A VAR ANALYSIS OF MONETARY POLICY IN TURKEY

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AYŞE ÖZDEN BİRKAN

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Prof.Dr. Bahattin Akşit
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Prof.Dr. Zehra Kasnakoğlu
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

Assoc.Prof.Dr. Nazım K. Ekinci
Supervisor

Examining Committee Members

Dr. Nadir Öcal

Dr. Jülide Yıldırım Öcal

ABSTRACT

Birkan, Ayşe Özden
M.Sc., Department of Economics
Supervisor: Assoc.Prof.Dr. Nazım K. Ekinci

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In this study, monetary policy in Turkey is analyzed within a vector autoregressive framework. Dynamic interrelations among the interest rate in the interbank money market, the interest rate on domestic borrowing auctions and the devaluation rate of the Turkish Lira, (TL), against the exchange rate basket of 1*USD+1.5*DM are investigated by use of non-causality tests, impulse response analysis and forecast error variance decomposition. Empirical results point to the fact that there are stable short term interactions among the three which can be exploited for monetary policy purposes.

Keywords: Monetary Policy, Vector Autoregression, Turkey

ÖZ

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Bu çalışmada Türkiye'de para politikası bir vektör otoregressif model çerçevesinde incelenmiştir. Bankalararası para piyasasındaki faiz oranı, kamu iç borçlanma ihalelerinde gerçekleşen faiz oranı ve Türk Lirası'nın bir Amerikan doları ve bir buçuk Alman markından oluşan döviz kuru sepeti karşısında değer kaybı arasındaki dinamik ilişkiler nedensellik sınamaları, itki tepki incelemesi, tahmin hatası ayrıştırması yöntemleri kullanılarak araştırılmıştır. Bulgular, üçü arasında para politikasında kullanılabilecek kısa dönemli etkileşimler olduğuna işaret etmektedir.

Anahtar Kelimeler: Para Politikası, VAR, Türkiye

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CHAPTER 1

INTRODUCTION

1.1 The Model

This study is an attempt to construct a vector autoregressive representation of the monetary policy setting in Turkey over the period January 1988-December 1997, with the aim of investigating the extent to which observations on the main indicators of the system support the existence of causal interrelations of the type employed in the argument of section 1.2. Particularly evidence on the short term independence of the interbank interest rate as a means of effecting the foreign exchange (FX) and domestic debt markets, will be sought.

Vector autoregression (VAR) is chosen because it does not require apriori assumptions regarding the endogeneity and exogeneity of variables. Thus it provides good opportunity to check for the validity of such presuppositions. Moreover innovation accounting within an estimated VAR model provides valuable insights on the short term interaction among the variables in the system and after-shock dynamics of the system. Of course one of the main uses of VAR models is forecasting, since the methodology can provide manageable representations of systems with a large number of variables. However this study is not oriented towards forecasting. The small and selective model we have constructed for purposes of isolating the presumably main interrelations would probably not be comprehensive enough to make quantitatively accurate forecasts.

Exchange rate, interbank interest rate and average interest rate on treasury auctions are chosen as the variables which are central to monetary policy, in accordance with the argument in section 1.2. From a portfolio decision point of view these are the prices of the three financial assets available for banks, namely foreign exchange, TL and government securities. To the extent that monetary policy is a question of manipulating the decisions of the major actors in the financial markets, these variables are expected to represent the monetary policy setting. Short term dynamics among the three are traced out in VAR framework so as to seek evidence of a pattern of short term interaction which constitutes a basis for effective policy.

The following chapter presents an overview of VAR methodology including a brief on stationarity; Chapter 3 introduces the data and investigates the time series properties of the data, while Chapter 4 is devoted to empirical findings. Conclusions and a general assessment of the model follow in Chapter 5.

1.2 Stylized Facts of the 1988-1997 Period

It is observed that economic policy in Turkey, in the late 1990s, centers around the questions of stability in the domestic debt and the foreign exchange markets. The contradictory forces of the necessity for increasing domestic borrowing and widespread currency substitution determine the direction of monetary policy.

In fact at the root of the problem is the fact that Turkey has a considerable debt, service of which cannot be realized by domestic sources without resort to external sources even at the best of times. This has been the case at least for the last two decades.

In early 1980s, in the aftermath of the debt crisis of late 1970s, the problem was one of making sure that the private sector accumulates FX and find means of transferring the accumulated FX to the public so as to service the external debt. FX accumulation by the private sector, through exports at the time, was achieved by a continuos devaluation of TL. However such a continuos devaluation policy had adverse effects on the fiscal balance, in that the depreciation of TL raises the domestic currency costs of the debt service. Nominal devaluations must be accompanied by increases in the domestic currency value of the primary surplus to keep the transfer abroad unchanged in foreign currency (Rodrik 1990). The alternative to increasing the primary surplus is resorting to inflation tax or domestic borrowing, leaving the alternative of acquisition of new external debt aside.

Domestic borrowing became an active and systematic policy option in mid-1980s, when institutional arrangements in the form of the establishment of TL and FX interbank markets, establishment of regular auctions were undertaken. The market for government securities enlarged as banks were put under the obligation of holding government securities as part of their liquidity requirements.

Financial liberalization and liberalization of capital flows, in late 1980s, made the policy combination of continuos devaluation, domestic borrowing and/or inflation rather problematic. The objective of financial liberalization was to enrich the menu of financial assets available to the private sector and to enhance their yields, which unfortunately contradicts with the necessity of low-cost domestic borrowing (Rodrik 1990). FX denominated assets guaranteed a considerable real return thanks to the downward biased exchange rate policy and constituted an important portfolio component for banks and households, as an indicator of accelerating currency substitution. This complicated the management of domestic debt.

The fact that government securities compete with FX denominated assets implies that exchange rate policy has consequences for domestic interest rates. Banks, which are the major buyers of government securities, have two ways of funding their purchases; either liquidating their FX holdings or collecting funds by increased interest rates on TL deposits, as long as they do not have access to central bank credits or foreign credits. In short maintaining a stable demand for government securities requires an interest rate on TL denominated financial assets that ensures a yield above the yield on FX assets. Thus continuos depreciation means continuously high domestic interest rates, so as to direct funds out of currency substitution. If a ceiling is to be maintained on domestic interest rates, either devaluation should be slowed down or external funds should be made available for the private sector. Thus, FX flows to the private sector were necessary for financing the domestic debt as well as the external debt.

External funds came with the liberalization of capital flows in 1989. The environment was one in which the public sector had declared preference of domestic borrowing for budget deficit financing and monetary policy had monetary control aspirations for reducing inflation.

Since 1986 the Central Bank of the Republic of Turkey was in internal practices of monetary targeting and engaged in institutional reforms directed to the creation of a financial system conducive to such a policy. The first program was announced in 1990. Among the announced aims were increasing net foreign assets and controlling domestic credit.

This announcement, which implied that money would not be created except for FX purchases and accordingly TL would be strong, coupled with high interests offered in treasury auctions, encouraged banks to hold open positions. The profitability of borrowing in FX and converting these funds into TL, investing in government securities attracted most financial intermediaries. However this system was highly fragile and signals of a downward movement of interest rates given by the canceling of bill tenders in late 1993, gave way to a reversal of expectations regarding the future strength of TL. Moreover, credit rating of the country was lowered by international rating institutions due to the severe detoriation in external balance and increased short term debt in 1993. The fall in creditworthiness implied a halt on external credit and consequently shortage of FX. These developments led to a severe financial crisis.

1994 started with heavy depreciation of TL, loss of reserves by the CBRT, soaring interest rates bankruptcies in the banking sector and continued with a stabilization program, April 5th Economic Measures Implementation Plan and a stand-by agreement with the IMF. The effects of the crisis continued until the last quarter of the year, in terms of temporary worker layoffs, plant holidays, etc.

1994 experience revealed strikingly the tendency of the economy to go into crisis in case of a shortage of external credit flows, as well as once more the centrality of exchange rate policy. Recovery came in 1995 with re-establishment of short term capital inflows.

Monetary policy thereafter has been directed towards increasing foreign assets in order to establish the credibility of exchange rate as the nominal anchor. Policy has been one of controlling the devaluation of TL against the foreign exchange basket composed of one US dollar and one and a half DM, while at the same time short term liquidity requirements of the banking sector were satisfied via the interbank market with the aim of maintaining the stability of the domestic debt market.

Since the second half of 1996, the CBRT has been following a policy of targeting a low level of volatility in interest rates in the interbank market. This policy implies stability in the money market and a lowering of the positioning risks of banks, which in turn makes possible lower-interest-longer-maturity domestic borrowing. It, at the same time, is expected to induce stability in the FX market.

Sustainability of this policy is dependent on the availability of external funds as well as the presence of a pattern of interaction among the major elements of the financial system which maintains the effectiveness of policy.

CHAPTER 2

VECTOR AUTOREGRESSION

2.1 Principles of VAR Modeling

Vector autoregression as a method of multivariate time series modeling is considered as one of the alternatives offered for the traditional methodology of structural multi equation modeling.

Structural multi equation modeling is characterized by five implicit assumptions which are:

1. A priori restrictions on variables
2. Time invariance of parameters
3. Parameter invariance with respect to changes in variables
4. Known causal ordering
5. No verification against rival models

Until late 1970s methodology in econometrics was not a frequently debated issue. Late 1970s, however, brought about a reconsideration of the principles of what is considered to be the traditional econometric methodology.

It is suggested that,(Pagan 1987), this reconsideration aimed at establishing a methodology which fulfills three main requirements which are:

1. Methodology should provide a set of principles to guide work in all its facets

2. By codifying the available body of knowledge it should facilitate the transmission of knowledge

3. Methodology should have a style of reporting of its own which is informative, succinct and readily understood

Vector autoregresssion claims to be an alternative to the traditional methodology, with the features stated above. It is revolutionary in the sense that what makes structural modeling "structural" is abandoned. Three basic features of this approach make it an altogether new way of macroeconometric modeling. These are, (Charemza and Deadman 1992),

1. There is no a priori endo-exogenous division of variables

2. No zero restrictions are imposed

3. There is no strict (and prior to modeling) economic theory within which the model is grounded

Thus VAR modeling resolves the identification problem. The problem of recovering the parameters of a structural model from reduced form coefficients, where the structural model itself cannot be estimated by OLS since it does not satisfy the requirement of zero covariance between explanatory variables and the error term, is circumvented. Unlike the case with conventional simultaneous equations modeling, in VAR framework it is not necessary to decide which variables enter which equation and which are endogenous, a priori, to achieve identifiability of the structural equations.

