do not affect the long-run equilibrium of the exchange rate. Tables 2.2 gives the estimation output for the probit analysis during the free float regime. We find that the probability of sale of US dollars is increased by the current volatility of the exchange rate and the deviation from both the five and 125-day moving average. Deviations from the five-day and 50-day moving average increase the probability of purchase while deviations from 125 day moving average decrease the probability of purchases. A lagged value of intervention increases the probability of intervention next day. These results indicate that the central bank is more responsive to longer term deviations and volatility during the free float regime.

Table 2.2: Estimation of Probit Intervention Model [a]

	Purchases of US Dollars		Sales of US Dollars	
	Coefficient	Standard Error	Coefficient	Standard Error
C	-1.11 ***	0.13	-4.15 ***	1.04
DEV_{t-1}^{5}	0.13 **	0.06	0.22 **	0.10
DEV_{t-1}^{50}	0.05 *	0.02	-0.24 **	0.11
DEV_{t-1}^{125}	-0.11 ***	0.01	0.23 **	0.10
σ_{t-1}^{2}	0.02	0.11	0.44 **	0.20
I_{t-1}^{b}	1.45 ***	0.15		
I_{t-1}^{s}			2.58 ***	0.35
McFadden R^2	0.45		0.820	
LR statistic(5 df)	339		335	
T[b]	587		587	

(a) Full period of 29 August, 2001 through 31 December, 2003.
(b) T denotes sample size
(*) denotes 10% significance level
(**) denotes 5% significance level
(***) denotes 1% significance level

$$I_t{}^b = \gamma_1{}^b + \gamma_2{}^b dev_{t-1}{}^{(m)} + \gamma_3{}^b \sigma_{t-1}{}^2 + \varepsilon_t{}^b$$

where $I_t{}^b = 1,\ \ US_t{}^b \rangle 0$ with $I_t{}^b = 0, otherwise$

and

$$I_t{}^s = \gamma_1{}^s + \gamma_2{}^s dev_{t-1}{}^{(m)} + \gamma_3{}^s \sigma_{t-1}{}^2 + \varepsilon_t{}^s$$

where $I_t{}^s = 1,\ \ US_t{}^s \rangle 0$ and $I_t{}^s = 0, otherwise$

2.4.1. Tobit and Censored Least Absolute Deviation Model

Another important kind of limited dependent variable model is one that is continuous over strictly positive values but is zero for a fraction of the population. Let y be a variable continuous over strictly positive values but that takes on zero with positive probability. The Tobit model is most easily defined as a latent variable model where

$$y^{*} = \beta_0 + x\beta + u, u \mid x \sim Normal(0, \sigma^2) \tag{2.6}$$

$$y = \max(0, y^{*}) \tag{2.7}$$

The latent variable y^{*} satisfies the classical linear model assumptions where it has a normal, homoscedastic distribution with a linear conditional mean. Equation (2.7) implies that the observed variable, y, equals y^{*} when $y^{*} > 0$ and 0, otherwise. Maximum likelihood estimation is used. Both heteroscedasticity and nonnormality result in the Tobit estimator $\hat{\beta}$ being inconsistent for β. This inconsistency occurs because the derived density of y given x hinges crucially on $y^{*} \mid x \sim Normal(x\beta, \sigma^2)$. Tests for heteroscedasticity and non-normality in the latent variable equation are easily constructed.

A useful test for heteroscedasticity is suggested by Wooldridge (2002) and obtained by assuming $Var(u \mid x) = \sigma^2 \exp(z\delta)$, where z is a 1xq subvector of x (z does not include a constant). The q restrictions $H_0 : \delta = 0$, can be tested using the Lagrange Multiplier (LM) statistic. We can also construct tests of non-normality that only require a standard Tobit estimation. The most convenient of these are derived as the conditional moment tests. See Pagan and Vella (1989). Powell (1984) suggests that a least absolute deviation estimation is a natural approach for censored data when the assumption of normality of the errors is suspect. It is possible to estimate β consistently without assuming a particular distribution for u and without even assuming that u and x are independent. Consider again the latent variable model , but where the median of u ,given x, is zero and

$$y^{*} = x\beta + u, \qquad Med(u \mid x) = 0 \tag{2.8}$$

$$Med(y \mid x) = \max[0, Med(y^{*} \mid x)] = \max(0, x\beta) \tag{2.9}$$

The equation (2.8) implies that $Med(y^{*} \mid x) = x\beta$, so that the median of y^{*} is linear in x. Importantly, equation (2.8) holds up under assumption (2.9) and no further distributional assumptions are needed. Assumption (2.9) suggests estimating β by solving

$$\min_{\beta}(1/N)\sum_{i=1}^{N} | y_i - \max(0, x_i\beta) | \tag{2.10}$$

The l east a bsolute d eviations e stimator f or t he c ensored r egression m odel (CLAD) minimizes the sum of absolute deviations of y_t from $\max(0, x_t\beta)$ over all β.

To obtain the CLAD estimates we use the methodology described in De Jong and Herrera (2004). Thus, we use an iterative linear programming algorithm, which was proposed by Buchinsky (1994). This procedure amounts to first solving the linear programming (LP) representation of the optimization problem

$$\min_{b}\left\{\frac{1}{T-1}\sum_{t=2}^{T}\left[\frac{1}{2}\operatorname{sgn}(y_t-\beta' x_t)(y_t-\beta' x_t)\right]\right\} \tag{2.11}$$

to obtain the $\tilde{b}^{(1)}$ estimates. Then solve the LP problem for $\tilde{b}^{(2)}$ using the observations for which $\tilde{b}^{(1)'}x_t > 0$. This procedure is repeated until the set of observation used in two consecutive iterations is the same. Standard errors for $\tilde{b}$ are obtained according to the method employed by De Jong and Herrera (2004). The reported standard errors for the Tobit estimates are the quasi-maximum likelihood standard errors.

2.4.2Estimation Output

In this section, we first estimate the reaction function using a Tobit model and check for homoscedasticity and normality. The empirical evidence shows that we have a heteroscedasticity and non-normality problem. Then we estimate the reaction function using a CLAD method where the new estimator is both consistent and asymptotically normal. First, we estimate the Tobit model for a managed float period. The empirical evidence is in Tables 2.3 and 2.4. We take the same deviation from the moving average values as we use in probit model. Deviation from both the short- and medium-term appears to have a significant effect Granger causing the sale of US dollars. The sale of US dollars is decreased by a deviation from the long-term and conditional volatility .

While the purchase of US dollar is increased by the deviation from long term, both the deviation from short-term and volatility has no effect on the purchases of US dollars. When we find that Jarque-Bera and LM tests indicate both non-normality and heteroscedasticity, we used CLAD method. With respect to the purchase of US dollars, CLAD results are the same as Tobit results except the volatility appears to have a significant effect Granger causing the purchase of US dollar. With respect to the sale of US dollars, contrary to Tobit results, deviation from the short- and long-term appear to have no significant effect. In all these estimations we find that a lagged value of intervention increases intervention next day.

Table 2.3: Estimation of Tobit Intervention Model[a]				
	Purchases of US Dollars		Sales of US Dollars	
	Coefficient	Standard Error	Coefficient	Standard Error
C	-61.95 ***	13.65	-113.56 ***	18.93
DEV_{t-1}^{5}	-8.56	9.55	26.35 *	15.16
DEV_{t-1}^{25}	-35.31 ***	10.91	49.75 ***	15.52
DEV_{t-1}^{50}	18.74 ***	5.97	-24.59 ***	8.39
σ_{t-1}^{2}	14.11	24.60	-90.46 **	44.75
I_{t-1}^{b}	0.66 ***	0.07		
I_{t-1}^{s}			0.77 ***	0.07
LM-Test[b]	823		926	
skewness	4.10		5.03	
kurtosis	27.54		48.38	
Jarque-Bera	33755		108877	
T[c]	1209		1209	

[a] Full period of 15 March, 1995 through 31 December, 1999.
[b] Lagrange Multiplier statistic to test for heteroscedasticity.
[c] T denotes sample size
(*) denotes 10% significance level
(**) denotes 5% significance level
(***) denotes 1% significance level

$$y^* = \beta_0 + x\beta + u, u \mid x \sim Normal(0, \sigma^2)$$

$$y = \max(0, y^*)$$

where y equals y^* when $y^*>0$ and 0, otherwise.

Table 2.4: Estimation of Powell Censored Least Absolute Deviation[a]

	Purchases of US Dollars		Sales of US Dollars	
	Coefficient	Standard Error	Coefficient	Standard Error
C	-13.07 ***	1.61	-102.85 ***	25.86
DEV_{t-1}^{5}	1.13	1.01	-4.87	13.55
DEV_{t-1}^{25}	-7.22 ***	1.21	30.24 **	15.42
DEV_{t-1}^{50}	4.83 ***	0.66	-0.88	8.40
σ_{t-1}^{2}	30.31 ***	2.57	-90.22 **	44.22
I_{t-1}^{b}	0.37 ***	0.01		
I_{t-1}^{s}			0.51 ***	0.04
skewness	3.63		2.54	
kurtosis	24.36		16.37	
Jarque-Bera	25521		10266	
T[(b)]	412		249	

(a) Full period of 15 March, 1995 through 31 December, 1999
(b) T denotes sample size
(*) denotes 10% significance level
(**) denotes 5% significance level
(***) denotes 1% significance level

$$y^{*} = x\beta + u, \qquad Med(u \mid x) = 0$$

$$Med(y \mid x) = \max[0, Med(y^{*} \mid x)] = \max(0, x\beta)$$

$$\min_{\beta}(1/N)\sum_{i=1}^{N} \mid y_i - \max(0, x_i\beta) \mid$$

Tables 2.5 and 2.6 gives the empirical evidence for both Tobit and CLAD estimations during the free float regime. First we estimate a Tobit model and find that sale of US dollars is determined by the current volatility of the exchange rate and deviation from long-term. With respect to the purchase of US dollar while deviation from long-term decreases the purchase of US dollar, deviation from both short- and the medium term increases. Lagged values of intervention increase the probability of intervention next day. When we find evidence for heteroscedasticity and non-normality, we estimate CLAD and contrary to Tobit results, we find that neither the representative deviations nor volatility has an effect on the sale the US dollars. The other interesting difference between the Tobit results is with respect to the purchases of US dollars. Deviation from the short-term has no effect on the purchase of US dollar. The sample size in free float regime is smaller than the one in managed float. So we suspect small sample size bias for CLAD estimatons. Khan and Powell (2001) suggests two-step estimators for these models to overcome the finite sample bias. In this respect an interesting extension of this research would be to use the two-step estimators method suggested by Khan and Powell (2001) in further research.

