ESTIMATING AND FORECASTING EXCHANGE RATE: COMPARISON OF STRUCTURAL AND VAR MODELS

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ABSTRACT

ESTIMATING AND FORECASTING EXCHANGE RATE : COMPARISON OF STRUCTURAL AND VAR MODELS

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The aim of this study is to compare the alternative exchange rate models according to their out of sample forecasting accuracy. For this reason three structural models of exchange rate have been developed under different assumptions and their time series representations have been utilized. Structural models of exchange rate are divided in to portfolio balance approach and monetary approach to exchange rate. Furthermore, these models are diversified according to the flexibility of prices in the short run and in the long run. For the time series representations of the vector autoregression models vector autoregression (VAR) and the Bayesian approach to vector autoregression models were used. In this context it has been shown that, in out of sample forecasts of short time horizons, Bayesian VAR models in general produce better forecasts.

Key Words: Exchange rate, Monetary approach, portfolio balance approach, purchasing power parity, vector autoregression models (VAR), Bayesian VAR models, out of sample forecasting, Theil U statistic.

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ÖZ

DÖVİZ KURU TAHMİN VE ÖNGÖRÜ ANALİZİ: VEKTÖR OTOREGRESYON (VAR) VE YAPISAL MODELLERİN KARŞILAŞTIRILMASI

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Bu çalışmada alternatif döviz kuru modelleri, öngörü başarısı açısından karşılaştırılmaktadır. Bunun için, farklı varsayımlar içeren üç yapısal döviz kuru modeli ve bu modellerin zaman serisi biçiminde formüle edilmiş yaklaşımları kullanılmıştır. Yapısal modeller, döviz kuruna potföy yaklaşımı ya da paracı yaklaşım olarak ayrılmakta ve bu modeller satınalma gücü paritesinin kısa ya da uzun dönemde geçerli olması varsayımlarına göre çeşitlendirilmektedir. Zaman serisi yaklaşımında ise vektör otoregresyon modelleri ve vektör otoregresyon modellerine Bayesci yaklaşım olarak şeklinde iki yöntem benimsenmiştir. Bu bağlamda, kısa dönemli döviz kuru öngörülerinde, Bayesci yaklaşımın vektör otoregresyon ve yapısal modellere göre daha iyi öngörüler türettiği gösterilmektedir.

Anahtar Kelimeler: Döviz kuru, döviz kuruna paracı yaklaşım, döviz kuruna portföy yaklaşımı, satınalma gücü paritesi, vektör otoregresyon modelleri (VAR), Bayesci VAR modelleri, öngörü, Theil U istatistiği.

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CHAPTER I

INTRODUCTION

In this study, the aim is to compare the forecast performances of three structural exchange rate models developed and intensively used in the economic literature, in the context of a Bayesian vector autoregression (VAR) model. ***" A vector autoregression model is a reduced form time series model of the economy that is estimated by ordinary least squares."*** [1]. A Bayesian VAR model further, is an extension of a VAR model, which is developed by assigning prior expectations on the coefficients of the variables in a model. In assigning prior expectations, our degree of belief about the significance of variables, in explaining the model's behaviour plays a crucial role.

Before estimating the exchange rate models with a Bayesian VAR approach, firstly a literature survey on exchange rate models is developed. There are basically two approaches to exchange rate models in the economic literature. First one is the monetary approach, which makes use of the purchasing power parity condition in explaining the behaviour of exchange rates, and the second one is the portfolio balance approach which emphasizes the importance of changes in current account for the behaviour of exchange rate. So in the context of these two approaches, the properties of three structural exchange rate models will be discussed. Among these three models, the Frankel-Bilson model, and the Dornbush-Frankel model are examples of the monetary approach with different assumptions about the flexibilty of prices. Also Hooper-Morton model will be explained for the portfolio balance approach which includes effects of the current account [2].

After the literature survey about exchange rate models, the theoretical background and properties of VAR models and in particular Bayesian approach to VAR models will be discussed. In building the three alternative VAR models for exchange rate determination and forecasting, we will make use of the three structural models discussed above.

Prior to forecasting the alternative VAR versions of alternative exchange rate models, the insample estimation properties will be analysed in order to clarify the significance of the exchange rate models, and whether they are improved by using VAR approach.

Finally, the out of sample forecasting performances of the structural models and the VAR models will be presented. Furthermore the VAR models, which are assigned prior distributions on their coefficients in the context of a Bayesian VAR approach will be presented. Then, in order to compare the forecast performances of the models, forecast errors and statistics concerning three different exchange rate models will be utilized and the applicability of these models to Turkey will be investigated.

NOTES

1. Keating (1992,37)

2. For the Frenkel Bilson model, Dornbush Frankel model and the Hooper Morton model see Meese and Rogoff (1983, 5)

CHAPTER II

STRUCTURAL EXCHANGE RATE MODELS

2.1 Introduction

There are several papers in the economic literature (Cornell (1977), Mussa (1979), Frenkel (1981)) concluding that exchange rates are largely unpredictable. Mc Donald and Taylor(1991) argue that:

"....the economics of exchange rates is also one of the least successful areas of economics in the sense that there is still virtually no consensus on the determinants of exchange rates and, moreover, few if any of the theories which have variously been proposed have withstood close empirical examination."