VAR methodology is one which starts with an "atheoretical" general vector autoregressive model of the form:

$$Z_t = \sum_{j=1}^{p} A_j Z_{t-j} + u_t \qquad (2.1.1)$$

where Z is the vector of all variables without any division of endo-exogenous variables, p is the order of lag length and u is the vector of error terms.

Simply the model involves regressing each current (non-lagged) variable in the model on all the variables in the model lagged a certain number (p) of times. (2.1.1) can be consistently estimated equation by equation by OLS as long as p is correctly chosen to avoid autocorrelation in the error term, since the lagged variables on the right hand side are not correlated with the error term.

The VAR model estimated is (2.1.1) and this is the model used for forecasting purposes. For policy analysis some more transformation is made on (2.1.1) to obtain the orthogonalized innovations form, where there is no contemporaneous correlation in the multivariate error term and equations which form the system can individually be used for policy analysis. Policy analysis in this context is investigating the impact of a known random shock on the system.

The methodology can be is summarized in four steps, (Pagan 1987):

1. Transform data to such a form that a VAR can be fitted to it

2. Choose as large a value p and dimension for Z_t as is compatible with the size of the data set available and then fit the resulting VAR

3. Try to simplify the VAR by reducing p or by imposing some restrictions upon the coefficients

4. Use the orthogonalized innovations representation to address the question of interest

The first step refers to making sure that the Z_t are stationary. At this stage it is worthwhile to remind some basic definitions regarding stationarity (Banerje, Dolado, Galbraith and Hendry 1993).

A stochastic process[1], $x(t)$, is called *strictly stationary* if, for any subset $(t_1, t_2, .., t_n)$ of T and any real number h such that $t_i+h \in T$, i=1,2,. ,n; we have

$$F(x(t_1),x(t_2),..,x(t_n))=F(x(t_1+h),x(t_2+h),..,x(t_n+h)),$$

where $F(\ .\ )$ is the joint distribution function of the n values. This means all the existing moments of the process are constant through time.

A process is *weakly stationary* or *covariance stationary* if,

$$E[\ x(t_i\ )] = E[\ x(t_i+h)] = \mu < \infty\ ,$$

$$E[\ x(t_i)^2] = E[\ x(t_i+h)^2] = \mu_2 < \infty, \quad \text{and}$$

$$E[\ x(t_i\ )\ x(t_j\ )] = E[\ x(t_i+h)\ x(t_j+h)] = \mu_{ij} < \infty\ ,$$

where μ, μ_2, and the μ_{ij} are constant over t, for all $t \in T$ and h such that $t_r+h \in T$ (r = I, j). That is, the contemporaneous second moments do not depend on time, and the lag dependencies are functions only of lag length.

A *white noise process* is a stationary process which has a zero mean and is uncorrelated over time; that is

[1] A stochastic process, is an ordered sequence of random variables $\{x(s,t), s \in S, t \in T\}$, such that, for each $t \in T$, $x(.,t)$ is a random variable on the sample space S, and for each $s \in S$, $x(s,.)$ is a realization of the stochastic process on the index set T (that is an ordered set of values , each corresponding to one value of the index set).

$\{x(t),\ t\in T\}$ is a white noise process if $\forall t\in T$, the following hold:

$$E[\ x(t)] = 0\ ,$$

$$E[(\ x(t))^2] = \sigma^2 < \infty\ ,$$

$$E[x(t)x(t+h)] = 0,$$

where $h\neq 0$ and $t+h \in T$. A white noise process is necessarily stationary.

What is meant by stationarity in the VAR context is covariance stationarity. Covariance stationary series are characterized by autocorrelation functions[2] that die down quickly, so a slow linear decline is an indicator of non-stationarity or a deterministic trend.

Non stationarity in time series causes problems in the statistical properties of the regression; conventional diagnostics like R^2 and t ratios turn out to be spuriously good failing to reflect the true performance of the model. Sims(1980) and Doan (1992) argue that variables entering the VAR may well be non-stationary and throwing away information by differencing and that detrending the variables can limit our understanding of the interrelationships among the variables. However, stationarity is indispensable for carrying out tests of hypotheses and policy analysis. Policy analysis requires the system to be stable and stability is closely linked with the variables being stationary (Lütkepohl 1993). Thus VAR modeling, for policy analysis, starts with determining the order of

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[2] Autocorrelation function is defined as $\rho(h)=\gamma(h)/\gamma(0)$, where $\gamma(0)$ is the variance of the process and $\gamma(h)$ is the autocovariance function defined as $\gamma(h)=E[(x(t)-\mu)(x(t+h)-\mu)]$, with $E(x_t)=\mu<\infty$.

integration[3] of the variables and trying to make them stationary through appropriate differencing.

2.2 Unit Root Tests

The most commonly used unit root test is the Augmented Dickey-Fuller (*ADF*) test. *ADF* is a generalization of the Dickey Fuller (*DF*) test which is a unit root test based on the estimation of

$$\Delta y_t = \delta y_{t-1} + u_t \qquad (2.2.1)$$

where u_t is assumed to be white noise, and testing the negativity of δ in (2.2.1), i.e. $H_0{:}\delta=0$ $H_A{:}\delta<0$. Student-*t* statistic used for testing this hypothesis has a distribution different than the normal distribution; critical values for this distribution are given by Dickey-Fuller (1984). Rejection of the null hypothesis implies that the coefficient of the lagged term in the autoregressive model is less than one and that $y_t \sim I(0)$. If one is not able to reject the null at the given significance level then either y_t is integrated of an order higher than zero or not integrated at all. In order to test whether $y_t \sim I(1)$, the equation to be estimated is:

$$\Delta\Delta y_t = \delta \Delta y_{t-1} + u_t \qquad (2.2.3)$$

[3] Some basic definitions regarding integration are
Definition 1: A non-stationary series which can be transformed to a stationary series by differencing d times is said to be integrated of order d; I(d).
Definition 2: A non-stationary series is said to be seasonally integrated of order (d, D), if it can be transformed to a stationary series by applying s-differences D times and then differencing the resulting series d times using first differences where s-differencing means applying the $x_t - x_{t-s}$ operator.

on the basis of which $H_0:\delta=0$ is tested against $H_A:\delta < 0$ using the same critical values as the previous case. If H_0 is rejected this means Δy_t is stationary that is $y_t \sim I(1)$. If H_0 is not rejected one can continue with testing whether $y_t \sim I(2)$ in the same manner. This will go on until an order of integration for y_t is established or it is realized that y_t cannot be made stationary by appropriate differencing.

ADF test is a generalization in the sense that it takes into account the possibility of autocorrelation in the error term, u_t. Lagged left hand side variables are included in the estimated equation in order to make up for autocorrelation in which case the equation to be estimated becomes:

$$\Delta y_t = \delta y_{t-1} + \sum_{i=1}^{k} \delta_i \Delta y_{t-i} + u_t \qquad (2.2.4)$$

where k is chosen large enough to approximate the autocorrelation, small enough to avoid excessive loss of degrees of freedom. Testing procedure is the same as explained above.The equation estimated in the *DF* (or *ADF*) procedure can be modified to take into account a drift (μ) term and deterministic trend (t); that is the same test can be performed by estimating

$$\Delta y_t = \mu + \delta y_{t-1} + u_t \qquad (2.2.5)$$

or

$$\Delta y_t = \mu + \alpha t + \delta y_{t-1} + u_t \qquad (2.2.6)$$

and using the appropriate degrees of freedom. It is also possible to test joint hypotheses regarding trend terms and δ using *LM* or equivalent statistics with again Dickey-Fuller tables. This kind of tests are common practice to determine the deterministic elements to be included in the *DF* regression. Below, in Table 2.2.1 are a summary of stylized tests for the existence of a drift and/or a trend in the *DF* regression. Critical values at the 5% level for *T*=100 are also given.

Table 2.2.1: Dickey-Fuller Tests

Model	Hypothesis	Statistic	Table
$\Delta y_t=\mu+\alpha t+\delta y_{t-1}+u_t$	$\delta=0$	τ_t	-3.45
	$\mu=0$ given $\delta=0$	$\tau_{\alpha t}$	3.11
	$\alpha=0$ given $\delta=0$	$\tau_{\beta t}$	2.79
	$\alpha=\delta=0$	ϕ_3	6.49
	$\mu=\alpha=\delta=0$	ϕ_2	4.88
$\Delta y_t=\mu+\delta y_{t-1}+u_t$	$\delta=0$	τ_μ	-2.89
	$\mu=0$ given $\delta=0$	$\tau_{\alpha\mu}$	2.54
	$\mu=\delta=0$	ϕ_1	4.71
$\Delta y_t=\delta y_{t-1}+u_t$	$\delta=0$	τ	-1.95

Philips-Perron test is another test of integration which is less restrictive in terms of its requirements of the properties of the error term. Philips-Perron test, Mills(1993), relaxes the assumptions regarding the error term and leaves room for a wide range of serial correlation and heterogeneity patterns. The test considers the test statistic for a unit root in

$$\Delta y_t = \alpha_0 + \alpha_1 \ y_{t-1} + u_t \qquad (2.2.7)$$

Since no lags of Δy_t are introduced in the regression, the statistic needs to be adjusted as,

$$Z(\tau_\mu)=\tau_\mu\ (\hat{\sigma}/\hat{\sigma}_{\tau 1})-1/2(\hat{\sigma}^2_{\tau 1}-\hat{\sigma}^2)\,T\{\hat{\sigma}^2_{\tau 1}\sum_{t=2}^{T}(y_{t-1}-\bar{y}_{-1})^2\}^{-1/2} \qquad (2.2.8)$$

where $\hat{\sigma}^2$ is the sample variance of u_t,

$$\bar{y}_{-1} = (T-1)^{-1}\sum_{t=1}^{T-1} y_t \qquad (2.2.9)$$

and

$$\hat{\sigma}^2_{\tau 1} = T^{-1}\sum_{t=1}^{T}\hat{u}^2_t + 2T^{-1}\sum_{j=1}^{l}\omega_{j1}\sum_{t=j+1}^{T}\hat{u}_t\hat{u}_{t-j} \qquad (2.2.10)$$

Results of *ADF* and Philips-Perron tests for the three variables in our system are given in Table 3.2.1 in Chapter 3.