Table 2.5: Estimation of Tobit Intervention Model[a]				
	Purchases of US Dollars		**Sales of US Dollars**	
	Coefficient	**Standard Error**	**Coefficient**	**Standard Error**
C	-136.79 ***	40.56	-58.58 ***	17.44
DEV_{t-1}^{5}	12.20 *	7.04	1.63	1.26
DEV_{t-1}^{50}	12.39 ***	4.54	-4.87 ***	1.79
DEV_{t-1}^{125}	-20.68 ***	5.58	4.82 ***	1.82
σ_{t-1}^{2}	4.49	13.91	5.32 ***	1.69
I_{t-1}^{b}	0.16 **	0.07		
I_{t-1}^{s}			0.69 ***	0.24
LM-Test[b]	341		121	
skewness	11.98		23.81	
kurtosis	181.48		573.53	
Jarque-Bera	793204		8017040	
T[c]	587		587	

(a) Full period of 29 August, 2001 through 31 December, 2003.
(b) Lagrange Multiplier statistic to test for heteroscedasticity.
(c) T denotes sample size
(*) denotes 10% significance level
(**) denotes 5% significance level
(***) denotes 1% significance level

$$y^{*} = \beta_0 + x\beta + u, u \mid x \sim Normal(0, \sigma^2)$$

$$y = \max(0, y^{*})$$

where y equals y^{*} when $y^{*}>0$ and 0, otherwise.

Table 2.6: Estimation of Powell Censored Least Absolute Deviation[a]

	Purchases of US Dollars		Sales of US Dollars	
	Coefficient	Standard Error	Coefficient	Standard Error
C	-6.86	13.19	-10.44	15.92
DEV_{t-1}^{5}	1.18	3.62	0.04	0.69
DEV_{t-1}^{50}	6.92 ***	2.29	-1.08	1.66
DEV_{t-1}^{125}	-6.92 ***	1.91	1.04	1.55
σ_{t-1}^{2}	-10.54	8.91	0.68	1.44
I_{t-1}^{b}	0.06 **	0.02		
I_{t-1}^{s}			0.90 ***	0.11
skewness	10.15		-1.80	
kurtosis	139.18		18.25	
Jarque-Bera	458938		5946	
T[b]	186		77	

[a] Full period of 29 August, 2001 through 31 December, 2003.
[b] T denotes sample size
(*) denotes 10% significance level
(**) denotes 5% significance level
(***) denotes 1% significance level

$$y^{*} = x\beta + u, \qquad Med(u \mid x) = 0$$

$$Med(y \mid x) = \max[0, Med(y^{*} \mid x)] = \max(0, x\beta)$$

$$\min_{\beta}(1/N)\sum_{i=1}^{N} \mid y_i - \max(0, x_i\beta) \mid$$

2.5 Conclusion

This chapter investigates the motivations for central bank intervention. We estimate the reaction function for both the managed float and free float regime separately. The empirical evidence gives different result for different regimes. First the probit model for managed float was estimated and it was found that the probability of sales of US dollars is increased by a deviation from both the short- and medium-term and the probability of purchases is increased by the deviation from the long-term. The probability of intervention is not determined by the conditional volatility for managed float and Tobit estimates give similar results.

Contrary to managed float period, both tobit and probit estimations indicate that the central bank is more responsive to volatility during a free float regime. While the sales of US dollars is determined by volatility and the deviation from long-term, purchase is determined by deviation from short- and medium term.

When we find non-normality and heteroscedasticity in Tobit results, we estimate all the reaction functions using a CLAD method so that we have consistent and asymptotically normal estimators. For managed float, different from the Tobit results, we find evidence that purchases of US dollar is increased by volatility and sales are only determined by deviation from medium term. For free-float regime, we find that neither the deviation from the 5,50 and 125 days moving average values nor volatility have an effect on the sales of the US dollars. In all the estimations, the common finding is that lagged value of intervention increases the intervention next day for both the managed and free float regime.

The sample size in free float regime is smaller than the one in managed float. So we suspect small sample size bias for CLAD estimatons. Khan and Powell (2001) suggest two-step estimators for these models to overcome the finite sample bias. In this respect an interesting extension of this research would be to use the two-step estimators method suggested by Khan and Powell (2001) in further research.

CHAPTER 3

Threshold Non-linear Estimation of the Central Bank Intervention Reaction Function

3.1 Introduction

In chapter two, the intervention reaction function is estimated using probit, tobit and censored least absolute deviation methods . In this chapter, we adopt a different approach and use a threshold model, with a view to extending our empirical understanding of the determinants of the Central Bank of Turkey`s intervention. This method is first used by Jun (2004). Jun(2004) mentions that the friction method adopted by Almekinders and Eijffinger (1996) and Kim and Sheen (2002) is not better than a simple linear model. A friction model involves specifying three separate distributional assumptions for the intervention series, and corresponds to the three different states of the intervention outcome. This approach allows a direct modeling of the relationship between the interventions and their determinants . The central bank is assumed to react to market conditions and constraints, but only after an intervention threshold is reached. The thresholds may differ for positive and negative interventions (purchase/sale of the foreign currency) and these may be estimated. Jun (2004) tests the friction hypothesis with a more flexible model using a threshold model that does not restrict the dependent variable to zero in the middle regime. In contrast to the friction model, the threshold variable that determines the regimes is one of the measures of the disorderly market conditions and it can be estimated by the method of least squares without assumptions regarding error distribution. Residual based test for misspecification are also applicable using this modeling approach. Section 3.2 gives a detailed description of the specification, estimation and test strategies of a threshold model in the context of intervention (Hansen, 1999, 2000). The empirical results with respect to the threshold model are given in section 3.3 and section 3.4 gives a brief conclusion.

3. 2 Estimation Of Threshold Models

The linear model of central bank reaction function is

$$y_t = x_t\beta + \varepsilon_t \tag{3.1}$$

where y_t denotes the actual purchases (sales) of US dollar and an m-regime threshold model allows the parameter vector β in the linear model (3.1) to change m times based on the values of the threshold variable η_t. A three regime threshold model can be written as

$$y_t = x_t\beta_1.I(\eta_t \le \gamma_t) + x_t\beta_2.I(\gamma_1 \le \eta_t \le \gamma_2) + x_t\beta_3.I(\eta_t \ge \gamma_2) + \varepsilon_t \tag{3.2}$$

where $I(.)$ is the indicator function, and $\beta_i = (\beta_{i0}\beta_{i1}......\beta_{ik})$, $i = 1,2,3$.

If x_t consists of lags of y_t only, it is called a threshold autoregressive (TAR) model. In addition, if η_t is one of the lagged y_t, the model becomes a self- exciting threshold autoregressive (SETAR) model. Some exogenous variables are used, such as deviation and volatility measures as explanatory variables, in addition to the autoregressive terms of y_t. The model is called a threshold model (Hansen, 2000). In our analysis, the threshold variable η_t is one of the exogenous variables. Specifically, we compare the $dev_{(t-1)}^{m}$ and $\sigma_{(t-1)}^{2}$, and choose the one that minimizes the sum of squared residuals as the threshold variable. The parameters $(\beta_1, \beta_2, \beta_3, \gamma_1, \gamma_2)$ can be estimated using conditional least squares. If the thresholds are given, the model becomes linear in the rest of the parameters and can be written as

$$y_t = \vartheta_t \theta + \varepsilon_t \tag{3.3}$$

where $\theta = (\beta_1, \beta_2, \beta_3)$ and the 3(k+1) row vector ϑ_t is

$$\vartheta_t = (x_t \beta . I(\eta_t \le \gamma_1)\ x_t \beta\ .I(\gamma_1 \le \eta_t \le \gamma_2)\ \ x_t \beta . I(\eta_t \ge \gamma_2)) \tag{3.4}$$

The θ in (3.3) can then be estimated by OLS. In defining the set of threshold observations

$$\Omega = \{\eta_t \mid t = 1, \ldots. T\} \tag{3.5}$$

For each pair of $(\eta_i, \eta_j) \in \Omega^2$ where $i, j = 1 \ldots\ldots T$ and $\eta_i \langle \eta_j$, substitute (η_i, η_j) for (γ_1, γ_2) in (3.4). Estimating (3.3) by using OLS, the sum of squared residuals $S(\eta_i, \eta_j)$ is obtained and is defined as

$$S(\eta_i, \eta_j) = \sum_{t=1}^{T} (y_t - \vartheta_t \theta)^2 \tag{3.6}$$

Then the pair of (η_i, η_j) that minimizes the sum of squared residuals will be the threshold estimates $(\hat{\gamma}_1, \hat{\gamma}_2)$. The estimates of the other parameters $(\hat{\beta}_1, \hat{\beta}_2, \hat{\beta}_3)$, are obtained as the OLS estimates of equation (3.2) with $\gamma_1 = \hat{\gamma}_1$ and $\gamma_2 = \hat{\gamma}_2$. This procedure requires $T(T-1)/2$ OLS regressions. Since we have two candidates for the threshold variable, the whole estimation process requires $T(T-1)$ OLS regressions. Although this is not a problem in the estimation stage, it becomes a critical problem in the hypothesis testing where the computation of bootstrap p-values requires thousands of replications of this procedure. In order to reduce this computational burden, Hansen (1999) proposes a two-step estimation procedure where the thresholds are estimated sequentially, one by one.