There are mainly two approaches to exchange rate, which are the monetary approach and the portfolio balance approach. In these models, monetary model focuses on equilibrium in money market and assumes that financial assets of two countries are perfect substitutes. Portfolio balance model relaxes the assumption of perfect substitutability. Also, these two models have extensions according to different assumptions about the speed of adjustment in the goods and money market (or financial asset market) as the exchange rate will be determined as a result of the clearing of both goods and money market. When prices are fixed in the short run (sticky price models), adjustment in both markets occur through changes in real output. However, when prices are flexible in the short run that is purchasing power parity always holds, the price level adjusts in order to clear the market (flexible price models). Furthermore, there are some special models which incorporate both the features of monetary model and portfolio balance model so as to combine the special effects of these two models on exchange rate.

Here in this chapter, in the discussion of alternative exchange rate models, we will refer to the arguments and theories developed by Murphy and Duyne (1980), Mussa (1979), Mc Donald and Taylor (1991), Bilson (1979), Frankel(1979) and finally Dornbusch (1976). Also after the discussion of the theoretical background of monetary and portfolio balance approach, the development of emprical exchange rate models will be demonstrated and they will further be used in the estimation and comparison of exchange rate models.

2.2 Theoretical Background of Exchange Rate Models

In the Mundel Flemming model the equilibrium exchange rate is determined by the equilibrium in the money market , goods market and the balance of payments which is zero under the assumption of flexible exchange rate (free float). The importance of the Mundel Flemming model was the introduction of asset markets and capital mobility to open economy. But however, it was only in terms of flow equilibria, that is imbalances in the current account were offset by capital account through capital flows.

2.2.1 Monetary Approach

The monetary approach to balance of payments introduced the concept of stock equilibria, by considering the money stocks and the demand for money in two countries as determinants of exchange rate which is the price of one countries money in terms of the other. In the monetary approach, equilibrium is reached through the money market. Here, bonds of two countries are assumed to be perfect substitutes. Generally, monetary models of exchange rate differ according to the speed of adjustment in prices. In this context we will present two alternative monetary models assuming flexible and sticky prices in the short run.

2.2.1.1 Flexible Price Monetary Model (FLPM)

In flexible price monetary model, it is firstly assumed that purchasing power parity always holds and there are stable money demand functions. Also as mentioned before bonds of both countries are perfect substitutes. The monetary equilibrium in domestic and foreign countries and the purchasing power parity condition (PPP) are given below: In logarithmic form:

$$md = p + ay - br \qquad (1)$$

$$md* = p * + a * y * - b * r* \qquad (2)$$

$$md = ms, \quad md* = ms* \qquad (3)$$

$$s = p - p* \qquad (4)$$

Where p and $p*$ are the logarithm of the price levels, y and $y*$ are the logarithm of real incomes, r and $r*$ are are the level of nominal interest rates of domestic and foreign countries respectively. Equation (4) defines the purchasing power parity condition (PPP) where s is the logarithm of nominal exchange rate. Here, the logarithm of real exchange rate is zero ($q = s - p + p*$).

In the flexible price monetary model (FLPM), the effects of an increase in money supply is the depreciation of exchange rate. Also, an increase in nominal interest rates leads to a reduction in money demand which in turn leads to exchange rate depreciation. Finally, a relative rise in domestic real income creates an excess demand for the domestic money stock leading to a reduction in expenditures. As the purchasing power parity always holds, falling prices as a result of the cut in expenditures will lead to exchange rate appreciation.

2.2.1.1A Frenkel Bilson Model

The Frenkel Bilson Model [1] is a version of flexible price monetary models. In addition to the assumptions above, it is assumed that both countries are large and the goods produced domestically and foreign are perfect substitutes.

By combining (1), (2), (3), (4) above and assuming that $a = a*$ and $b = b*$, we arrive at the Frenkel Bilson model.

$$s = (m - m*) - a(y - y*) + b(r - r*) \qquad (5)$$

2. 2.1.2 Sticky Price Monetary Model

In order to improve the monetary model, sticky price monetary model (SPM) was developed mainly by Dornbush (1976) which did not assume continuous PPP and thus incorporated the overshooting of nominal and real exchange rate above their long run PPP levels.

Assumptions of the Dornbush model are as follows:

1. The country is small and it faces a given foreign interest rate with the given price of imports.

2. Prices and output are sticky in the short run but in the long run purchasing power parity (PPP) holds.

3. Bonds of both countries are assumed to be perfect substitutes, while the goods produced domestically and foreign are not perfect substitutes.