2.2.3 Determining *p* and the number of variables in a VAR

The second step of VAR modeling is deciding on the number of variables to be included and the lag length.

Concerning the question of deciding on the number of variables to be included in the VAR, depending on the sample size, VAR models with too many variables are rarely feasible. Difficulty stems from the fact that with too many variables and lags the number of parameters become excessively large and degrees of freedom are rarely enough to estimate them properly. Thus a priori choice among the candidate variables have to be made which can be considered a divergence from the atheoretical, non-structural nature of VAR modeling.

The order of the VAR model of (2.2.1), i.e. *p*, can be selected either by the help of model selection criteria such as the Akaike Information Criterion (*AIC*), the Shwarz Bayesian Criterion (*SC*), Hannan-Quinn Criterion (*HQ*) or by means of a sequence of system reduction tests.

Using *AIC*, *SC* or *HQ*, the statistics should be computed for variants of the model with different lag lengths and the model with the lowest *AIC*, *SC* or *HQ* should be chosen, where, (Lütkepohl 1993),

$$AIC(p) = \ln|\Sigma(p)| + 2pk^2/T \qquad (2.3.1)$$

$$SC(p) = \ln|\Sigma(p)| + pk^2(\ln(T)/T) \qquad (2.3.2)$$

$$HQ(p) = \ln|\Sigma(p)| + 2pk^2(\ln(\ln(T))/T) \qquad (2.3.3)$$

where $|\Sigma(p)|$= determinant of the variance covariance matrix of the residuals

k = number of variables in the system

T = number of observations

The appropriate lag length can also be decided by starting with the longest feasible length given degrees of freedom considerations and paring down through a series of *Langrange Multiplier*(*LM*) tests or the *F* approximation for likelihood ratio based (*LR*) tests, as given by *PCFIML*, (Doornik and Hendry 1994).

Generally, in applied work, lag length is chosen on the basis of *SC* and *HQ* as well as sequential *LR* tests and variants, while Monte Carlo experiments suggest that *AIC* has a bias to choose a longer than appropriate length. One suggestion of an ascending order of effectiveness of the criteria in question is *SC*, *LR*, *HQ* and *AIC*(Köse and Uçar 1996).

These tests assume that the lag length is the same for all equations in the system in order to be able to use OLS efficiently. It is also possible to allow for different lag lengths and differing regressors in the equations of the model. In such cases seemingly unrelated regressions (*SUR*) provide efficient estimates of the VAR coefficients. Thus, when there is good reason for letting lag lengths differ across equations the so-called near-VAR can be estimated using *SUR*. However that would be inadequate for subsequent analyses, namely innovation accounting, using the estimated system.

2.4 Causality

The third step of simplification concerns reducing the size of the unrestricted VAR model by eliminating those coefficients for which the hypothesis that they are jointly equal to zero cannot be rejected. Such tests of joint hypotheses can be carried out using *LR*, *LM* and *Wald* statistics in the usual manner. It may not be always possible to pare down the system by such tests owing to concerns of lag structure and reliability of the tests. However even if a VAR is overparametrized it would do for purposes of analyzing the interrelations within the system as long as we are not after making forecasts (Enders 1995).

Testing zero restrictions in a VAR model is made in the context of causality analysis. The most widely used definition of causality in econometrics is the Granger definition of causality which is, (Charemza and Deadman 1992):

<u>Definition 2.4.1a:</u> x is a Granger cause of y, (denoted $x \Rightarrow y$), if present y can be predicted with better accuracy

by using past values of x rather that by not doing so, other information being identical.

Definition 2.4.2a: Instantaneous causation, (denoted $x \Leftrightarrow y$), exists if present values of y can be predicted better by using present and past values of x, ceteris paribus.

or, in a different formulation:

Definition 2.4.1b: If $MSE(y^*_t | U_{t-1}) < MSE(y^*_t | U_{t-1} \backslash X_{t-1})$, then $x \Rightarrow y$

Definition 2.4.2b: If $MSE(y^*_t | U_t \backslash y_t) < MSE(y^*_t | U_t \backslash X_t, y_t)$, then $x \Leftrightarrow y$;

where MSE = mean square error of prediction

y^*_t = an unbiased prediction of y_t

U_t = information set at time t.

Testing for causality, i.e. $x \Rightarrow y$, with these definitions boils down to testing whether x can be eliminated from that part of a VAR model which describes y. The most widely used test for this purpose is the Granger non-causality test.

Granger test, for the bivariate case is conducted by estimating;

$$y_t = A_0 D_t + \sum_{j=1}^{k} \alpha_j y_{t-j} + \sum_{j=1}^{k} \beta_j x_{t-j} + u_t \qquad (2.4.1)$$

where $A_0 D_t$ denotes the deterministic part of the equation (intercept, deterministic trend, seasonals etc.)and testing whether $\beta_1 = \beta_2 = \beta_3 = \ldots = \beta_k = 0$ using an F, LM or LR test. If β_i are zero x does not Granger cause y.

For the multivariate case block exogeneity, or more appropriately block causality tests which involve the testing of zero coefficients on past values of a group of variables in the equations of the rest of the variables can be conducted. These tests give information on whether the lags of a particular variable (or a group of variables) improve forecasts of the rest of the variables. This test is useful for deciding whether to include a variable into the VAR. For our purposes, which do not involve forecasting, the results are used to elaborate on the structure of the interrelations among the three variables in question.

2.5 Innovation Accounting

The last step of policy analysis refers to innovation accounting which consists of impulse response analysis and forecast error variance decomposition. These two techniques can provide insights regarding the dynamic structure of the system and the causality structure in the system. If there is a reaction of one variable to an impulse in another variable, the latter variable can be called causal for the former and the decomposition of the forecast error variance of a variable into components accounted for by innovations in the variables of the system can be interpreted with reference to causality, (Lütkepohl 1993).

2.5.1 Impulse Response Analysis

Impulse response analysis, which refers to tracing out the system's response to a shock in one of the variables is based on the fact that a stationary VAR(p)process of the type

$$Z_t = \sum_{j=1}^{p} A_j Z_{t-j} + u_t \qquad (2.1.1)$$

can be shown to have a moving average or innovations representation

$$Z_t = \mu + \sum_{j=0}^{\infty} A_j u_{t-j} \qquad (2.5.1.1)$$

where $\mu=E(Z_t)$. In computing the impulse responses the mean term is dropped since it is not of much interest in this context. In (2.5.1.2), the klth element of A_j represents the reaction of the kth variable to a unit shock experienced by the lth variable, j periods ago provided that the shock is not contaminated by other shocks to the system, (Lütkepohl 1993).

If the variables have different scales innovations of one standard deviation are considered rather than unit shocks. Such rescaling of impulse responses gives a better picture of the dynamic relationships since the average size of the innovations occurring in a system depends on their standard deviation.

Both procedures assume that a shock occurs only in one variable at a time. However contemporaneous correlation of the error terms may indicate that a shock in one variable is likely to be accompanied by a shock in another variable. Under these circumstances it is unrealistic to assume that at the time of the innovation all other residuals are zero, as is the case with the above procedures. In order to overcome this complication it is suggested in the literature to use,

$$Z_t = \sum_{j=0}^{\infty} M_j \, w_{t-j} \qquad (2.5.1.2)$$

where the components of $w_t = (w_{1t} \ldots . w_{kt})'$ are uncorrelated and have unit variance, $\Sigma_w = I_k$. (2.5.1.3) is obtained by decomposing the variance-covariance matrix of the residuals of the original system, (2.1.1), Σ_u , as $\Sigma_u = P.P'$, where P is a lower triangular matrix and defining $M_j = A_j.P$ and $w_t = P^{-1}.u_t$. Now, it is reasonable to assume that a change in one component of w_t has no contemporaneous effect on the other components, because the components are orthogonal, i.e. uncorrelated. Σ_u is usually decomposed by Cholesky decomposition. With some manipulation on the basis of this decomposition, the VAR model can be transformed into a recursive model whereby the kth equation contains only variables prior to k, and not those after it, on the right hand side. As such z_{st}, the sth element of Z_t, cannot have an instantaneous impact on z_{kt} ,the kth element of Z_t, for $k<s$. This type of causality is called *Wold* causality. Thus, the complexity arising from the fact that impulse responses are sensitive to changes in the order the variables enter the VAR and that the decomposition of Σ_u is non-unique, can be handled by selecting the ordering of variables on the basis of Wold causal ordering. Sims'(1980) advice in this respect is to experiment with different orderings and evaluate the sensitivity of results to changes in the ordering. One criterion for this purpose is looking at the correlation coefficients between the residuals, defined as $\rho_{ij} = \sigma_{ij}/\sigma_i\sigma_j$. As a rule, it is suggested that, (Enders 1995), if $|\rho_{ij}|>0.2$, the correlation is significant and the ordering is influential on the results, otherwise the ordering may be considered immaterial.

As presented in Chapter 4, in this study we have made use of this rule to assess the sensitivity of the results to ordering. We have also experimented with different orderings and decided on the order to be used with an *ad hoc* principle based on a *Wold*-type idea.