First we estimate a two-regime model as

$$y_t = x_t\alpha_1.I(\eta_t \leq \gamma) + x_t\alpha_2.I(\eta_t \geq \gamma) + \varsigma_t \tag{3.7}$$

The threshold estimate $\hat{\gamma}$ for the two regime models is the same as either $\hat{\gamma}_1$ or $\hat{\gamma}_2$ and useful in reducing the running time for the estimation of the three regime model of (3.2). It is also true that $\hat{\alpha}_1 = \hat{\beta}_1 \; if \; \hat{\gamma} = \hat{\gamma}_1, or \; \hat{\alpha}_2 = \hat{\beta}_3 \; if \; \hat{\gamma} = \hat{\gamma}_2$. The two step approach proposed by Hansen (1999) consists of the following steps :

1) Estimate the two regime model and obtain $\hat{\gamma}$ which is the element of $\Omega = \{\eta_t \mid t = 1, \dots. T\}$ that minimizes the sum of squared residuals.
2) Estimate the three regime model (3.3) after setting the $\gamma_1 and \gamma_2$ in (3.4) as either $(\hat{\gamma}, \eta_t)$ or $(\eta_t, \hat{\gamma})$ for each $\eta_t \in \Omega$. By assumption, $\gamma_1 \langle \gamma_2$.

Hansen (1999) mentions that if the true model is a three-regime model but a two-regime model is estimated, $\hat{\gamma}_1$ will be consistent for one pair of the (γ_1, γ_2). Then if (γ_1, γ_2) is estimated by least-squares enforcing that one element of γ equals $\hat{\gamma}_1$, then the second stage estimate $\hat{\gamma}_2$ will be consistent for the remaining element of the pair (γ_1, γ_2). Furthermore, this method is iterated at least once; that is, (γ_1, γ_2) is estimated by least squares enforcing the constraint that one element of γ equals $\hat{\gamma}_2$, yielding a refined estimate $\hat{\gamma}_1$. This iteration makes the estimates of (γ_1, γ_2) obtained by the two-step method asymptotically efficient.

If there are T elements in Ω for each of the N candidates of the threshold variable, then the two-step approach requires (2T-1) N regressions. In order to estimate the multi-regime model of (3.2), some restrictions must be imposed on the range of $\gamma_1 and \gamma_2$ so that each regime has at least the minimum required number of observations . One obvious requirement is that the number of observation of each regime, T_i for $i = 1,2,3$ must be greater or equal to the number of explanatory variables, k+1. Another more important requirement is concerned with the asymptotic properties of the estimators and test statistics. For a linear model, we can rely on consistency of the OLS estimator if T is large. Similarly, with three regime model of (3.2), we need to have large T_i for each regime because the conditional least squares procedure is equivalent to splitting the sample into three sub-samples and then estimating β_i using only T_i observations. This involves three smaller regressions and is faster than running one large regression with equation (3.3). Hansen (1999) explains that it is necessary to have $T_i / T \geq \tau$ for some $\tau \rangle 0$ as $T \to \infty$. In practice, however, it is inevitable to choose τ somewhat arbitrarily. Hansen (1999) suggests $\tau = 0.10$.

The next step is to test if the nonlinear model in (3.2) is a better specification than the linear model in equation (3.1). This is equivalent to testing the null hypothesis of

$$H_0 := \beta_1 = \beta_2 = \beta_3 = \beta \tag{3.8}$$

Hansen(1999) suggests a test statistics of

$$F = T(\frac{S_L - S_T}{S_T}) \tag{3.9}$$

where S_L is the sum of squared residuals from LS estimation of the linear model (3.1) and S_T is the sum of squared residuals from the three-regime model (3.2). When the thresholds are known, F is asymptotically equivalent to the usual F statistic. Since the thresholds are unknown and not identified under (3.8), however, F follows an unknown asymptotic distribution. Bootstrapping methods are relied on to compute the p-values with and without the conditional heteroscedasticity assumption.

Under the homoscedastic error assumption, a set of bootstrap errors are obtained, with $\tilde{\varepsilon} = \{\tilde{\varepsilon}_t \mid t = 1,.....T\}$ by randomly drawing T times with the replacement from the OLS residuals $\hat{\varepsilon} = \{\hat{\varepsilon}_t \mid t = 1,.....T\}$ of the linear model (3.1). A set of data on the dependent variable is generated then by

$$\tilde{y}_t = \tilde{x}_t \hat{\beta} + \tilde{\varepsilon}_t \tag{3.10}$$

where $\tilde{x}_t = (1, dev_{(t-1)}{}^{m}, \sigma_{(t-1)}{}^{2}, \tilde{y}_{t-1}, \tilde{y}_{t-2}, \ldots, \tilde{y}_{t-p})'$ and $\hat{\beta}$ is the OLS estimate of equation (3.1). Substituting $\tilde{y}_t$ for y_t in the linear model and the threshold models, the models are re-estimated to get one value of $\widetilde{F}$ which is

$$\widetilde{F} = T\left(\frac{\widetilde{S}_0 - \widetilde{S}_1}{\widetilde{S}_1}\right) \tag{3.11}$$

where $\tilde{S}_0$ and $\tilde{S}_1$ are the sum of squared residuals from the linear model and the threshold model, respectively, with bootstrap data. Out of 1000 replications, the proportion of $\tilde{F}$ greater than F is the approximate p-value.

Under heteroscedastic error assumption, the procedure is a bit more complicated because we have to impose heteroscedasticity on the bootstrap errors $\tilde{\varepsilon}$. First each element of the OLS residual vector $\hat{\varepsilon}$ is divided by an estimate of the conditional standard deviation $(\sqrt{\hat{h}_t})$ to obtain a set of homoscedastic errors of

$$\overset{\approx}{\varepsilon} = \{\overset{\approx}{\varepsilon}_t \mid \overset{\approx}{\varepsilon}_t = \hat{\varepsilon}_t / \sqrt{\hat{h}_t}, t = 1, \ldots\ldots. T\} \tag{3.12}$$

The conditional variance estimate, $\hat{h}_t$, is obtained as the fitted value from an auxiliary regression of $\hat{\varepsilon}_t^{\,2}$ on $x_t{}^2 = (1, [dev_{(t-1)}{}^{(m)}]^2, [\sigma_{(t-1)}{}^2]^2, y_{(t-1)}{}^2, y_{(t-2)}{}^2, \ldots\ldots, y_{(t-p)}{}^2)'$

$$\hat{\varepsilon}_t^2 = x_t^2 \delta + \upsilon_t \tag{3.13}$$

$$\hat{h}_t = x_t^2 \hat{\delta} \tag{3.14}$$

where υ_t is an error term and $\hat{\delta}$ is the vector of OLS estimates in that auxiliary regression. Now the random draws are from these standardized errors of ε^* and the t-th bootstrap error $\tilde{\varepsilon}_t$ is

$$\tilde{\varepsilon}_t = \approx{\varepsilon}_t \sqrt{\tilde{h}_t} \tag{3.15}$$

where $\tilde{h}_t = \tilde{x}_t^2 \hat{\delta}$ and $\tilde{x}_t = (1, dev_{(t-1)}^2, \sigma_{(t-1)}^2, \tilde{y}_{t-1}, \tilde{y}_{t-2}, \ldots\ldots, \tilde{y}_{t-p})$. Once the value of $\tilde{\varepsilon}_t$ is given, the value of the dependent variable $\tilde{y}_t$ is computed by (3.10). It is important to note that $\tilde{h}_t \neq \hat{h}_t$ and $\tilde{x}_t \neq x_t$. $\tilde{x}_t$ contains lags of $\tilde{y}_t$, $\tilde{h}_t$, $\tilde{\varepsilon}_t$ as well as $\tilde{y}_t$, and must be computed recursively. The rest of the bootstrap procedure is the same as the homoscedastic case.

If the linearity hypothesis is rejected in favor of the threshold model, Hansen (1997, 2000), in turn, provides a method to construct an asymptotically valid confidence interval for the threshold of the two regime model. Unfortunately, to date the asymptotic distributions of the threshold estimators (γ_1, γ_2) are not developed for three or higher order models.

3.3 Tests for Nonlinearity and Estimation Output of Reaction Function

We estimate the reaction functions for the Central Bank of Turkey for both managed float and free float regime. For each of the subsamples, the two regime and three-regime threshold reaction functions are estimated using GAUSS programs. This estimation precedes hypothesis tests, but begins with the results of the tests whether two-regime or three regime threshold nonlinearity exists in the reaction function.

The tests of nonlinearity for a managed float regime are presented in Table 3.1. The test statistics F_{12} for a one-regime, versus a two-regime linear model is 27.35. The p-values are computed as the proportion of those bootstrap simulations out of 1000 replications that have the F-statistic larger than 27.35. When the errors in the linear model are assumed to be homoscedastic, the p-value is 0.01. Therefore,we reject (fail to accept) the null hypothesis of linearity against a two-regime threshold-nonlinearity at 5% level. Correcting for heteroscedasticity, the p-value is about 0.37 and we do not reject the null of linear reaction function. Against the three-regime alternative, the F_{13} statistic from the estimation is 50.09. The bootstrap p-value is 0.02 with homoscedasticity. Therefore we reject the null of the linear reaction function at 5 %. With heteroscedasticity, the p-value is 0.27 and fail to reject the linearity. Since we cannot reject linearity against three-regime nonlinearity, it is not suprising to find that the three-regime model is no better than a two-regime model. The F_{23} statistic is clearly significant with homoscedasticity assumption but not with the heteroscedasticity assumption for the regression errors.