4. Also there is the assumption of uncovered interest rate parity condition (UIP), which means that the expected exchange rate depreciation is equal to the interest rate differential of two countries:

$$\dot{s} = r - r^* \tag{6}$$

Where $\dot{s}$ is the expected rate of depreciation, and r and r^* are the respective interest rates of both countries. Furthermore under the assumption of rational expectations the expected rate of depreciation is equal to the actual rate of depreciation.

5. Finally, since PPP does not hold in the short run Dornbush differentiates the long run equilibrium exchange rate with the current exchange rate as:

$$\dot{s} = n(\bar{s} - s) \qquad (7)$$

That is, expected rate of depreciation is proportional to the difference between the long run equilibrium exchange rate ($\bar{s}$) and the current exchange rate.

Dornbush model also incorporates the money market, goods market and the excess demand equation to the exchange rate model. To summarize the Dornbush model [2] we have:

$$\dot{s} = r - r* \qquad (6)$$

$$\dot{s} = n(\bar{s} - s) \qquad (7)$$

$$md = p + ay - br \qquad (8)$$

$$\ln D = c + d(s - p) + ey - fr \qquad (9)$$

Demand for goods depend on relative price of domestic goods, real income and interest rate.

$$\dot{p} = g(ED) = g(\ln D - y) \qquad (10)$$

Where $\dot{s}$ is expected exchange rate depreciation, $\bar{s}$ is the logarithm of the long run equilibrium exchange rate, *md*, *p*, *y* are the logarithm of money demand, price level and real income respectively. Also, *ED (ED=lnD - y)* and *lnD* are excess demand and the logarithm of demand for domestic output respectively. An increase in the price of domestic goods ($\dot{p}$) is proportional to excess demand.

Overshooting in the Dornbush model occurs as follows:

Suppose there is a reduction in the money supply. Since prices are sticky, real money supply will fall increasing the interest rates. Then higher interest rates will induce capital inflow which will in turn appreciate the exchange rate. However, according to the uncovered interest parity (UIP) condition, the foreign investors will be aware of the fact that they are artificially forcing up the exchange rate, and they will expect the exchange rate to depreciate. However, as long as the interest rate differential is greater than the expected rate of depreciation there are gains from investing in domestic country. So, foreign investors will continue to buy domestic currency until the expected rate of depreciation is equalized with the interest rate differential (i.e the capital market gain) between the two countries. As a result the exchange rate will overshoot its PPP level in the short run. In the medium run, prices begin to fall because of the initial cut in the money supply (people will reduce expenditures). As prices fall, the real money supply will increase which will in turn reduce the interest rate. Finally, the reduction in interest rate will cause exchange rate to depreciate to its long run PPP level.

2.2.1.2A Dornbush Frankel Model

The Dornbush Frankel model [3] is developed by the addition of several assumptions by Frankel. In fact, Frankel developes a model which combines some features of the Dornbush model and the Frenkel Bilson model. Like the Frenkel Bilson model, he drops the small country assumption. Like the Dornbush model, he assumes that the prices are sticky and output is fixed in the short run and PPP holds only in the long run. Furthermore, Frankel also incorporates the impact of inflation differential to the expected rate of depreciation. That is:

$$\dot{s} = n(\bar{s} - s) + (\inf e - \inf e*) \tag{11}$$

Here *infe* and *infe** are the inflational expectations in the domestic and foreign countries respectively.

We know that expected rate of depreciation is proportional to the difference of the long run equilibrium and short run exchange rate in Dornbush. By the addition of inflational expectations the effect of the Dornbush model will be reinforced. For example, an increase in the money supply will increase real money supply and reduce interest rates in the short run. This will lead to exchange rate depreciation and the overshooting of long run equilibrium. But since money supply has been increased there will be expectations of inflation and the depreciation in the exchange rate will be greater. However, in the long run prices and interest rates will increase, inflational expectations will be reduced and the exchange rate will appreciate. The derivation of Dornbush Frankel model is represented in Murphy and Duyne (1980, 644). First we combine (1), (2) and (3) which are the domestic and foreign money demand respectively, and the PPP condition. Since here we differentiate between the long run equilibrium and short run exchange rates we write the PPP condition which holds in the long run as:

$$\bar{s} = \bar{p} - \bar{p}* \qquad (12)$$

So by combining (1), (2), (3) we have:

$$\bar{s} = (\bar{m} - \bar{m}*) - a(\bar{y} - \bar{y}*) + b(\bar{r} - \bar{r}) \qquad (13)$$

superscript "   " is for long run rates or values. By combining (13) with (11) and (6),

$$\dot{s} = n(\bar{s} - s) + (\inf e - \inf e*) \qquad (11)$$

$$\dot{s} = r - r* \qquad (6)$$

We have:

$$r - r* = n(\bar{m} - \bar{m}*) - an(\bar{y} - \bar{y}*) + nb(\bar{r} - \bar{r}*) - ns + (\inf e - infe*) \quad (14)$$