2.5.2 Forecast Error Variance Decomposition

The other component of innovation accounting, forecast error variance decomposition, is also based on the moving average representation with orthogonal innovations. For,

$$Z_t = \sum_{j=0}^{\infty} M_j w_{t-j} \qquad (2.5.1.2)$$

with the variance-covariance matrix of the orthogonalized innovations equal to the identity matrix, $\Sigma_w = I_K$, the error of the optimal one-step ahead forecast for the *h*th period is,

$$Z_{t+h} - Z_t(h) = \sum_{i=0}^{h-1} \phi_i u_{t+h-i} = \sum_{i=0}^{h-1} \phi_i P P^{-1} u_{t+h-i} = \sum_{i=0}^{h-1} M_i w_{t+h-i} \qquad (2.5.2.1)$$

Denoting the *mn*th element of M_i by $\eta_{mn,i}$, the *h*-step forecast error of the *j*th component of Z_t is,

$$Z_{j,t+h} - Z_{j,t}(h) = \sum_{i=0}^{h-1} (\eta_{j1,i} w_{1,t+h-i} + \ldots + \eta_{jK,i} w_{K,t+h-i})$$

$$= \sum_{k=1}^{K} (\eta_{jk,0} w_{k,t+h} + \ldots + \eta_{jk,h-1} w_{k,t+1}) \qquad (2.5.2.2)$$

The forecast error of the jth component consists of innovations of all other components of Z_t as well. Since $\Sigma_w = I_k$, the mean square error of $Z_{j,t}(h)$ is

$$E(Z_{j,t+h}-Z_{j,t}(h))^2 = \sum_{k=1}^{K} (\eta^2_{jk,0}+.+\eta^2_{jk,h-1}) \qquad (2.5.2.3)$$

Accordingly,

$$\eta^2_{jk,0} + \ldots + \eta^2_{jk,h-1} = \sum_{i=0}^{h-1} (e_j' M_i e_k)^2 \qquad (2.5.2.4)$$

is the contribution of innovations in the kth variable to the forecast error variance of the jth variable, where e_k is the kth column of I_K. Dividing (2.5.2.4) by

$$MSE(Z_{j,t}(h)) = \sum_{i=0}^{h-1} \sum_{k=1}^{K} \eta^2_{jk,i} \qquad (2.5.2.5)$$

gives

$$\omega_{jk,h} = \sum_{i=0}^{h-1} (e_j' M_i e_k)^2 / MSE(Z_{j,t}(h)) \qquad (2.5.2.6)$$

which is the proportion of the h-step forecast error variance of the jth variable accounted for by innovations in the kth variable. Thus the forecast error variance is decomposed into components accounted for by innovations in the different variables of the system.

Innovation accounting is the most criticized step of the VAR methodology. Criticisms center around the arbitrariness of the decomposition rule and the question of what meaning should be attached to responses to orthogonalized innovations. The latter point of criticism regards assuming no contemporaneous correlation among the residuals and constructing artificial devices to make working with this assumption possible, as deficient as imposing a priori structural restrictions on the system.

In spite of these limitations, a well constructed and carefully interpreted VAR model, especially for macroeconomic variables, is accepted to provide insights to the dynamic interrelations among the variables; thus the extensive empirical literature on VAR models.

CHAPTER 3

THE DATA

3.1 Definitions

Monthly observations over the period 1988:1-1997:12 (T=120) on three variables, as defined below, are used in this study.

INTER is the monthly averages of overnight interbank interest rates, weighted by total volume of transactions. The source of the data is the Central Bank of the Republic of Turkey.

TBILL is average annual compound interest rate on treasury bills of 3, 6, 9, 12, 36 months and broken maturity weighted by net sales, obtained from the Undersecretariat of Treasury.

FX is the nominal exchange rate basket composed of 1*USD+1.5*DM. The source of the data is the Central Bank of the Republic of Turkey.

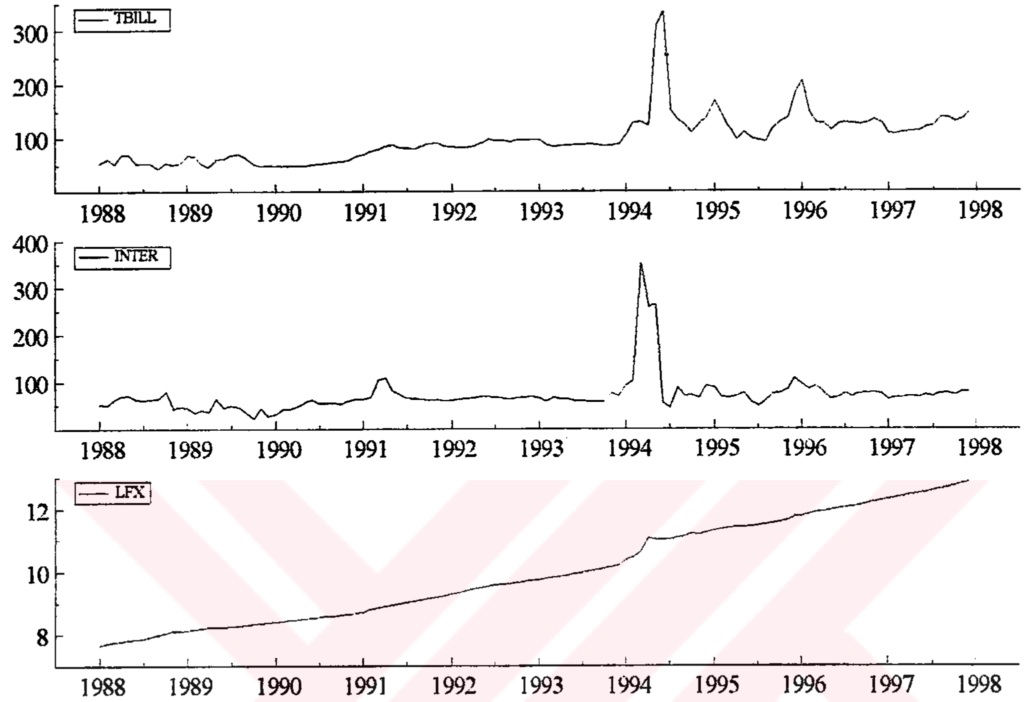
FX is used in logarithmic form, denoted LFX hereafter, while the two interest rates are used without any transformation, as they are already in percentage form.

3.2 Graphical Analysis

A preliminary idea about the time series properties of the series can be obtained by having a look at

Figure 3.2.1, which depict the series against time in levels.

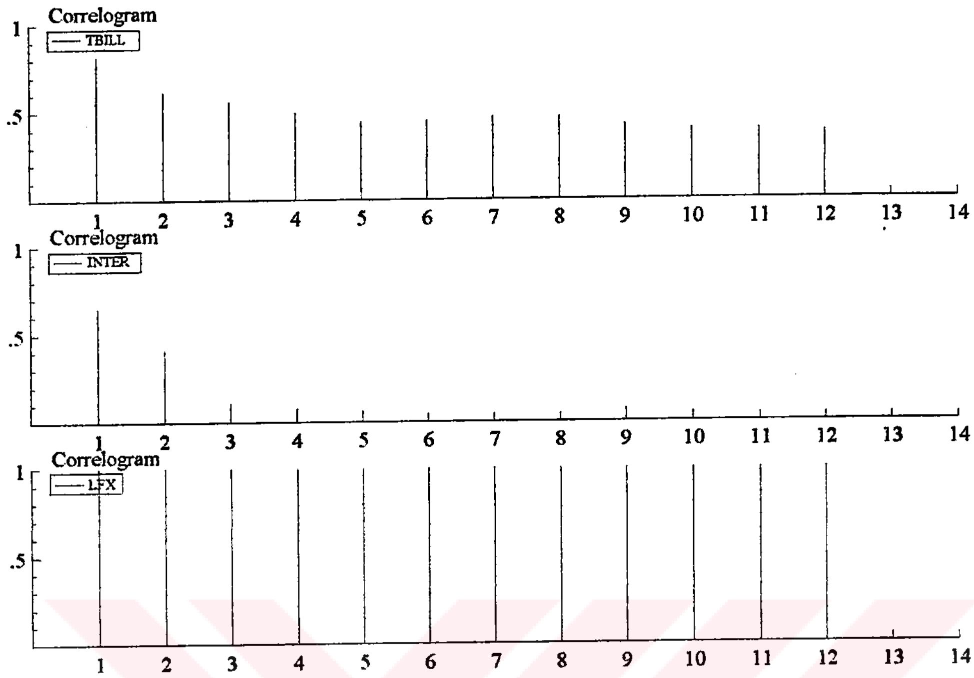
Figure 3.2.1: TBILL, INTER and LFX Against Time



A first glance at the graphics give the impression that the variables have moved to a higher level in 1994 and they follow a more stable path after the second half of 1994. This observation is considered in Chapter 4, in constructing the model.

Examining the ACFs can provide some more information that will guide us in the formal tests. Below; in Figure 3.2.2, are the autocorrelation functions of the series.

Figure 3.2.2: Autocorrelation Functions



INTER seems to be stationary and TBILL to have a deterministic component that slows down the decay of the ACF. LFX on the other hand is likely to have a unit root. This graphical analysis seems to advice some differencing on LFX.

3.3 Results of Unit Root Tests

In order to avoid overdifferencing, the exact order of integration will be established through formal tests. Below in Table 1 are the DF and Philips-Perron statistics for INTER, TBILL and LFX.

Table 3.3.1: Unit Root Tests

DF	INTER	TBILL	LFX	DLFX
τ_t (-3.45)	-4.313*	-4.524*	-1.607	-8.802
τ_{at} (3.11)	0.092	0.117	3.826*	-0.025
τ_{bt} (2.79)	-0.061	0.038	1.755	0.030
ϕ_3 (6.49)	9.2963*	10.1940*	5.7034	77.473*
ϕ_2 (4.88)	6.204*	6.8595*	126.44*	77.473*
τ_μ(-2.89)	-4.184*	-3.189*	1.525	-8.641*
$\tau_{a\mu}$(-2.54)	0.079	0.308	10.820*	0.02
ϕ_1 (4.71)	17.516*	5.1353*	120.71*	74.665*
τ (-1.95)	-1.908	-0.991	11.031	-5.366*
pp(-2.89)	-41.298*	-19.449*	0.446	-96.501*

Notes: No serial correlation in the error term was observed for the DF equations. (*) denotes the rejection of the null hypothesis at the 5% level. In parentheses are the 5% critical values for a sample size of 100.