Table:3.1 Test for Non-linearity

Managed Float Period (February 7, 1995- December,31 1999)

F-statistics		ρ-values	
		Homoscedastic	Heteroscedastic
F_{12}	27.35	0.01	0.37
F_{13}	50.09	0.02	0.27
F_{23}	22.24	0.06	0.2

The estimation results can be found in Table 3.2. The second column is for the linear model, the next two columns are for the two-regime threshold model, and the last three columns contain the estimation results with the three-regime model. As for the linear model, among the three measures of the disorderly market conditions (dev_{t-1}^{5}, dev_{t-1}^{25}, σ_{t-1}^{2}), the estimate of dev_{t-1}^{5} is significant at 5 % and the estimate of σ_{t-1}^{2} is significant at 10%. The coefficients of dev_{t-1}^{5} and dev_{t-1}^{25} have an expected negative signs implying that the central bank`s intervention tends to be a gainst the wind. On the contrary, the coefficient of σ_{t-1}^{2} is positive. Out of the two lags of the dependent variable, both of them are significant at 1% level. Overall, the implication is that recent interventions increase the expected amount of intervention in the near future. These two lags are enough to eliminate the serial correlation in the residuals. Ljung-Box test statistics indicate that there are no serial correlations in the residuals up to order of 10 ($Q_{(10)} = 13.2$, with a 5% critical value of 18.31).

However, there is strong evidence for heteroscedasticity ($Q^{2}_{(10)}$=107.48). A separate regression of the squared residuals on squared regressors (as reported in table 3.3), indicates that the errors are heteroscedastic and, therefore, White`s heteroscedasticity consistent standard errors are reported in table 3.2.

Table 3.2: Estimation of Threshold Intervention Reaction Function[a] (η_t=dev$_{t-1}^{5}$)

Variable	Linear	Two-regime		Three-regime		
		Regime 1	Regime 2	Regime 1	Regime 2	Regime 3
Constant	0.04	0.03	-0.05	-0.01	0.72 *	-0.05
	(0.07)	(0.09)	(0.25)	(0.10)	(0.43)	(0.25)
$Dev_{t-1}^{(5)}$	-0.13 **	-0.07	-0.12	-0.104	-0.83 *	-0.12
	(0.06)	(0.09)	(0.15)	(0.13)	(0.43)	(0.15)
$Dev_{t-1}^{(25)}$	-0.01	-0.002	0.002	0.015	-0.04	0.002
	(0.02)	(0.03)	(0.05)	(0.03)	(0.07)	(0.05)
σ_{t-1}^2	0.26 *	0.19	0.57 **	0.192	0.34	0.57 **
	(0.15)	(0.27)	(0.27)	(0.31)	(0.91)	(0.27)
y_{t-1}	0.37 ***	0.29 ***	0.59 ***	0.344 ***	0.26 ***	0.59 ***
	(0.04)	(0.04)	(0.10)	(0.05)	(0.06)	(0.10)
y_{t-2}	0.18 ***	0.18 ***	0.13	0.291 ***	0.09 *	0.13
	(0.04)	(0.04)	(0.08)	(0.06)	(0.05)	(0.08)
T	1234	939	295	545	394	295
R^2	0.25	0.19	0.37	0.26	0.14	0.37
F_{all}=0	84.94					
γ_1		0.94		0.57		
γ_2				0.94		
$R^2_{(all)}$	0.25	0.27		0.28		
Skewness	-0.58	-0.57		-0.62		
Kurtosis	13.31	12.6		12.34		
Q_{10}	13.2	11.89		13.63		
Q^2_{10}	107.48	122.19		114.88		

[a] Full period of 7 February, 1995 through 31 December, 1999.
[b] Numbers in parathesis are heteroscedasticity adjusted standard errors.
[c] F_{all}=0 tests overall significance except the constant.

(*) denotes 10% significance level
(**) denotes 5% significance level
(***) denotes 1% significance level

$$y_t = x_t\beta_1.I(\eta_t \le \gamma_t) + x_t\beta_2.I(\gamma_1 \le \eta_t \le \gamma_2) + x_t\beta_3.I(\eta_t \ge \gamma_2) + \varepsilon_t$$

where $I(.)$ is the indicator function, and $\beta_i = (\beta_{i0}\beta_{i1}......\beta_{ik})$, $i = 1,2,3$.

Table 3.3. Least Square Estimation of Conditional Variance Managed Float Period (February 7, 1995- December,31 1999)

Variable	Estimate	Standard Error
Constant	0.87	0.15
$Dev(5)_{t-1}^2$	0.08	0.05
$Dev(25)_{t-1}^2$	-0.012	0.01
Vol_{t-1}^2	-0.52	0.22
y_{t-1}^2	0.11	0.06
y_{t-2}^2	0.04	0.03
F-Test	40.19	
(p-value)	0.00	

Tests for nonlinearity (Table 3.1) show that a rejection of both two-regime and three-regime models versus the linear model. Despite this result, it is worth mentioning that with two regime model, the optimal threshold variable is estimated to be dev_{t-1}[5] and the point estimate of the threshold η_t is 0.94. This positive threshold indicates that the strongest non-linearity in the central bank's reaction function exists when the dollar appreciates rapidly. This indicates that, in light of the history of the exchange rate policy under managed float, the central bank is more sensitive to appreciation of the dollar. In the case of the three-regime model, the estimate of the second threshold is also positive.

The test results for both the non-linearity and the estimation output of the reaction function for the free float regime are given in tables 3.4 and 3.5.

Table:3.4 Test for Non-linearity

Free Float Period (April, 10 2001- December,31 2003)

F-statistics		**ρ-values**	
		Homoscedastic	**Heteroscedastic**
F_{12}	25.64	0.05	0.37
F_{13}	48.29	0.39	0.41
F_{23}	21.83	0.33	0.25

The test statistics F_{12} for a one-regime linear model versus a two-regime model is 25.64. The p-values are computed as the proportion of those bootstrap simulations out of 1000 replications that have the F-statistic > 25.64. When the errors in the linear model are assumed to be homoscedastic, the p-value is 0.05. Therefore, we reject (fail to accept) the null hypothesis of linearity against a two-regime threshold-nonlinearity at 5% level. With correction for heteroscedasticity, the p-value is about 0.37 and we do not reject the null of linear reaction function. Against a three-regime alternative, the F_{13} statistic from the estimation is 48.29. The bootstrap p-value is 0.39 with homoscedasticity and 0.41 with heteroscedasticity. and we fail to reject the linearity. Since we cannot reject linearity against three-regime nonlinearity , it is not suprising to see that the three-regime model is no better than a two-regime model. The F_{23} statistic is clearly insignificant with or without the heteroscedasticity assumption for the regression errors.

The estimation results are given in table 3.5. As for the linear model, among the three measures of disordely market conditions (dev_{t-1}^{5} , dev_{t-1}^{25} , σ_{t-1}^{2}) , only the estimate of σ_{t-1}^{2} is significant (1 % level) and has an expected negative sign implying that the central bank`s intervention tends to be against the volatility, but not the deviation from the trend. Out of the three lags of the dependent variables, all of them are significant at 1% and 5%. Overall, the implication is that recent interventions increase the expected amount of intervention in the near future. These three lags are enough to eliminate serial correlation in the residuals. Ljung-Box test statistics indicate that there are no serial correlations in the residuals up to order of 10 ($Q_{(10)}$ = 13.35, 5% critical value 18.31). Also, there is no evidence for heteroscedasticity ($Q^2_{(10)}$=0.12). A separate regression of the squared residuals on squared regressors, as reported in table 3.6 also indicates that the errors are not heteroscedastic. As a result, a two-regime threshold is preferred to linearity and three regimes.

Table 3.5: Estimation of Threshold Intervention Reaction Function[a] ($\eta_t=\sigma_{t-1}^2$)

Variable	Linear	Two-regime		Three-regime		
		Regime 1	Regime 2	Regime 1	Regime 2	Regime 3
Constant	0.13 ***	0.29	0.08 ***	0.31	-0.002	0.015
	(0.03)	(0.40)	(0.03)	(0.40)	(0.36)	(0.03)
$Dev_{t-1}^{(5)}$	-0.03	-0.04	-0.02	-0.04	0.08 **	-0.03 *
	(0.02)	(0.09)	(0.02)	(0.09)	(0.04)	(0.02)
$Dev_{t-1}^{(25)}$	-0.002	-0.1 *	0.002	-0.10 *	-0.02	0.011
	(0.01)	(0.06)	(0.01)	(0.06)	(0.01)	(0.01)
σ_{t-1}^2	-0.05 ***	-0.6	-0.04 ***	-0.65	0.14	-0.03 ***
	(0.01)	(1.05)	(0.01)	(1.04)	(0.53)	(0.01)
y_{t-1}	0.13 ***	0.04 **	0.32 ***	0.04 **	1.02 ***	0.21 **
	(0.05)	(0.02)	(0.12)	(0.02)	(0.34)	(0.09)
y_{t-2}	0.08 ***	0.24	0.04 *	0.24	-0.012	0.03
	(0.03)	(0.20)	(0.02)	(0.20)	(0.01)	(0.07)
y_{t-3}	0.1 **	0.24	0.06 **	0.24	-0.003	0.22 **
	(0.04)	(0.22)	(0.03)	(0.21)	(0.01)	(0.09)
T	687	161	526	162	200	325
R^2	0.11	0.05	0.2	0.05	0.14	0.34
$F_{all}=0$	14.06					
γ_1		0.45		0.45		
γ_2				0.89		
$R^2_{(all)}$	0.11	0.14		0.16		
Skewness	10.72	10.61		10.81		
Kurtosis	159.07	157.21		162.93		
Q_{10}	13.35	8.98		4.62		
Q^2_{10}	0.12	0.13		0.14		

(a) Full period of 10 April, 2001 through 31 December, 2003.
(b) Numbers in parathesis are heteroscedasticity adjusted standard errors
(c) $F_{all}=0$ tests overall significance except the constant

(*) denotes 10% significance level
(**) denotes 5% significance level
(***) denotes 1% significance level

$$y_t = x_t\beta_1.I(\eta_t \le \gamma_t) + x_t\beta_2.I(\gamma_1 \le \eta_t \le \gamma_2) + x_t\beta_3.I(\eta_t \ge \gamma_2) + \varepsilon_t$$

where $I(.)$ is the indicator function, and $\beta_i = (\beta_{i0}\beta_{i1}......\beta_{ik})$, $i = 1,2,3$.