By assuming that equilibrium nominal interest rate differential is equal to expected inflation differential, i.e $\bar{r} - \bar{r}* = (\inf e - \inf e*)$ we arrive at:

$$s = (\bar{m} - \bar{m}*) - a(\bar{y} - \bar{y}*) + (1 + nb)/nb(\inf e - \inf e*) - 1/n(r - r*) \quad (15)$$

Here spot rate is determined by the difference of the logarithm of long run equilibrium money supply and real income, expected inflation differential and short term interest rate differential. Note that the effects of short term interest differential are opposite in the flexible price monetary model of Frenkel Bilson (see (5)) because in the Frenkel Bilson model, prices are flexible and PPP always holds. So, an increase in interest rates immediately increases prices and depreciates the exchange rate. However, in Dornbush Frankel model, increases in interest rates leads to appreciation in the short run.

2.2.2 Portfolio Balance Approach

In monetary models, only the equilibrium conditions in the money market is considered as these models assume perfect substitutability of domestic and foreign non-money assets which can be aggregated into a single asset namely bonds. But portfolio balance models (PBM) by relaxing the assumption of perfect substitutability, incorporates the effects of non-money assets in exchange rate determination, and in the long run they allow for wealth effects of current account. For example a surplus in the current account represents an increase in the net domestic holdings of foreign assets which effects the level of wealth and in turn level of asset demand and finally the exchange rate.

However, in the short run wealth is constant and exchange rate is determined by supply and demand in asset market. So the portfolio balance model incorporates the effects of current account, which is a proxy for foreign asset holdings. That is, current account reflects the accumulation of foreign asset holdings over time.

There are several models for portfolio balance approach to exchange rate with different assumptions for example: Kouri (1976), Isard (1978) and Branson (1977, 1979) [4]. As argued, in the portfolio balance approach, the short run exchange rate is determined by the equilibrium in the financial asset market, in which wealth is assumed to be fixed.

2.2.2A Branson Model

In presenting the portfolio balance approach, we take the Branson model as an example. Here, it is assumed that prices and output are fixed in the short run, and furthermore foreign money and bonds are aggregated to form a single composite interest bearing asset. Finally, it is assumed that domestic money and bonds are held only in the domestic country.

So, the exchange rate determination in the portfolio balance model is represented in Branson (1977) as:

$$W = M + B + SF \quad (16)$$

$$M = M(r, r*)W \quad Mr < 0, \quad Mr* < 0 \quad (17)$$

$$B = B(r, r*)W \quad Br > 0, \quad Br* < 0 \quad (18)$$

$$SF = F(r, r*)W \quad Fr < 0 \quad Fr* < 0 \quad (19)$$

Here, W is wealth and the model is homogeneous in real wealth and prices so that it is written in nominal terms. Also, expectations are assumed to be static which means that expected rate of depreciation is zero. M and B are demand for money and domestic bonds respectively. F is the level of foreign interest bearing composite asset held by the domestic private sector. S is the level of exchange rate.

Here an excess supply of money leads to an increased demand for foreign and domestic bonds. As a result, interest rates fall and exchange rate depreciates. An increase in domestic holdings of foreign assets, F, above equilibrium leads to an excess supply of foreign currency since foreign bonds will be sold, and leads to the appreciation of exchange rate. As the exchange rate appreciates, the value of foreign bonds in terms of domestic currency falls until the domestic value of the new level of foreign bond holdings is equalized with the initial value with interest rate unchanged.

Finally, when domestic holdings of domestic bonds increase, there will be an excess supply of domestic bonds forcing up the interest rate. Then, foreign bonds will be substituted by domestic bonds causing appreciation of exchange rate.

However, the wealth effect of the increase in domestic bonds may lead to an increase in the demand for foreign assets. So the result will depend on the degree of substitutability between domestic and foreign bonds. If they are close substitutes, the substitution effect will dominate the wealth effect and exchange rate will appreciate.

The results of a monetary policy in the portfolio balance model in the short run can be summarized as follows: An open market operation of government by increasing money supply through buying domestic bonds, will reduce the interest rates of domestic bonds (note that W is constant as increased money holdings will be equal to the reduction of domestic bond holdings) . The higher interest in foreign bonds will produce increased demand for foreign bonds, leading to exchange rate depreciation. Similarly, an open market operation by buying foreign bonds will lead to a fall in interest rate and exchange rate depreciation. But the effects of an open market operation by buying domestic bonds or foreign bonds will be different in the sense that, the fall in the interest rates will be larger and the depreciation of the exchange rate will be smaller in the case of open market operations through buying domestic bonds. The reason is that, the open market purchases of domestic assets effect the domestic interest rate directly while open market purchases of foreign assets effect the exchange rate directly.

Branson et al. (1977) estimates the portfolio balance model by ignoring the effect of an increase in domestic bonds which have ambiguous effect on exchange rate. The model is as follows:

$$S = a + bM + cM* + dCA + eCA* \qquad (20)$$

$$b>0, \quad c<0, \quad d<0, \quad e>0$$

Here, CA and $CA*$ are the cumulated current account surpluses of both countries to represent the total private stocks of net foreign assets. S is the level of exchange rate and M, $M*$ are money supplies for domestic and foreign countries respectively.