Table 1 suggests that INTER~I(0), TBILL~I(0) with a drift and LFX~I(1). Thus in the VAR model, interbank interest rate and treasury bill rate will be used in levels and the first difference of the logarithm of the basket-exchange rate, i.e. the rate of devaluation of the TL against the USD-DM basket, will be used. Hereafter, the first difference of LFX, (LFX - LFX(-1)), is denoted as DLFX. The results indicate that we will not have to consider deterministic terms other than a drift in formulating the system.

CHAPTER 4

EMPIRICAL RESULTS

4.1 The Model

This chapter is devoted to presenting a VAR model for overnight interbank interest rates, average interest rate on treasury auctions and the rate of devaluation of TL against the foreign exchange basket of *USD* and *DM* for the period 1988M1-1997M12. Dynamic short term interrelations among the three will be investigated and the claim that the *CBRT* can use the interbank rate to mediate the financing requirements of the treasury and the stability of the FX market will be questioned. In this context, evidence on the short term independence of the interbank rate as a policy tool for controlling the exchange rate will be sought.

The use of the rate of devaluation of TL against the basket is required by stationarity concerns presented in Chapter 3. Moreover it is more consistent with the theory of interest rate parity.

In deciding on the appropriate lag length, tests of system reduction and information criteria as computed by *PCFIML* are used. These are given in Table 4.1.1 and Table 4.1.2, below.

Table 4.1.1: Information criteria

system	lag	log-likelihood	SC	HQ	AIC
6	2	-34.46552	4.1543	2.9427	1.6155
5	3	3.11263	3.8625	2.5210	0.9444
4	4	34.95252	3.6731	2.2018	0.3759
3	5	54.08356	3.7106	2.1095	0.0342*
2	6	88.51834	3.4748*	1.7439*	0.4193
1	7	101.42754	3.6235	1.7628	0.1888

Note: (*) denotes the selected model.

Table 4.1.2: Tests of system reduction

System 5 --> System 6:	F(9, 192) =	6.7876 [0.0000]	*
System 4 --> System 6:	F(18, 215) =	6.5833 [0.0000]	*
System 3 --> System 6:	F(27, 213) =	5.6901 [0.0000]	*
System 2 --> System 6:	F(36, 207) =	6.3582 [0.0000]	*
System 1 --> System 6:	F(45, 199) =	5.6099 [0.0000]	*
System 4 --> System 5:	F(9, 185) =	5.4128 [0.0000]	*
System 3 --> System 5:	F(18, 206) =	4.3647 [0.0000]	*
System 2 --> System 5:	F(27, 205) =	5.2085 [0.0000]	*
System 1 --> System 5:	F(36, 198) =	4.4792 [0.0000]	*
System 3 --> System 4:	F(9, 177) =	2.9774 [0.0025]	*
System 2 --> System 4:	F(18, 198) =	4.4370 [0.0000]	*
System 1 --> System 4:	F(27, 196) =	3.6463 [0.0000]	*
System 2 --> System 3:	F(9, 170) =	5.4459 [0.0000]	*
System 1 --> System 3:	F(18, 189) =	3.6772 [0.0000]	*
System 1 --> System 2:	F(9, 163) =	1.8017 [0.0715]	

Note: (*) denotes significance at 5% level. In parentheses are p-values.

Although *AIC* selects system 3 with 5 lags, *SC* and *HQ* select system 2 with 6 lags and the *F* approximation to the *LR* test given by *PCFIML* does not accept the reduction by 9 parameters for eliminating lag 6. Thus 6 is the appropriate lag length for the system. Accordingly the analysis starts with a VAR(6) model of INTER, TBILL and DLFX.

The deterministic part of the model consists of a set of seasonal dummies and 10 dummies on observations for which the error lies outside two standard deviations, in addition to a constant. The outlying observations are 1988M11, 1989M8, 1989M10, 19891M12, 1991M3, 1991M4, 1994M1, 1994M3, 1995M9 and 1995M12. They are consequences of the fact that financial markets are highly sensitive to developments outside these markets. The first quarter of 1994 is a period of turmoil in the financial markets, while second half of 1995 is unstable due to uncertainty brought about by economic and political developments including the public employee strike of September and the general elections of December.

The results of the OLS estimation of the model are given in Table 4.1.3.

Table 4.1.3: Unrestricted VAR Coefficients

Lags	INTER		DLFX		TBILL	
	Coef.	t-prob	Coef.	t-prob	Coef.	t-prob
INTER_1	0.5811	0.0000	0.0013	0.0000	-0.1465	0.0118
INTER_2	0.0029	0.9556	-0.0011	0.0000	0.3912	0.0000
INTER_3	-0.2005	0.0018	0.0000	0.7678	-0.0090	0.9237
INTER_4	0.0994	0.1417	0.0002	0.2298	-0.4584	0.0000
INTER_5	0.1251	0.0750	0.0000	0.8662	0.3402	0.0018
INTER_6	-0.0782	0.1242	-0.0002	0.2618	-0.1924	0.0138
DLFX_1	213.7900	0.0000	-0.0209	0.7973	281.6600	0.0000
DLFX_2	18.4890	0.6760	0.0164	0.8884	-15.7070	0.8146
DLFX_3	5.6905	0.8909	0.1605	0.1459	21.8520	0.7282
DLFX_4	1.8618	0.9646	-0.0641	0.5636	59.1350	0.3538
DLFX_5	-123.320	0.0016	-0.0380	0.7026	84.2530	0.1426
DLFX_6	-20.5910	0.5582	0.1819	0.0531	-68.1190	0.2031
TBILL_1	-0.2465	0.0001	-0.0005	0.0018	1.0334	0.0000
TBILL_2	0.3054	0.0011	0.0009	0.0002	-0.7194	0.0000
TBILL_3	-0.0250	0.7962	-0.0007	0.0062	0.5984	0.0001
TBILL_4	0.0453	0.6188	0.0003	0.2201	-0.2268	0.1030
TBILL_5	-0.1616	0.0304	-0.0002	0.2554	0.0477	0.6687
TBILL_6	0.1541	0.0001	0.0002	0.0342	0.1539	0.0061
Const.	19.9740	0.0000	0.0114	0.1795	1.2532	0.7953

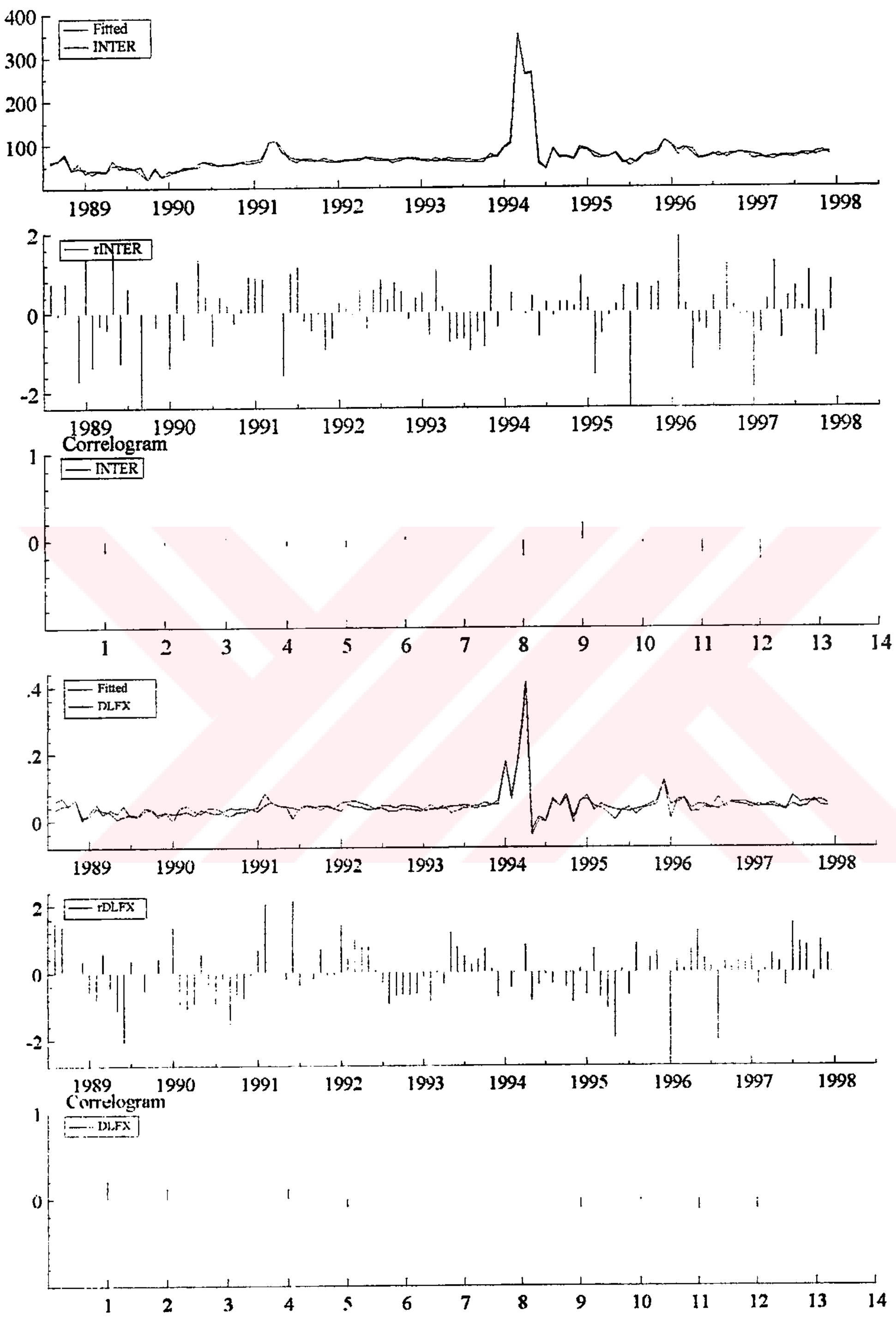
(Equation: INTER, DLFX, TBILL)