Table 3.6 Least Square Estimation of Conditional Variance
Free Float Period (April, 10 2001- December,31 2003)

Variable	Estimate	Standard Error
Constant	0.760	0.430
$Dev(5)_{t-1}^2$	-0.003	0.020
$Dev(25)_{t-1}^2$	-0.001	0.002
Vol_{t-1}^2	-0.001	0.001
y_{t-1}^2	0.010	0.002
y_{t-2}^2	0.001	0.002
y_{t-3}^2	0.003	0.002
F-Test	0.11	
(p-value)	0.99	

With the two-regime model, the optimal threshold variable is estimated to be σ_{t-1}^2 and the estimate of the threshold variable is 0.45. This threshold indicates that the strongest non-linearity exists in the central bank's reaction function when there is volatility. This supports the claim that the central bank is more sensitive to volatility in a free float regime. Most of the observations are in regime two. The coefficient of σ_{t-1}^2 is significant at a 1% level in this regime. This indicates that central bank's intervention is against the volatility when the volatility is greater than the threshold variable. This indicates that the central bank is more responsive to high levels of volatility in a free float regime. Similar to the two regime model, the coefficent of σ_{t-1}^2 is significant at a 1% level in regime three. This result supports the finding in two-regime model such that central bank is more responsive to high levels of volatility.

3.4 Conclusion

The empirical evidence from the threshold model gives consistent results with the policies implemented by the central bank during the period investigated. For a managed float period, we reject both the two regime and three regime model. The linear models give that deviation from the 5 days moving average and recent interventions matter but not the volatility. For a free float period, under the assumption of homoscedastic errors, we fail to accept linearity against the two regime model and both volatility and recent interventions matter. These findings are consistent with the announcement of the CBRT such that the aim is not to affect the level of the exchange rate but rather the excess volatility.

CHAPTER 4

Risk Premium and Central Bank Intervention

4.1 Introduction

There has been an enormous amount of literature concerning the effects of intervention on currency markets and the motivations for such interventions. These results are mixed and depend on which exchange rate is analyzed , what sample period is studied and also what intervention strategy is followed. There is empirical evidence that indicates that some types of intervention can affect the risk premium in forward markets. However, the risk premium is not necessarily the intended target of the intervention .

The Forward exchange rate is a contractual exchange rate established at the time of a transaction that will take place at the maturity time t+1 and usually is regarded as the unbiased predictor of the future spot exchange rate. Contrary to popular theory, empirical evidence shows that the forward rate is a biased predictor of the future spot rate and/or is evidence of a risk premium. See Hansen and Hodrick (1980), Hakkio (1981), Baillie et al.(1983), and Baillie (1989). The forward premium anomaly, where the currency of the country with the higher rate of interest is more likely to appreciate than depreciate, is generally regarded as one of the most important unresolved paradoxes in international finance. Numerous explanations have been proposed to explain the forward premium anomaly, but, to date, no one has been able to fully explain the available empirical evidence. See Evans and Lewis (1995), Kaminsky (1993), Lewis(1988) Frankel and Froot (1987), Lewis (1989), Elliot and Ito (1995).

In a study by Bailie and Osterberg (1997a), Hodrick's model (Hodrick, 1989) is extended to allow central bank intervention to have a direct effect on the risk premium. Baillie and Osterberg (1997a) find that purchases of US dollars by the Federal Reserve Bank appear to significantly increase the excess dollar denominated returns for both the DM-$ and the Yen-$ markets. Consistent with this study, Baillie and Osterberg (2000) found that the intervention variables affect the risk premium in an analysis where the relationship between daily deviations from uncovered interest rate parity and intervention are investigated by using daily overnight euro-currency deposit rates.

Central Banks use intervention as a policy instrument. Despite its frequent use, intervention continues to be debated as a policy tool due to the controversy over whether it can achieve the policy goals of either changing the level of nominal exchange rates or reducing its volatility. In studies investigating the impact of intervention directly on the levels of exchange rates, it has generally been found that either intervention has no significant effect or that its outcomes are the opposite of those intended. In the first chapter of this study, the effect of intervention on spot exchange markets is discussed in detail as well as an empirical analysis of the Turkish spot market. This chapter aims to investigate the effect of intervention on risk premium and to asses whether intervention helps to explain the forward premium anomaly, as found by Baille and Osterberg (1997, 2000). The analysis is done for Turkish economy, where the economy is small and has high inflation. Section 4.2 describes the details of the model, Section 4.3 gives the data, Section 4.4 presents the estimation output and Section 4.5 discusses the results.

4.2 Details of the model: Risk Premium and Intervention

The Covered Interest Rate Parity Condition tells us the relationship between spot rates, forward rates and interest rates.

$$(f_{t,l} - s_{t+l}) = (i_{t,l} - i^{*}_{t,l}) \tag{4.1}$$

s_t and $f_{t,l}$ corresponds to logarithmic values of spot and forward exchange rates, respectively. Also $i_{t,l}$ denotes the domestic currency return on an l-period risk free dollar bond, denominated in terms of domestic currency where as $i^{*}_{t,l}$ is the foreign currency return on a risk free bond denominated in terms of the foreign currency. It implies that the country with the higher rate of interest has experienced an expected depreciation of currency. Sometimes, the relationship between forward rates and future spot rates is simply expressed in terms of the forward rate as being an unbiased predictor of the future spot exchange rate and is given by

$$f_{t,l} = E_t s_{t+l} \tag{4.2}$$

where s_{t+l} is the logarithm of the spot exchange rate and $f_{t,l}$ is the logarithm of the forward rate for maturity in time t+l. This is widely rejected by the empirical studies. See Hansen and Hodrick (1980), Hakkio (1981), Baillie et al. (1983), Baillie (1989). This has led to a type of model as in

$$f_{t,l} = E_t s_{t+l} + \rho_t \tag{4.3}$$

where ρ_t is a time dependent risk premium. The dependent variable in this study is the difference between expected rate of appreciation of the US dollar and the forward premium or in other words risk premium, which is defined as $(s_{t+k} - f_t)$. Note that

$$(s_{t+k} - s_t) - (i_t - i_t^*) = s_{t+k} - s_t - (f_t - s_t) = s_{t+k} - f_t \tag{4.4}$$

Hence,

$$(s_{t+k} - f_t) = \rho_t + u_{t+k} \tag{4.5}$$

where u_{t+k} is the rational expectations error associated with using the forward rate to predict the spot rate k periods and u_t is serially uncorrelated for lags greater than k, so $E(u_t u_{t+h}) = 0$ for h > k. This restriction is consistent with u_t, following a moving average process of order k-1 .

Baillie and Osterberg (1997a) extend Hodrick's 1989 model based on a consumption based asset pricing model, where risk premium depends on the conditional variance of production, money growth rates, consumption's share of production and intervention variables.

$$\rho_t = \alpha_1 \sigma_{yt}{}^2 - \alpha_2 \sigma_{yt}{}^{2*} + \alpha_3 \sigma_{\Omega t}{}^2 - \alpha_4 \sigma_{\Omega t}{}^{2*} + \alpha_5 \sigma_{\varsigma_t}{}^2 - \alpha_6 \sigma_{\varsigma_t}{}^{2*} + \alpha_7 \tau_t - \alpha_8 \tau_t{}^* \quad (4.6)$$

where $\sigma_{yt}{}^2$ and $\sigma_{\Omega t}{}^2$ are the conditional variances of logarithms of production and the gross growth rate of the currency, respectively. The variable $\sigma_{\varsigma_t}{}^2$ denotes the conditional variance of the share of the currency used for intervention. The intervention variable $\tau_t = M^* / M$, which is defined as the share of currency held by a foreign government for intervention operations. Astericks denote foreign country equivalents. The difference between this and Hodrick's model is the addition of the conditional means and variances of the two intervention variables in the risk premium. The model does not impose any restrictions on whether or not sterilization occurs. The model is estimated from daily data in order to determine the relatively short-lived effect of intervention on risk premium. Hence it is not possible to include the variances of production, money growth rates, and foreign currency holdings as a proportion of money stock. The spot exchange rate, the forward exchange and the intervention variables, which are all observed daily , are the variables included in the estimated model. Hence the risk premium ρ_t in (4.6) is considered to be determined by

$$(s_{t+k} - f_t) = \varepsilon_t + \sum_{j=1,21} \theta_j \varepsilon_{t-j} + b_0 + b_1 US_t{}^b + b_2 US_t{}^s \quad (4.7)$$

$$\varepsilon_t = z_t \sigma_t \quad (4.8)$$

$$\sigma_t{}^2 = \omega + \alpha \varepsilon_{t-1}{}^2 + \beta \sigma_{t-1}{}^2 \quad (4.9)$$

The first two terms on the right hand side of Eq (4.7) corresponds to u_t and ε_t is a serially uncorrelated white noise process, and θ_j are the moving average parameters. The explanatory variables, $US_t^{\ b}, US_t^{\ s}$ include the intervention variables. Conditional variance in equation (4.10) is represented by a linear GARCH (1,1) process.