An increase in domestic money supply depreciates, and an increase in foreign money supply appreciates the exchange rate. Also an increase in home country supplies of foreign bonds appreciates, but an increase in foreign country supplies of domestic bonds depreciates the exchange rate. Finally, when we consider the dynamic adjustment in the portfolio balance model, we have to consider the wealth effects of the current account. Now, we have seen that a rise in the money supply would depreciate the exchange rate with sticky prices. But we can also say that a rise in the money supply would eventually lead to a rise in the domestic price level which in turn would effect net exports and have implications in the current account of the balance of payments. Finally, the level of wealth would be effected which feeds back to asset market and exchange rate behaviour. Now, we can define the current account as:

$$CA = TB(S/p) + r^*F \tag{21}$$

Here, TB is the trade balance which improves as exchange rate S depreciates or the prices fall assuming that the Marshall-Lerner condition holds. Also r^*F is the interest income from holdings of foreign assets.

To see the long run effects of an open market operation through buying bonds, first assume that the current account balance is zero with a zero trade balance initially. Now, we know that an open market purchases of domestic assets immediately depreciates the exchange rate. Assuming that Marshall-Lerner condition holds, the depreciation will lead to a surpluss in the trade balance and hence a surpluss in the current account. So domestic residents will begin to acquire net foreign assets. Then as it was shown before, an increase in foreign assets will lead to an appreciation of exchange rate which will worsen the trade balance. Furthermore, because of the increase in the money supply, the price level will eventually rise causing a further deterioration of the trade balance.

So to summarize, at first the exchange rate will depreciate in the short run leading to a trade surpluss, bur however the exchange rate will begin to fall as holdings of foreign assets accumulate with a deterioratring trade balance.

Finally when the current account becomes zero again, then trade balance should go into deficit since the domestic wealth holders have now acquired foreign asset holodings and they are receiving r^*F amount of foreign income. Consequently, a deficit in trade balance requires a further appreciation in exchange rate. So we aso have another type of overshooting in the portfolio balance model; at first the exchange rate jumps immediately but in the longer run exchange rate appreciates slowly to its long run level.

2.2.2B Hooper Morton Model as a Synthesis of Monetary Approach and Portfolio Balance Approach

In exchange rate models, attempts have been made to combine the features of monetary and portfolio balance models in order to overcome their defects. The problem with monetary approach is the ignorance of imperfect substitutability of bonds, when especially the risk factor comes into picture. Also, the portfolio balance model has defects because of the formulation of static expectations, i.e. expected rate of depreciation is zero.

However, we should also note that there are rational expectation approaches to portfolio balance models which incorporate expectations about the future current account (Branson 1983, 1984). Hooper Morton attempted to form a synthesis of monetary and portfolio balance models of exchange rate. Firstly, they seperate the nominal equilibrium exchange rate to its relative price and real components:

$$\bar{s} = \bar{p} - \bar{p}* + \bar{q} \tag{22}$$

Here q is the equilibrium real exchange rate. It is also assumed that expected change in the equilibrium real exchange rate is zero, and q changes in response to unexpected shocks or news about current account:

$$\bar{q}_t = qo + \alpha \Sigma_{i=0}^{\infty}(CA_{t-1} - E_{t-i-1} CA_t) \tag{23}$$

That is the equilibrium real exchange rate in period t is a function of the initial rate (*q0*) and the cumulative sum of past unexpected shocks to the current account. Furthermore, in the Hooper-Morton model, the uncovered interest parity condition (UIP) is reformulated as:

$$r_t - r*_t - \dot{s}_{t+1} = \rho \qquad (24)$$

Where, ρ is a risk premium and it is assumed to be constant.

Now, by combining (11) with (24):

$$\dot{s}_{t+1} = n(\bar{s} - s)_t + (\inf e - \inf e*)_t \qquad (11)$$

and then substituting (13), (22), and (23)

$$\bar{s}_t = (\bar{m} - \bar{m}*) - a(\bar{y} - \bar{y}*) + b(r - r*) \qquad (13)$$

and reminding that $\bar{r} - \bar{r}*$ = *(infe - infe*)*, we arrive at the relation defining the exchange rate equation below [5].

$$s_t = (m_t - m_t*) - a(y_t - y_t*) + (\inf e_t - \inf e_t*) - c[(r_t - \inf e_t) - (r_t* - \inf e_t*)] + d\rho + \Sigma_{t=0}^{\infty}(CA_{t-1} - E_{t-1}CA_{t-1}) + \bar{q}0 \qquad (25)$$

The above formulation (25), which represents a synthesis of portfolio balance and monetary approaches is highly complicated. As it is difficult to formulate the unanticipated shocks to the trade balance and the risk premium, we estimate the Meese and Rogoff formulation of the Hooper-Morton model.