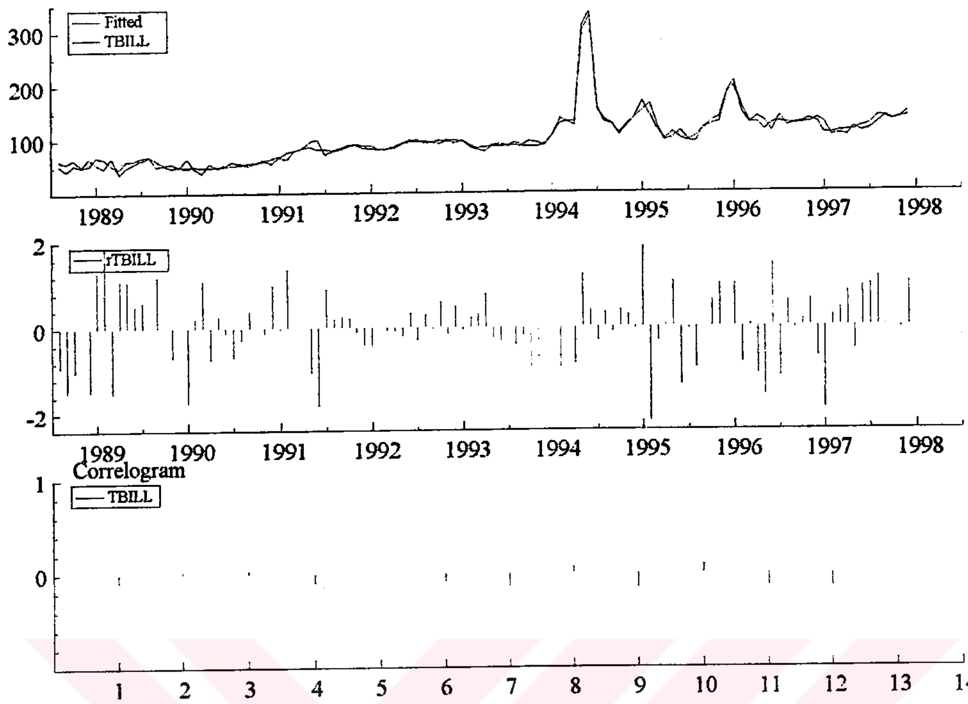
Note: Coefficients for deterministic regressors other than the constant are not given, since they are of little interest in the present context. It has been observed that outlier dummies are significant in all the equations, while seasonal dummies are effective in attaining the normality of DLFX residuals and the vector error.

The plot of actual and fitted values and residuals with their correlograms for individual equations are given in Figure 4.1.1.

In Table 4.1.4, the results of diagnostic tests and measures of goodness of fit are presented.

Figure 4.1.1: Goodness of Fit and Residual Graphics




Fitted
TBILL
300
200
100
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
rTBILL
2
0
-2
1989
1990
1991
1992
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1994
1995
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1997
1998
Correlogram
TBILL
1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14

Table 4.1.4: Goodness of Fit and Diagnostic Tests

	INTER	DLFX	TBILL	VAR
cor.actual& fitted	0.99193	0.95392	0.98465	
$\hat{\sigma}$	6.3222	0.016702	9.5778	
Portmanteau(12)	22.215	15.411	14.31	
$F_{ar}(7, 66)$	0.40505 [0.8959]	1.8273 [0.0966]	0.75856 [0.6237]	
$F_{arch}(7, 59)$	1.2126 [0.3103]	0.7746 [0.6109]	0.84374 [0.5559]	
$F_{het}(36, 36)$	0.62583 [0.9177]	0.45939 [0.9890]	1.0155 [0.4817]	
$\chi_{nd}^2(2)$	4.675 [0.0966]	4.497 [0.1056]	1.7458 [0.4177]	
Vect.Port.(12)				121.64
F^v_{ar} (63,150)				1.730 * [0.0036]
F^v_{het}(216,192)				0.4682 [0.0000]
$\chi_{nd}^{2v}(6)$				10.979 [0.0890]

Note: (*)denotes significance at 5% level. In parentheses are p-values. The tests presented above are, tests for autocorrelation, test for autoregressive conditional heteroscedasticity, test for heteroscedasticity, test for normality, while the last four are tests of autocorrelation, heteroscedasticity and normality for the vector. Detailed information on these tests can be found in the manual for *PCFIML*.

The results presented above suggest that the model is statistically satisfactory. The problem with the serial correlation in vector error is due to the period in question. Our experiments with additional lags and/or dummies did not give satisfactory results[1] .

Commenting on the basis of significance of the regressors and the correlation of actual and fitted values, we can say that the model fits the behavior of the series TBILL and INTER better than DLFX. The course

[1] Reduction tests were performed for all lags starting with 24; discontinuous combinations of lags that are feasible given the sample size were also tried, none helping to eliminate the serial correlation in the vector error.

of the series DLFX may be influenced by factors other than those entering the model.

For the period in question, we observe that, at the 5% level, interbank interest rate is explained by first and third own lags; first and fifth lags of the rate of devaluation; first, second and sixth lags of T-Bill rate and a constant.

In the equation for the rate of devaluation, only the first and second lags of the interbank rate in addition to the first, second, third and sixth lags of T-Bill rate are significant at the 5% level. It is observed that the rate of devaluation is not at all dependent on own past values.

The reason for the large coefficients of DLFX in the equations of INTER and TBILL is most probably variables missing from the model. It seems that DLFX plays an important role in INTER equation as in TBILL equation but not *vice versa*.

T-Bill rate is explained by first, second, third and sixth own lags, the first lag of the rate of devaluation and all the lags of the interbank rate except the third.

In Table 4.1.5, lag length dynamics, which give information on the possibility of reducing the system are presented.

Table 4.1.5: Lag Length Dynamics

	INTER	DLFX	TBILL
$F_{l=1}$ (3,71)	123.610 *	23.0343 *	58.1572 *
	[0.0000]	[0.0000]	[0.0000]
$F_{l=2}$ (3,71)	20.5432 *	0.0950115	16.5384 *
	[0.0000]	[0.9626]	[0.0000]
$F_{l=3}$ (3,71)	3.59474 *	1.06837	6.28956 *
	[0.0177]	[0.3681]	[0.0008]
$F_{l=4}$ (3,71)	9.23233 *	0.304174	1.20764
	[0.0000]	[0.8223]	[0.3133]
$F_{l=5}$ (3,71)	4.41611 *	5.53876 *	1.97310
	[0.0066]	[0.0018]	[0.1258]
$F_{l=6}$ (3,71)	3.90122 *	1.49709	9.72135 *
	[0.0122]	[0.2228]	[0.0000]

Note: (*)denotes significance at 5% level. In parentheses are p-values.

In spite of the existence of insignificant lags for individual equations, as indicated by Table 4.1.5 and probability values in Table 4.1.3, it is not possible to achieve further parsimony without destroying the lag structure and detoriating the diagnostics. Thus, this is, in fact, the optimal form of our model on which causality tests and innovation accounting will be performed.

4.2 Causality

The results of block causality or more appropriately block exogeneity tests are given in Table 4.2.1. Interpretation of the tests requires some attention, though. Although these are so-called causality tests, they are in fact tests of whether a variable improves forecasts of another one or a group of others, i.e. whether one *Granger-causes* the other(s).

Table 4.2.1: Tests of Block Causality

```
Wald test for testing zero restrictions on the lags of INTER
in the equations for TBILL and DLFX:
GenRes Chi^2(12) =      515.97 [0.0000] *

Wald test for testing zero restrictions on the lags of DLFX
in the equations for TBILL and INTER:
GenRes Chi^2(12) =      96.326 [0.0000] *

Wald test for testing zero restrictions on the lags of TBILL
in the equations for INTER and DLFX:
GenRes Chi^2(12) =      67.075 [0.0000] *

Wald test for testing zero restrictions on the lags of INTER
and DLFX in the equation for TBILL:
GenRes Chi^2(12) =      434.66 [0.0000] *

Wald test for testing zero restrictions on the lags of INTER
and TBILL in the equation for DLFX:
GenRes Chi^2(12) =      430.77 [0.0000] *

Wald test for testing zero restrictions on the lags of DLFX
and TBILL in the equation for INTER:
GenRes Chi^2(12) =      318.52 [0.0000] *
```

Note: (*) denotes significance at the 5% level. In parentheses are p-values.

The results given above suggest that a complex dynamic structure is present. It is not possible to catch clues on the interrelations between specific variables even on the basis of probability values. Lags of all three have significance in the other two equations but this reveals nothing in terms of the bivariate relations or the order of determination of the three. Thus we cannot find support for our previous finding regarding the exogeneity of DLFX within the test results reported in Table 4.2.1. Another point is that we cannot put forth any exogeneity claim for the interbank interest rate on the basis of these results. Neither can we draw clues for any alternative claim.

It should be noted, however, that the results presented in Table 4.2.1 can be misleading since the presence of autocorrelation in the vector error and a considerable number of outliers in our model may have influenced the tests.

4.3 Impulse Responses

Our investigation continues with impulse response analysis. The correlation of unrestricted form residuals given in Table 4.3.1, imply that the results of impulse response analysis for this model are likely to be sensitive to the order in which the three variables enter the VAR model. In order to avoid imposing theory-based restrictions which imply prejudices regarding causal relationships among the variables, it has been decided to order the variables on the basis of the date on which the unprocessed series, TBILL INTER and DLFX, take their extrema in the 1994 crisis; earliest being the first, next the second and last the last. The decision is made by careful examination of the series and their graphs in levels, where it has been observed that INTER takes its maximum value in 1994M3, DLFX in 1994M5 and TBILL in 1994M6. The order, as such, is INTER, DLFX, TBILL[2] .