Bollerslev (1986) introduced the GARCH(Generalized Autoregressive Conditional Heteroscedasticity) process, which extends the ARCH model to make $\sigma_t^{\ 2}$ a function of lagged values of $\sigma_t^{\ 2}$ as well as the lagged values of $\varepsilon_t^{\ 2}$. Bollerslev (1986) required all the coefficients to be positive to ensure that the conditional variance is never negative. The quasi-maximum likelihood estimation is used.

4.3 Data

In this study, the data is provided by the Central Bank of Turkey, the Istanbul Stock Exchange and Federal Reserve Bank Board of Governors. The November 1993 through December 2002 data sample consists of daily spot offer rates, interbank overnight interest rates, treasury bill rates, 30-day euro dollar rates and daily intervention variables. Intervention values are millions of US dollars. This study uses the daily amount of net dollar purchases (sales), daily spot offer rates and interest rates. The analysis separately covers both the managed float and free float period in terms of exchange rate regime. The development of a futures market is very new to the Turkish Economy. The forward exchange rate is calculated. The implied forward rate[12] is

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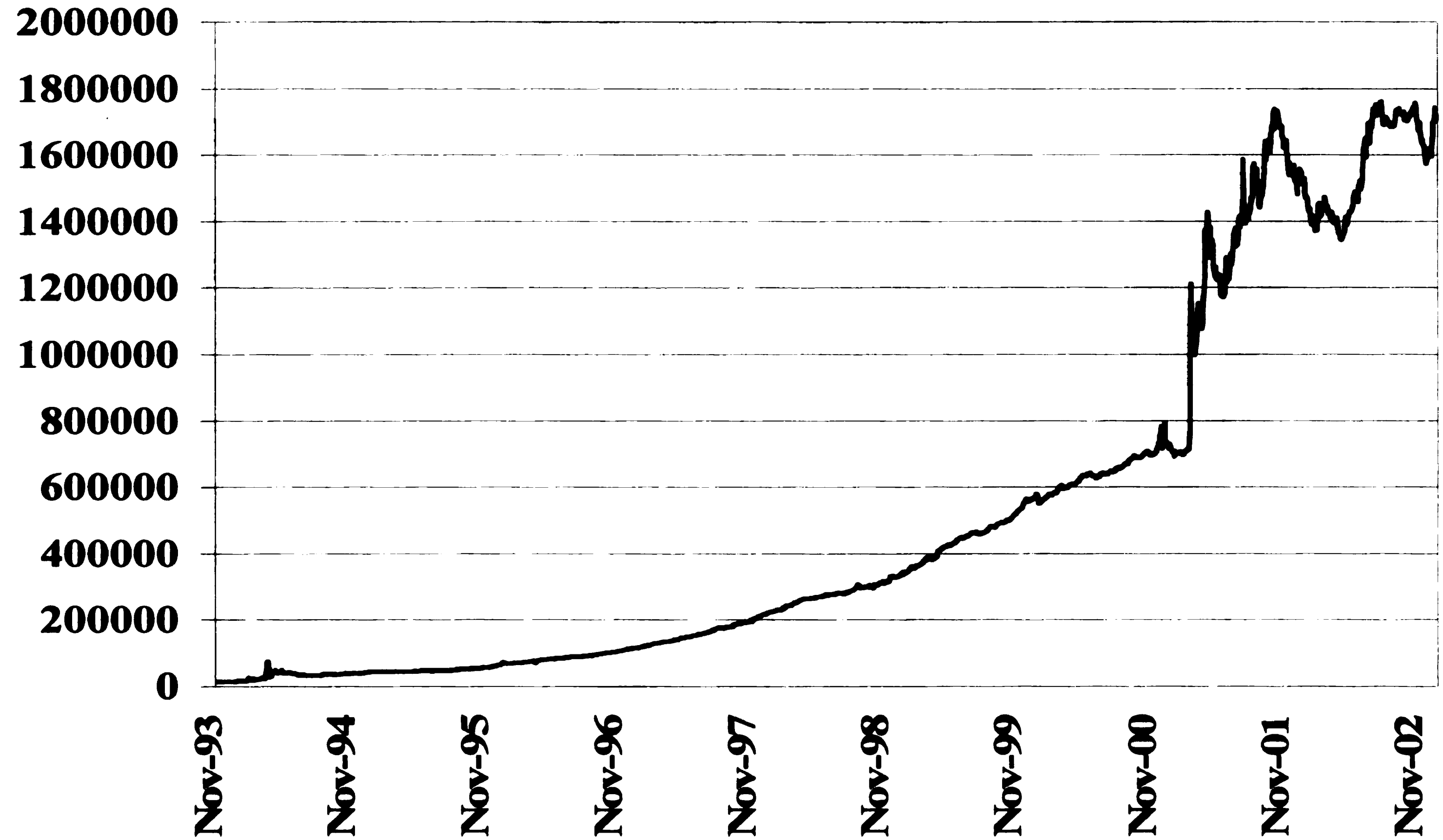
[1] 360-day is assumed as the basis for interest quoations instead of 365, see Grabbe (1996).
[2] The Implied Forward Rate is calculated as given in Grabbe (1996).

$$F_{t,30} = \frac{S_t(1 + i^*_t(\frac{30}{36000}))}{(1 + i_t(\frac{30}{36000}))} \tag{4.11}$$

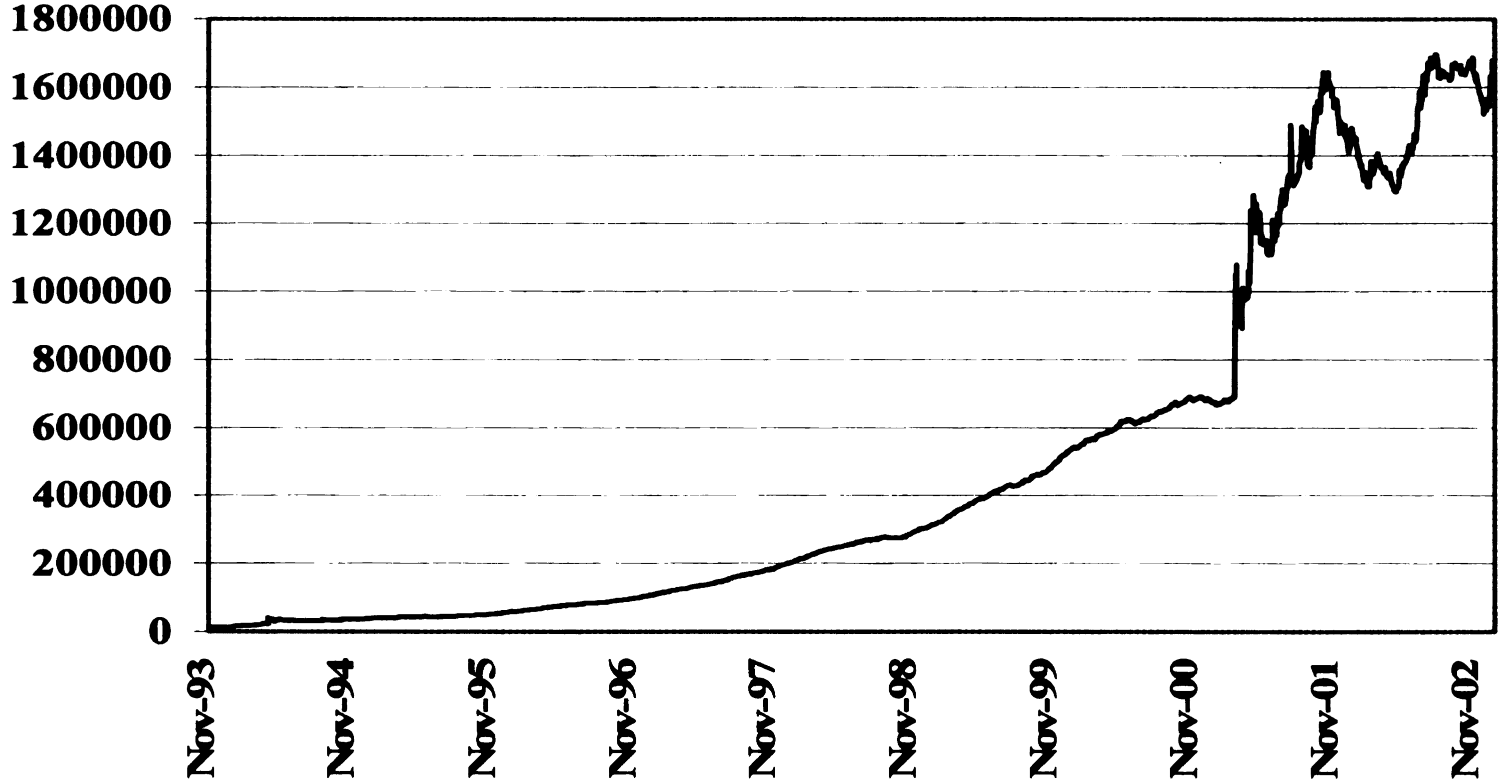
where $F_{t,30}$ is the daily 30-day forward rate, S_t is the daily spot rate as TL/USD, see Figure 4.1 and Figure 4.2. i^*_t is a proxy the 30 day treasury-bill interest rates for Turkey. Daily interest rates for treasury bills traded in the secondary market is obtained from the Istanbul Stock Exchange. The interest rate of which the treasury bill has the closest maturity to 30 days is chosen for each day. i_t is a proxy for 30-day euro dollar rates.