The Meese and Rogoff formulation is simply an extension of the sticky price monetary approach (Dornbush-Frankel model), by incorporating the effects of the current account. So by including the effects of the cumulative trade balances to equation (15), we arrive at the Hooper-Morton version developed by Meese and Rogoff:

$$s = (m - m^*) - a(y - y^*) - b(r - r^*) + c(infe - infe^*) - dTB + eTB^* \quad (26)$$

TB and TB* are domestic and foreign trade balances (surplus here) respectively. Surplus in domestic trade balance by creating an excess supply of foreign currency, leads to exchange rate appreciation, while a surplus in foreign trade balance leads to exchange rate depreciation. Here, in estimating the Hooper-morton model (26), since we will estimate and forecast the TL/$ rate, we will be using US trade balance for foreign trade balance.

In fact, one of the defects of using the current account or the trade balances as a proxy for foreign asset holdings is that, they are not bilateral. That is, in estimating the TL/$ rate we should in fact use the bilateral current account with USA in order to reflect the domestic holdings of USA assets, or the USA holdings of domestic assets.

Also when we consider the total USA holdings of foreign assets, the share of Turkey (as a foreign asset in USA portfolio) woud in fact be irrelevant (if we consider Turkey as a small country when compared with USA). So, we may expect the USA current account to be rather ineffective in determinig TL/$ rate. For that reason, we also estimate an alternative of the Hooper and Morton model by removing the USA trade balance and using the Turkish current account since it is available:

$$s = (m - m^*) - a(y - y^*) - b(r - r^*) + c(infe - infe^*) - dCA \qquad (27)$$

Here a surplus in Turkish current account is expected to appreciate, and a deficit is expected to depreciate the exchange rate.

2.3 Summary

We have three models which will be used as a basis for the estimation and forecasting of exchange rate for Turkey in the context of a vector autoregression (VAR) model. In fact, these models are nested in the Hooper Morton model:

1. Hooper Morton Model (Meese-Rogoff version)

$$s = (m - m^*) + a(y - y^*) + b(r - r^*) + c(infe - infe^*) + dTB + eTB^* \quad (28)$$

$a<0$, $b<0$, $c>0$, $d<0$, $e>0$ as TB is in deficit for USA and Turkey

1.a. Hooper Morton with Turkish Current Account

$$s = (m - m^*) - a(y - y^*) - b(r - r^*) + c(infe - infe^*) - dCA \quad (29)$$

$a<0$, $b<0$, $c>0$, $d<0$, $e = 0$

2. Dornbush Frankel Model

$a<0$, $b<0$, $c>0$, $d = 0$, $e = 0$

3. Frenkel Bilson Model

$a<0$, $b>0$, $c=0$, $d=0$, $e=0$

NOTES

1. For the Frenkel Bilson model see Meese and Rogoff (1983,5).

2. The equations of Dornbush model is explained in detail in Dornbush (1976).

3. For the Dornbush Frankel model see Meese and Rogoff (1983,5).

4. The portfolio balance models mentioned are discussed in detail in Murphy and Duyne (1980, 629-64327).

5. For the details of the development of Hooper-Morton model see Mc Donald and Taylor (1991,196).

CHAPTER III

STRUCTURAL VERSUS VAR MODELS

3.1 Identification Problem in Simultaneous Equations

Usually, economic theories developing structural models, make use of simultaneous equation systems as an efficient way of capturing the existing casual relations in the economic system.

A simultaneous equation system is composed of endogeneous (jointly dependent) and exogeneous (predetermined) variables, in which, the exogeneous variables becomes the cause of endogeneous variables.

Here, one problem of the simultaneous equation systems is that, the specification of economic models depending on a specific economic theory, may contain some relations which can lead to identification problems and necessitate modifications in estimation. A simple demand and supply model can be presented as an example of such condition: Consider a stochastic model in which *Qd* is the quantitiy demanded, *Qs* is the quantity supplied and *P* is the price of the good.

$$Qd_t = a + bP_t + v_t \qquad b<0 \qquad (1)$$

$$Qs_t = c + dP_t + u_t \qquad d>0 \qquad (2)$$

$Qs_t = Qd_t$ $\quad v_t$ and u_t are white noise

Here, for the model to be estimated consistently by least squares estimation, the exogeneous variables must be independent of the error terms. However, in the above model the exogeneous variable *Pt* is correlated with error terms *vt* and *ut*. It can be easily seen as:

$$P_t = (c/1-d) - (a/b-d) + (u_t/b-d) - (v_t/b-d) \qquad (3)$$

So, a random shock in disturbances will cause *Pt* to change. As a result there is a simultaneous equation bias in the model caused by the correlation of jointly dependent variables *Pt*, Q*dt* and Q*st* with the residuals *vt* and *ut*.

" Theoretical advancements were mainly concerned with the development of estimation methods which took account of the 'simultaneous equation bias' that resulted from the correlation of error terms with some of the exploratory variable in the model " [1].