---

[2] Our experiments with different orderings did not lead to significant differences in the response structure. In order to single out an ordering we have set the mentioned principle with the belief that order of determination in such a volatile period, when main policy systems were broken down

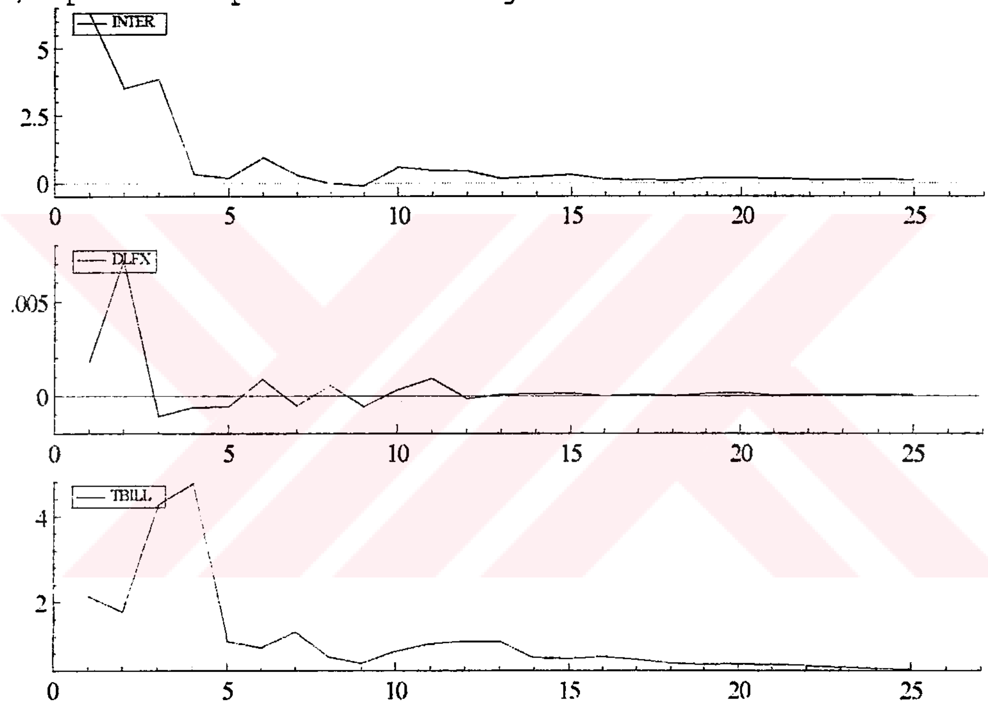
Table 4.3.1: Correlation of Residuals

	INTER	DLFX	TBILL
INTER	1.0000		
DLFX	0.10596	1.0000	
TBILL	0.22339	-0.39612	1.0000

Impulse responses over a horizon of 24 months are given in Figure 4.3.1, below.

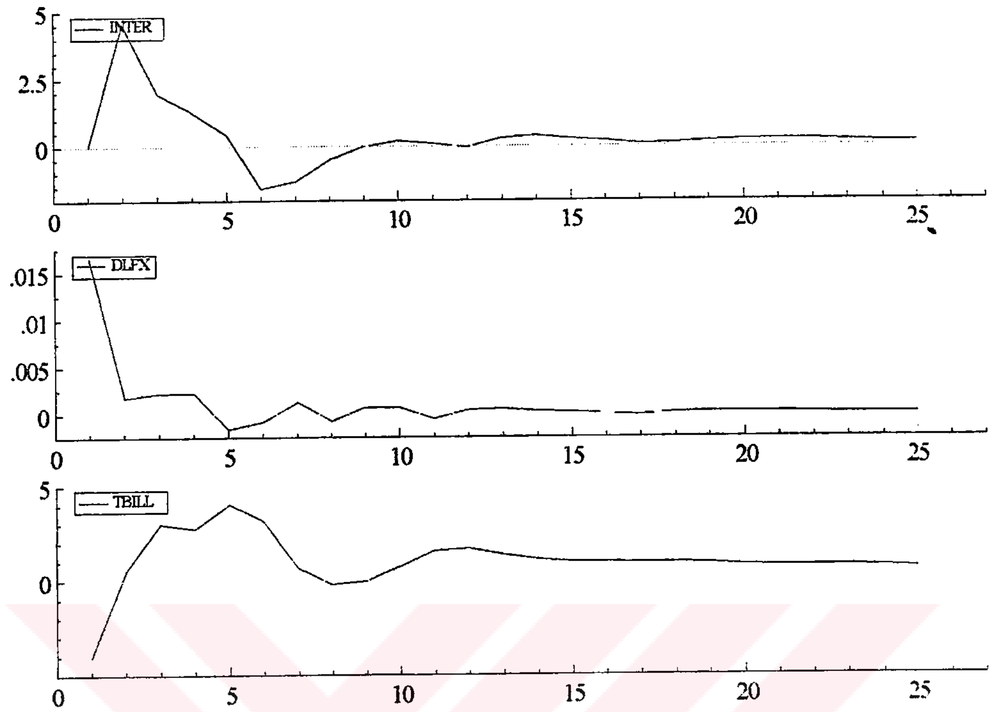
Figure 4.3.1: Impulse Responses

a) Impulse responses to orthogonal innovations in INTER

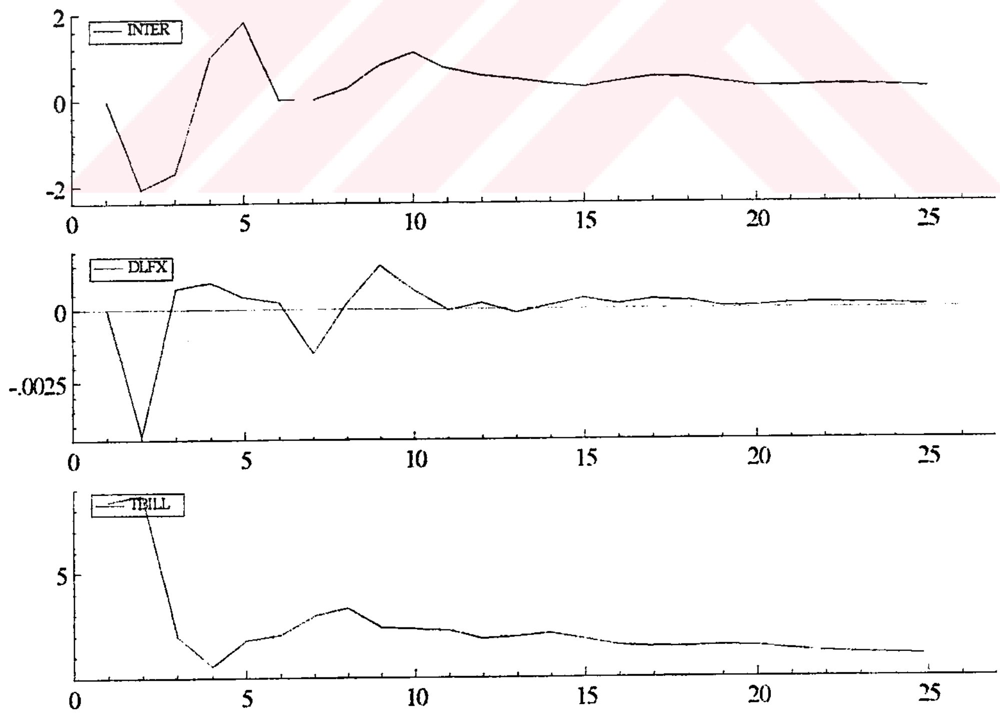


would be the best and least conditioning approximation to the appropriate ordering.

b) Impulse responses to orthogonal innovations in DLFX



c) Impulse responses to orthogonal innovations in TBILL



It is observed that a one-standard-error shock to the interbank interest rate dies down in approximately five months, with slight swings continuing until the thirteenth month after the shock. After that the interbank rate converges to its pre-shock level. In response to such a shock the rate of devaluation makes a sharp jump to an extremum in the second month. In the third month it reverts to its initial level and with slight swings until the thirteenth month, it converges to its pre-shock value. T-Bill rate responds with a fast upward movement after a lag of two months and reaches a peak in the fourth month following the shock. It converges almost completely to its pre-shock level in the fifth month with slight swings until the fourteenth month. On the whole, the effects of a shock to the interbank rate on all the variables die down within a year.

The consequences of an orthogonal innovation in the rate of devaluation seems to die away even more quickly. The shock itself fades away almost completely by the fifth month. The interbank rate reaches a peak in the second month and falls well below its initial value by the sixth month and starts recovering. In the ninth month, it stabilizes at its original value. The initial fall in the T-Bill rate in the first month is followed by a recovery until the fifth month when it reaches a maximum. With a slow decay until the twelfth month, it converges to its initial level.

A shock to the T-Bill rate almost dies away in the fourth month, while its asymmetric effects on the rate of devaluation and the interbank rate continue for about a year. In the second month both interbank rate and T-Bill rate reach their minimal value. After that the rate of devaluation stabilizes in the third month while the interbank rate moves to a maximum in the fifth month and stabilizes thereafter.

After shock adjustment in case of a shock to any one of the three variables in the system takes about a year, with little volatility in the second half of the year.

4.4. Forecast Error Variance Decompositions

Further information on the interaction among the three variables can be gained from the examination of the decomposition of forecast error variances. Below in Table 4.4.1, variance decompositions based on the same ordering as for impulse responses, over a horizon of 24 months are given.