Figure 4.1 : Forward Exchange Rate TL/USD [(a)]



(*) Daily Forward Rate of TL/USD including the full period of 1 November, 1993 through 31 December, 2002.

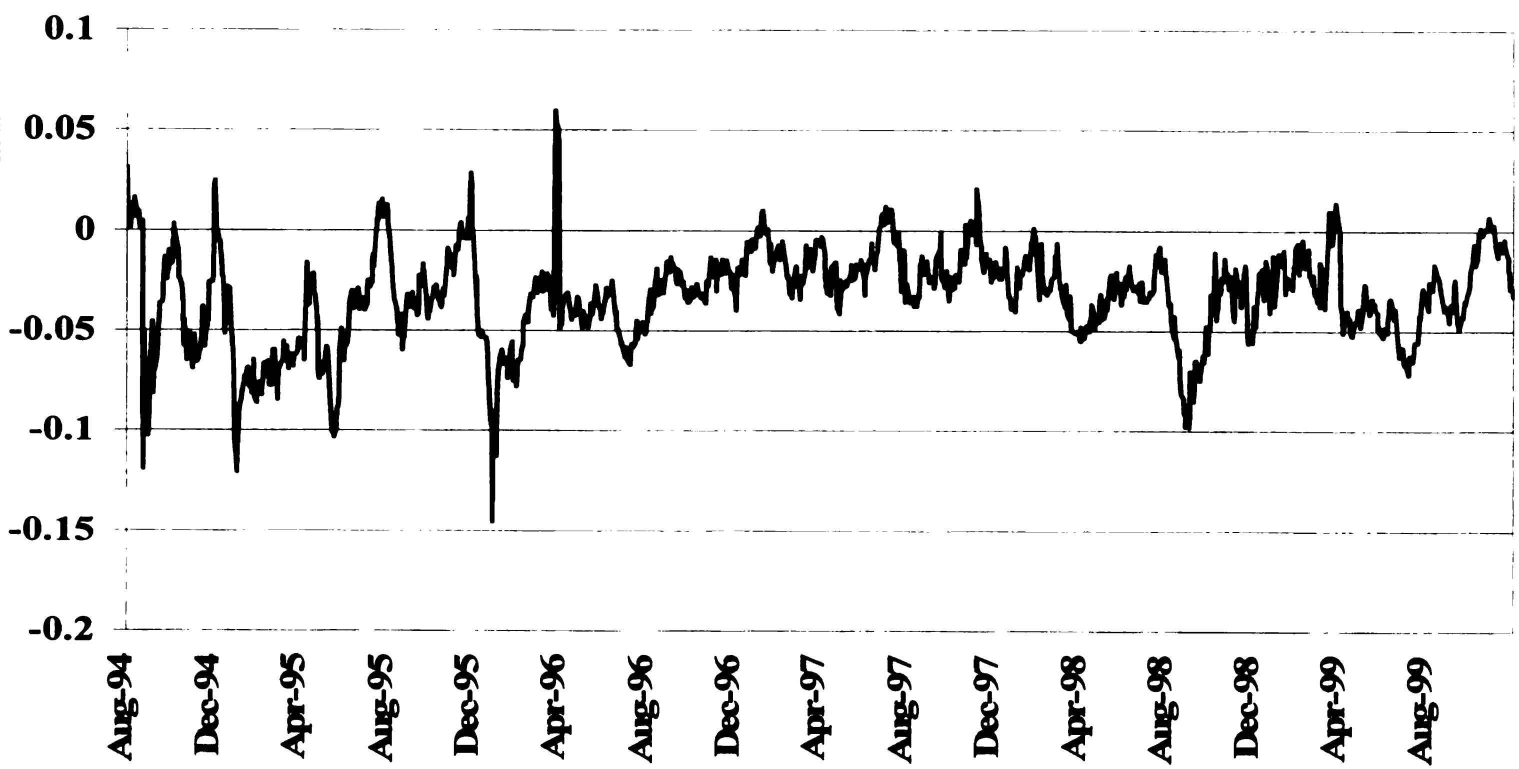
Figure 4.2 : Spot Exchange Rate TL/USD[a]



(*) Daily Spot Rate of TL/USD including the full period of 1 November, 1993 through 31 December, 2002.

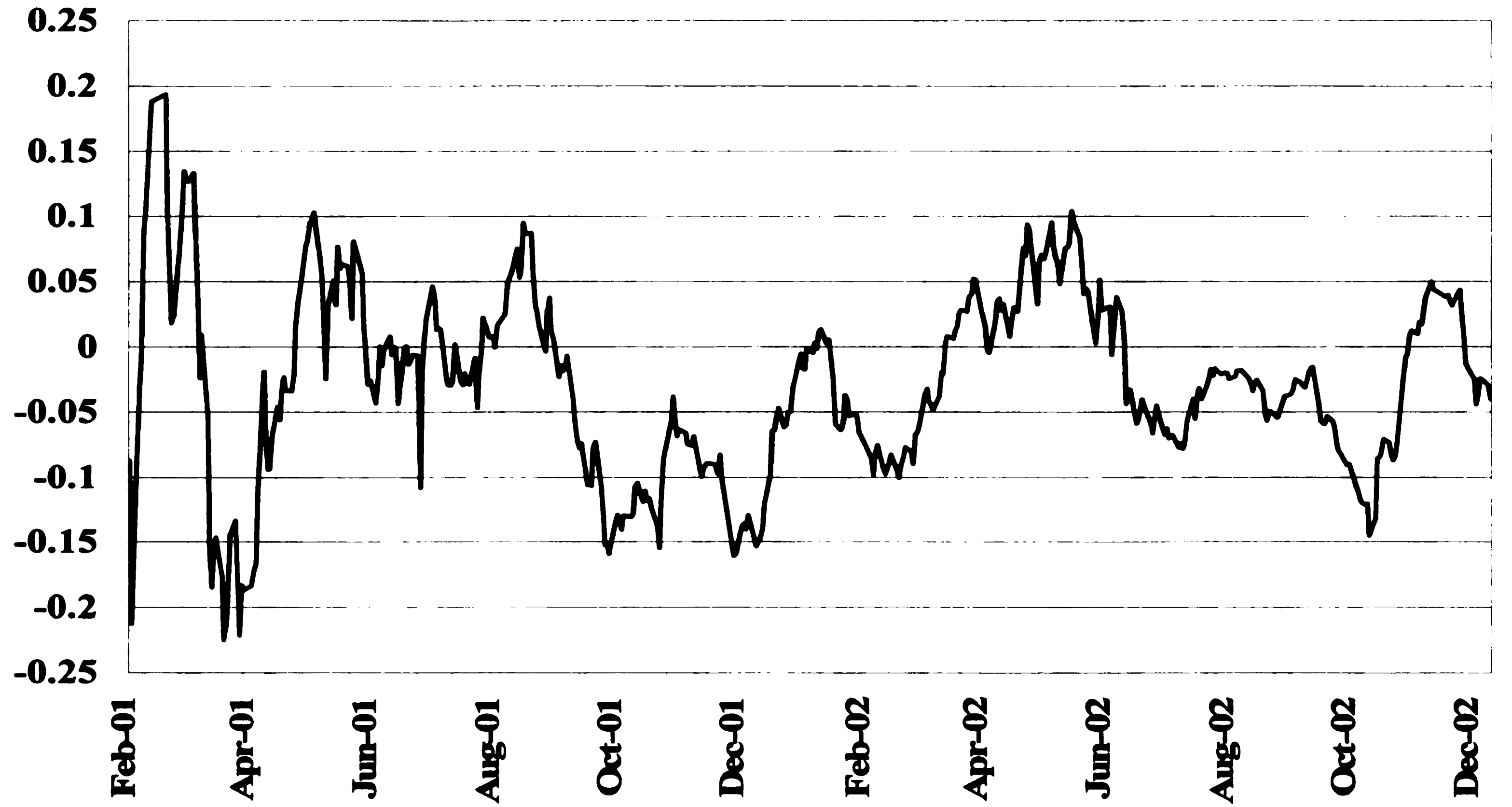
In this study, the forward rate quotations are matched with the future spot rate so that both represent contracts that would be delivered on the same day. The details of settlement procedures in the spot and forward markets are discussed in detail by Riehl and Rodriquez (1977). The important aspect here is the number of working days in the contract period varies. One reason is that delivery delays often occur around the first of the month. Contracts also are not settled on weekends or on holidays in either of the two countries for a given exchange rate . This exact matching reveals that for the data used in this study, k, the number of working days from the day of the forward quote to the time of settlement in the spot market varies from 20 to 26. Since the most common value of k in our sample is 22, u_t, the forecast error is estimated as an MA(21) process. This analysis has been done for two sub-periods due to the difference in economic policies. The first sub-period covers between August 1, 1994 and November 30, 1999. and the second one between February 22, 2001 and December 31, 2002. The forecast error for two sub-periods are shown in Figure 4.3 and in Figure 4.4

Figure 4.3: Forward rate forecast error[a]



(*) Daily Forward rate forecast error of TL/USD including the full period of 1 August, 1994 through 30 November, 1999.

Graph 4.4: Forward rate forecast error[a]



(*) Daily Forward rate forecast error of TL/USD including the full period of 22 February, 2001 through 31 December,2002.

4.4 Estimation Output

The details of the estimated model from the daily risk –premium and intervention data are given in Table 4.1 and Table 4.2. The model possess estimated moving average coefficients that approximately decline linearly with the lag. Diagnostic testing of the model fails to provide evidence for a higher order moving average process. Also a linear GARCH (1,1) process is found to be an adequate representation of the conditional second moments for the managed float period and a linear integrated GARCH (1,1) is adequate for free float period.