It is seen that there is no possibility of estimating the coefficients of the demand-supply model by estimating the reduced form.

However, if the model is constructed as:

$$Qd_t = a + bP_t + eY_t + v_t \qquad (4)$$

$$Qs_t = c + dP_t + fP_{t-1} + u_t \qquad (5)$$

$$Qs_t = Qd_t$$

Then the model becomes identified with *Qt* and *Pt* endogeneous, *Yt* and *Pt-1* being exogeneous variables. Here, also it is possible to solve for the parameters of the model by estimating the coefficients of the reduced form which is derived in several econometric textbooks.

In a multi-equation modeling, as a result of the identification problem, some variables may be deleted from the model by imposing zero restrictions, or some other variables may be added in order to identify an economic model; as in the demand-supply model presented above.

In order to overcome the identification problem, some variables which are not considered in the economic model should be added or an economically meaningful variable should be deleted from the model. So in some cases the relations indicated by economic theory can not be tested exactly but a modification becomes necessary in estimation. This problem have been a critisizm for the simultaneous equation systems.

Another critisism for multi-equation modeling is, the division of variables as endogeneous and exogeneous variables. Why should a variable be determined outside the system (i.e. having been determined already for any time period of interest). For example, in the case of economic forecasting, in one (or more) step ahead forecasts of the endogeneous variables, one should have knowledge about the value of the exogeneous variable at time 't' (t+firtst in two step ahed or t+ith in i+1 step ahed forecasts) which may not be available. Othervise, the modeler must built another model to estimate the value of the exogeneous variable for period 't' (t+1 for one for two step ahed forecasts or t+i for i+1 step ahed forecasts). Then one would forecast the dependent variable conditional on the predictions of the exogeneous variable.

The VAR (vector autoregression) model overcomes the expense of applying zero restrictions on a multivariate model by removing the distinction between dependent and predetermined variables. So in a VAR model, the problem of conditioning a forecast on exogeneous variable does not exist since there are no apriori division of variables as endogeneous or exogeneous.

As a result: First, VAR models become capable of incorporating dynamic inter-relationships between time series variables. Second, models become closed by removing the distinction between exogeneous and endogeneous variables.

3.2 Restrictions Caused by Economic Theory

Litterman (1979, 4) argues that:

"The usual method of imposing restrictions seems to be to assume that no variables enter a particular equation other than those for which there is a particular economic theory to justify their inclusion".

A structural model relies on a particular economic theory in which all the variables entering the model justify the economic theory under discussion.

" Sims..... questioned the sense of developing sophisticated econometric models on the faundation of incredible identifying restrictions, from apriori theory, especially when many of these restrictions are of necessity untestable"[2].

So, the structural models contain exclusionary restrictions depending on the economic theory that they rely on. A model builder, at first, should make a subjective decision on the specific theory and casual relations among the several (sometimes opposing) theoretical models. As opposed to the structural approach, a Var model does not rely on a specific economic theory and assumes that:

"...... in general it is likely that movements of all variables may affect the behaviour of all other variables" *[3].*

That is in a VAR model, each variable of economic interest is dependent up on its own lagged values with the lagged values of every other variable in the system. Then each current variable in the model is regressed on all other variables lagged a certain number of times. Of course, it is not possible to include all variables in the system to a VAR model since the model becomes increasingly overparametrized.

" If each variable is allowed to influence every other variable with a distributed lag of reasonable length, without restriction, the number of parameters grows with the square of the number of variables, and quickly exhausts degrees of freedom" [4].

That is to say, a VAR model is also not free from prior restrictions as there are limits to the number of variables that can enter a model and the maximum number of lags depending on the range of data. So, prior to modelling, depending on general economic principles, some variables has to be excluded from the model. Furthermore, in econometric literature, there are also structural approachs to VAR models [5]

3.3 Characteristics of a VAR Model

A VAR model is a linear dynamic system generated by a stochastic difference equation, in which each variable is a linear function of its own lagged values, lagged values of other variables and a disturbance term [6].

A VAR model can be written as:

$$Yi_t = Ai + Bi_{11}Y1_{t-1} + Bi_{12}Y1_{t-2} + \dots\dots\dots + Bi_{1m}Y1_{t-m} + Bi_{21}Y2_{t-1} + Bi_{22}Y2_{t-2}$$

$$+ \dots\dots\dots\dots\dots + Bi_{2m}Y2_{t-m} + \dots\dots\dots\dots Bi_{n1}Yn_{t-1} + \dots\dots\dots + Bi_{nm}Yn_{t-m} + ui_t$$

$$i = 1 \dots\dots\dots\dots\dots n \qquad (6)$$

Here *Yit* is a vector of dependent variables, *Ai* is the vector of deterministic variables, *Bikj* is a vector of coefficients such that :

Each *Bikj* is the coefficient of the variable *Ykt* lagged *j* times (i.e. *Yk*(*t-j*)) for each equation i. Finally uit is the vector for the disturbance term which are white noise.