Table 4.4.1: Forecast Error Variance Decompositions

a)Decomposition of Variance for Series INTER

Step	Std Error	INTER	DLFX	TBILL
1	5.081461367	100.00000	0.00000	0.00000
2	7.069934050	67.71588	26.72457	5.55954
3	7.999090967	67.91976	24.77795	7.30229
4	8.110032083	66.17991	25.69338	8.12671
5	8.250594345	63.98052	24.99766	11.02182
6	8.383711378	62.80274	26.52233	10.67493
7	8.453844044	61.83471	27.66674	10.49855
8	8.465967227	61.65798	27.81281	10.52921
9	8.491574017	61.29452	27.64562	11.05986
10	8.553079760	60.73045	27.27891	11.99064
11	8.581349706	60.51901	27.10897	12.37202
12	8.601130570	60.42090	26.98662	12.59248
13	8.613672603	60.26990	26.97679	12.75331

14	8.626647637	60.13468	27.03145	12.83387
15	8.635660802	60.08458	27.03840	12.87702
16	8.644417538	59.98065	27.01978	12.99958
17	8.654910201	59.84784	26.95943	13.19273
18	8.665187200	59.71391	26.90424	13.38185
19	8.673411983	59.63238	26.87753	13.49009
20	8.679328490	59.57982	26.87937	13.54080
21	8.685639004	59.51403	26.89092	13.59505
22	8.692161361	59.43773	26.90040	13.66187
23	8.698024546	59.37107	26.89517	13.73376
24	8.702682055	59.32133	26.88585	13.79282

b)Decomposition of Variance for Series DLFX

Step	Std Error	INTER	DLFX	TBILL
1	0.013424340	1.12267	98.87733	0.00000
2	0.015106409	15.65074	78.95159	5.39767
3	0.015247884	15.70933	78.85428	5.43639
4	0.015377332	15.54778	78.87608	5.57614
5	0.015442804	15.50853	78.91634	5.57514
6	0.015475048	15.64530	78.78702	5.56768
7	0.015563803	15.55313	78.32262	6.12424
8	0.015583154	15.60548	78.27606	6.11846
9	0.015647789	15.57412	77.75642	6.66946
10	0.015667645	15.55673	77.68596	6.75731
11	0.015690110	15.72722	77.53432	6.73845
12	0.015694224	15.72594	77.52994	6.74413
13	0.015699682	15.71601	77.54006	6.74393
14	0.015700970	15.71533	77.53904	6.74563
15	0.015704633	15.71231	77.51393	6.77377
16	0.015705125	15.71132	77.50942	6.77926
17	0.015707418	15.70772	77.49137	6.80091
18	0.015709022	15.70453	77.47925	6.81622
19	0.015709918	15.70580	77.47756	6.81663
20	0.015710872	15.70993	77.47326	6.81681
21	0.015711962	15.70787	77.46976	6.82236
22	0.015712737	15.70698	77.46356	6.82946
23	0.015713373	15.70621	77.45810	6.83569
24	0.015713821	15.70640	77.45451	6.83908

c)Decomposition of Variance for Series TBILL

Step	Std Error	INTER	DLFX	TBILL
1	7.69813911	4.99010	17.82275	77.18715
2	10.50357117	4.54244	9.71954	85.73802
3	11.42214990	12.85543	12.64935	74.49523

4	12.26037688	20.95135	14.25696	64.79170
5	12.79959411	19.68718	19.61356	60.69926
6	13.16199422	18.94343	22.12595	58.93062
7	13.42311021	18.81746	21.43003	59.75251
8	13.69250681	18.26274	20.60905	61.12820
9	13.83034557	18.01109	20.20086	61.78806
10	13.98507674	17.85128	19.94567	62.20305
11	14.17935067	17.70604	20.17652	62.11744
12	14.34867441	17.66304	20.61919	61.71777
13	14.50024910	17.65894	20.76053	61.58054
14	14.63502909	17.48909	20.75745	61.75346
15	14.73951176	17.37891	20.75416	61.86693
16	14.82215025	17.34367	20.79766	61.85868
17	14.89640355	17.30161	20.86017	61.83821
18	14.96642799	17.23365	20.92624	61.84010
19	15.03673481	17.15840	20.96701	61.87459
20	15.10169140	17.10243	20.97270	61.92488
21	15.15611402	17.06239	20.98573	61.95187
22	15.20306429	17.03347	21.01817	61.94836
23	15.24564553	17.00206	21.06145	61.93649
24	15.28481918	16.97070	21.10397	61.92533

According to Table 4.4.1, at horizons within a year about 60% of the forecast error variance of the interbank rate is explained by own shocks, while shocks in the rate of devaluation start to explain 26% of the variance in the second period, continuing thereafter. This can be interpreted as an indication of the fast interaction the interbank rate and the rate of devaluation. T-Bill rate innovations have a stable share of about 10% after the fifth month.

For the rate of devaluation, 77% percent of the variance is explained by own innovations, while interbank rate innovations explain 15% of it. T-Bill rate has a constant small share of 6%. This supports our previous finding, based on the estimation results, on the relative exogeneity of the devaluation rate.

Interbank innovations gain this 15% explanatory power as early as the second period and continue in a stable fashion, which may mean that there are immediate and stable effects of interbank rates on the devaluation rate.

For T-Bill rate, innovations in the interbank rate explain 17% of the variance. Own innovations explain 60% of the variance over the horizon of two years. Innovations in the rate of devaluation have an explanatory share of 20%.

On the whole the rather small and unchanging share of T-Bill rate innovations in accounting for forecast error variances of the interbank rate and the rate of devaluation can imply that the latter two are rather exogenous with respect to T-Bill rate. The observation that only 60% of the variance of T-Bill rate is explained by own innovations is an indication of the fact that the movement of T-bill rate is contingent upon shocks to interbank interest rate and the devaluation of TL.

The forecast error variance decompositions presented above do not provide enough evidence to make such assertive statements regarding the relation between interbank rates and the rate of devaluation, as the interbank rate is exogenous relative to the rate of devaluation. What is clear is the existence of close interaction in the form of, possibly, a feedback type of relation.

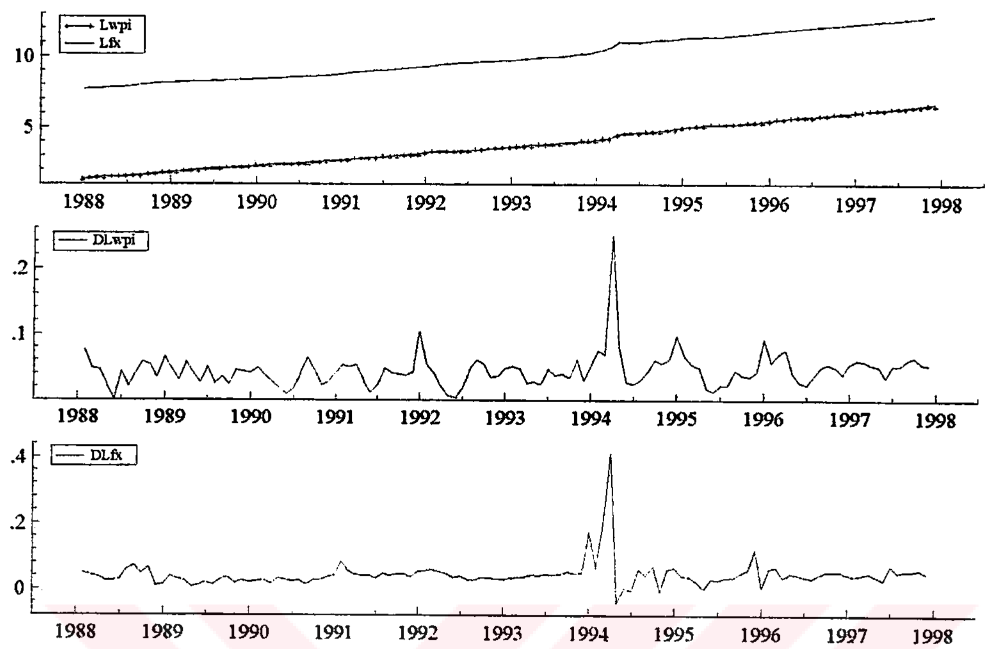
CHAPTER 5

CONCLUSION

The empirical results presented in Chapter 4 demonstrate that our model even at this highly simplified level is a satisfactory representation of the main relations in Turkish financial system.

In summary, our findings point to the fact that the rate of devaluation is influenced by factors other than the interbank interest rate and the interest rate on treasury auctions. The missing variable that would explain the behavior of the rate of devaluation is the inflation rate. Inflation is assumed to be determined exogenously for this system. It is well known that what the *CBRT* calls controlling the exchange rate is keeping to a purchasing power parity type of relation. This is depicted in Figure 5.1, where the logarithm of the wholesale price index with 1994 as the base year (LWPI), the logarithm of the nominal exchange rate basket of 1*USD+1.5*DM (LFX) and the two in first differences (DLWPI,DLFX) are plotted against time. Including inflation rate in this model would make it an altogether different exercise which is inconvenient for our previously stated purposes.

Figure 5.1 Inflation and the Rate of Devaluation



Although this simple model has not provided a yes-no type of answer to the question of short term independence of the interbank rate as a policy tool for exchange rate stabilization, we have observed that independent interbank rate impulses do have a stable and immediate effect on the devaluation rate. Thus the policy of inducing stability in the FX market by controlling short term liquidity via the interbank market, followed by the *CBRT* does have a basis which is supported by the data.

Another finding relates to the relation of domestic borrowing to the interbank interest rate and the exchange rate. We have observed that the interbank rate and the rate of devaluation are rather exogenous with respect to the interest rate on domestic debt, while the interest rate on treasury auctions receives considerable feedback from the two. This is representative of a situation where the treasury is ready and bound to borrow at any cost and accordingly it adjusts the interest to be offered to the conditions of the TL and FX markets. This is consistent with the fact that options of deficit financing alternative to domestic borrowing are not available or feasible for the public most of the time.

The model of Chapter 4 suggests an after shock adjustment path for the interbank rate, T-Bill rate and the rate of devaluation which is consistent with what has been observed in the Turkish financial system in 1994. Six months of volatility in financial markets, followed by more shallow movements for another six months is consistent with the 1994 experience.

Most probably, a more comprehensive model would be informative of other interesting relations. A model inclusive of variables representing other components of monetary policy (money supply, central bank reserves, interest rate on repurchase and reverse repurchase agreements, short term cash credits to the public sector, etc.); the external balance of the economy (external debt stock, average interest rate on external debt, maturity structure of external debt, short term capital inflows, etc.); other aspects of domestic borrowing (term structure, indexation, etc.); price movements; creditworthiness (international rating, financial fragility index, etc.) and certain political factors that effect budget performance, is a natural extension of this experiment. However in such a over-informative model it is not likely that bilateral interactions or a causal structure can be isolated. Such a model would probably be an adequate tool for forecasting.

An extension without changing the basic intention of this study, would be to keep on with this model and analyze the long run relations within the system. Our preliminary experiments in this respect, which are not reported here, reveal that such an exercise is likely to provide informative results.

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