The most interesting aspects of the estimated models in Tables 4.1 and 4.2 concern the coefficients of the variables associated with intervention. In particular, unlike Baillie and Osterberg (1997a) , both purchases and sales of US dollars by the Central Bank of Turkey appear to have no effect on the size of risk premium for TL/USD for the free float period. Similar results are found for the managed float period but the buying of US dollars appear to have significant effect at a 20 percent significance level. This finding is expected to be the result of high inflation in Turkish Economy. Efforts of disinflation were not successful through 1990s and stability in the foreign exchange market was uncommon. Under these circumstances, factors affecting the interest rates are related to stability in both the domestic market and government debt management. The Central Bank of Turkey aimed at achieving stability in the markets. Under these circumstances, no relation is expected between risk premium and intervention.

Table 4.1: Estimation of Intervention/Risk Premium Model: TL/$ [a]

Conditional Mean Parameters	Coefficient	Standard Error	Coefficient	Standard Error
b_0	0.0 ***	0.01	0.0 ***	0.004
$b_1(US^b)$			0.0	0.0002
$b_2(US^s)$			0.0	0.0001
θ_1	0.9 ***	0.04	0.9 ***	0.055
θ_2	0.7 ***	0.07	0.7 ***	0.062
θ_3	0.7 ***	0.12	0.7 ***	0.098
θ_4	0.7 ***	0.14	0.7 ***	0.121
θ_5	0.7 ***	0.13	0.7 ***	0.11
θ_6	0.7 ***	0.11	0.7 ***	0.108
θ_7	0.6 ***	0.08	0.6 ***	0.078
θ_8	0.5 ***	0.06	0.5 ***	0.065
θ_9	0.6 ***	0.05	0.6 ***	0.059
θ_{10}	0.6 ***	0.05	0.6 ***	0.058
θ_{11}	0.5 ***	0.07	0.5 ***	0.075
θ_{12}	0.5 ***	0.06	0.5 ***	0.065
θ_{13}	0.4 ***	0.06	0.4 ***	0.063
θ_{14}	0.5 ***	0.06	0.5 ***	0.064
θ_{15}	0.4 ***	0.06	0.4 ***	0.059
θ_{16}	0.3 ***	0.06	0.3 ***	0.064
θ_{17}	0.2 ***	0.05	0.2 ***	0.058
θ_{18}	0.2 ***	0.05	0.2 ***	0.058
θ_{19}	0.2 ***	0.05	0.2 ***	0.056
θ_{20}	0.2 ***	0.05	0.2 ***	0.049
θ_{21}	0.1 ***	0.03	0.1 ***	0.042
Conditional Variance Parameters				
ω	0.0	0.0	0.0 *	0.0
α	0.3	0.1	0.3 **	0.1
β	0.6 **	0.1	0.6 ***	0.1
Skewness	1.07		1.00	
Kurtosis	23.34		22.45	
Q_{20}	24.20		22.44	
Q_{20}^2	13.36		13.23	
T	1347		1347	

(a) Full period of 1 August, 1994 through 30 November, 1999.
(*) denotes 10% significance level
(**) denotes 5% significance level
(***) denotes 1% significance level

$$(s_{t+k} - f_t) = \varepsilon_t + \sum_{j=1,21} \theta_j \varepsilon_{t-j} + b_0 + b_1 US_t^{\,b} + b_2 US_t^{\,s}$$

$$\sigma_t^2 = \omega + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2$$

$\varepsilon_t = z_t \sigma_t$ with z_t is iid (0,1)

Table 4.2: Estimation of Intervention/Risk Premium Model: TL/$ [a]

Conditional Mean Parameters

	Coefficient	Standard Error	Coefficient	Standard Error
b_0	-0.035 **	0.016	-0.03 **	0.016
$b_1(US^b)$			0.00	0.0007
$b_2(US^s)$			0.00	0.0014
θ_1	0.99 ***	0.058	0.99 ***	0.060
θ_2	0.80 ***	0.067	0.80 ***	0.068
θ_3	0.83 ***	0.081	0.85 ***	0.081
θ_4	0.70 ***	0.083	0.70 ***	0.082
θ_5	0.75 ***	0.085	0.76 ***	0.088
θ_6	0.74 ***	0.092	0.75 ***	0.097
θ_7	0.70 ***	0.096	0.70 ***	0.100
θ_8	0.65 ***	0.096	0.66 ***	0.099
θ_9	0.75 ***	0.086	0.75 ***	0.092
θ_{10}	0.87 ***	0.081	0.87 ***	0.079
θ_{11}	0.76 ***	0.067	0.77 ***	0.069
θ_{12}	0.76 ***	0.076	0.77 ***	0.082
θ_{13}	0.79 ***	0.087	0.80 ***	0.085
θ_{14}	0.68 ***	0.063	0.67 ***	0.063
θ_{15}	0.66 ***	0.078	0.68 ***	0.083
θ_{16}	0.61 ***	0.082	0.60 ***	0.081
θ_{17}	0.56 ***	0.090	0.55 ***	0.086
θ_{18}	0.61 ***	0.093	0.62 ***	0.095
θ_{19}	0.41 ***	0.099	0.40 ***	0.099
θ_{20}	0.45 ***	0.101	0.45 ***	0.093
θ_{21}	0.26 ***	0.073	0.27 ***	0.072
Conditional Variance Parameters				
ω	0.00	0.00	0.00	0.00
α				
β	0.13 **	0.061	0.13 **	0.061
Skewness	-0.33		-0.31	
Kurtosis	5.71		5.64	
Q_{20}	14.39		15.63	
Q_{20}^2	13.19		13.16	
T	467		467	

(a) Full period of 22 February, 2001 through 31 December, 2002.
(*) denotes 10% significance level
(**) denotes 5% significance level
(***) denotes 1% significance level

$$(s_{t+k} - f_t) = \varepsilon_t + \sum_{j=1,21} \theta_j \varepsilon_{t-j} + b_0 + b_1 US_t^{\,b} + b_2 US_t^{\,s}$$

$$\sigma_t^2 = \omega + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2$$

$$\varepsilon_t = z_t \sigma_t \quad \text{with} \quad z_t \quad is \quad iid \quad (0,1)$$

4.5 Conclusion

This chapter is concerned with the relation between the risk premium and central bank intervention. Forward rates are calculated for the Turkish Lira-US$ exchange market and then the effect of central bank intervention on the risk premium is presented. Using high quality daily intervention data from the Central Bank of Turkey as well as implied forward rates, an MA(21)-GARCH(1,1) model is estimated. Both purchases and sales of US dollars by the Central Bank of Turkey appear to have no effect on the size of risk premium for TL/USD for the free float period. Similar results are found for the managed float period. No empirical support is found for the theoretical model, with intervention having a significant effect on the risk premium.

CHAPTER 5

CONCLUSION

This dissertation provides an econometric analysis of the effects of and motivation for central bank intervention in Turkey during the period 1993 - 2003. In the first chapter, we investigate the effect of intervention on both the level and volatility of spot returns in Turkey. It is a common belief among policy-makers that central bank intervention is effective. However, the empirical evidence is mixed, and indeed, tends to suggest ineffectiveness overall. In this dissertation, we add to the existing empirical evidence, and find that central bank intervention is not effective in the Turkish foreign exchange market during the period November 1st 1993 until December 31st 2003. We estimate a linear GARCH(1,1) model for different sub-periods including and excluding the crisis periods. The results show that intervention does not affect the level of spot returns both in the managed and free float regime except during the sub-period January 1st 2000 - February 21st 2001. While intervention has no effect on volatility in the managed float regime, it increases volatility in a free float regime. With respect to the effect of the short-term interest rate, an increase in overnight interest rates appreciates the US dollar in a managed float regime but has no effect in a free float regime.

The second chapter investigates the motivation for central bank intervention. We estimate the reaction function for both the managed float and free float regimes separately. The central bank intervention reaction function is estimated using probit, tobit models and then using the censored least absolute deviation method. The empirical evidence gives different results for different regimes. First we estimated a probit model for a managed float and find that the probability of selling the US dollar is increased by the deviation from both the short and the medium term. The probability of a purchase, on the other hand, is increased by the deviation from the long-term. Finally, the probability of intervention is not determined by the conditional volatility for the managed float. Our tobit estimates give similar results. In contrast to a managed float, both our tobit and probit estimates suggest that the central bank is more responsive to volatility during a free float regime. While the sale of the US dollar is determined by volatility and the deviation from the long-term, its purchase is determined by the deviation from the short and medium term. When non-normality and heteroscedasticity in the tobit results are found, all the reaction functions are estimated using the CLAD method so that we get asymptotically normal and consistent estimators. For a free-float regime, we find that neither the deviation from the 5, 50 and 125 days moving average values nor volatility have any effect on the sales of the US dollar. In all of the estimations, the common finding is that the lagged value of intervention increases the next day intervention for both a managed and free float regime.

Chapter three examines the intervention reaction function using the Threshold model in the non-linear estimation of the reaction function. For a managed float period, we fail to accept both the two regime and three regime model. The linear models give that deviation from the 5 days moving average and recent interventions matter but that volatility does not. For a free float period, under the assumption of homoscedastic errors, we fail to accept linearity against the two regime model and both volatility and recent interventions matter. These findings are consistent with the announced intention of the CBRT not to affect the level of the exchange rate but rather the excess volatility.

Chapter four is concerned with the relation between the risk premium and central bank intervention. Forward rates are calculated for the Turkish Lira-US$ exchange market and then the effect of central bank intervention on the risk premium is presented. Using high quality daily intervention data from the Central Bank of Turkey as well as implied forward rates, an MA(21)-GARCH(1,1) model is estimated. Both purchases and sales of US dollars by the Central Bank of Turkey appear to have no effect on the size of the risk premium for TL/USD for the free float period. Similar results are found for the managed float period No empirical support is found for the theoretical model, with intervention having a significant effect on the risk premium.

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