Litterman (1979, 5-6) arques that in a Hilbert space; i.e. any complete space with norm defined by inner product having the following properties:

1. $(X + Y)Z = XZ + YZ$
2. $(aX)Z = aXZ$
3. $XY = YX$
4. $X \neq 0 \ XX > 0$

with stationary series and zero mean covariance stationary process; a linear peojection operator can be defined such that the linear projections of Yt on the spaces spanned by the sets,

$$\{ Yt\text{-}1\}, \{Yt\text{-}1,\ Yt\text{-}2\}, \ldots\ldots\ldots\ldots \{Yt\text{-}1,\ Yt\text{-}2, \ldots\ldots Yt\text{-}n, \ldots\ldots\}$$

(i.e. sets of lagged values of Yt) converge to a random variable $\hat{Y}_t$. Furthermore, the projection based on a finite past can approximate the projection based on infinite past. So, a model with finite lag can approximate the infinite lag. In fact, according to a theory of Wold [7] any stationary stochastic process can be divided into a deterministic and non deterministic component such that, the non-deterministic part can be represented as a moving average. Furthermore, if the mooving average component is invertible, then the stationary stochastic process can be approximated by finite order autoregrassions; which is the case for VAR model.

Furthermore, in Litterman(1979, 9-11), it is shown that maximum likelihood estimation of a VAR model is the same as minimizing the sum of squared residuals in each equation seperately. That is to say, we can estimate the VAR model by ordinary least squares equation by equation, by using finite order lags, according to Wold's arqument.

NOTES

1. Charemza, Deadman (1992,181).

2.Clements, Mizon (1990, 4).

3. Litterman (1979).

4. Sims (1980,16).

5.Keating (1992).

6. The properties and the estimation techniques are largely discussed in Litterman (1979, 5-15). Here, rather than the details, the results of these properties are presented with reference to Litterman(1979).

7. Wold (1954). also the Wold's arqument and its consequances are largely discussed in Litterman (1979).

CHAPTER IV

BAYESIAN APPROACH TO VECTOR AUTOREGRESSIONS

In estimating and forecasting a model, the forecaster may have personal beliefs about economic theory; the relations between economic variables and the economic system. Bayesian approach to forecasting is a way of combining personal beliefs with the data, in the context of an econometric model. That is, with the help of Bayesian approach, it is possible to effect the information coming from historical data by making use of the model builders' prior beliefs or expectations.

4.1 Effects and Uses of Prior Expectations in Estimating an Econometric Model

Bayesian approach may be effective in overcoming two problems of estimation: First one is the problem of choosing the variables to be included in the model.

That is the choice of restricting the coefficients of some variables to zero, prior to historical evidence.

" Econometric theory is the main source of priors in structural models, and these priors are built into the model by excluding most variables from most equations" [1].

So, in structural models, a model builder has to use his prior beliefs coming mostly from his theoretical knowledge and perspectives for deciding on a model and variables to be used in estimation.

When a structural model is selected among its rivals, it can be said that the variables contained in the rival models are treated as if their coefficients are restricted to zero. So, a choice of a model eventually brings out the prior certainity that the coefficients of the variables which are not captured in the selected model are zero regardless of historical evidence.

The prior beliefs and expectations are much more reduced in a VAR model; which relates the future values of a set of variables to their past values through lags of each variable, without the justification of economic theory. However, since it is not possible to incorporate all the economic variables in a VAR model, the model builder has to decide on choosing a set of variables to be used among all variables in the system depending on prior expectations. Although there are not so strict restrictions in a VAR model compared with structural models, VAR models often lead to problems of overparametrization because of so much variables and lags.

A Bayesian VAR (BVAR) model can be thought of as a bridge between VAR and structural models by the inclusion of prior expectations often formed by the information from economic theory. Structural models may be too rigid in the form of ignoring some variables and the possible relations that are not implied in the theory. Furthermore, sometimes the theory may be incomplete and lead to misleading results. But on the other hand, VAR models are free from economic theory and may incorporate so many relations.

On the other hand, VAR models have a drawback of overparametrization caused by including so many variables and furthermore they may also imply accidental relationships between variables because of the lack of theoretical insight.

BVAR models as a result, bring flexibility to structural models and they include prior expectations developed by economic theory to VAR models. That is, BVAR models combine theoretical expectations with unrestricted VAR models.

The second problem which may be eased by using Bayesian approach, is the problem of the relative significance of variables in a model and statistical procedures. It is clear that a modeler may have some prior expectations concerning the relative significance of each variable in the sense that, some variables may be expected to influence the dependent variable more srongly than the others. For example, in a VAR model, prior to estimation, it may be expected that the influence of the lags of the dependent variable may be reduced as the number of lags increase.

In unrestricted VAR and structural models, because of statistical procedures like OLS regression, the possible values of the coefficients are equally likely. But the modeler, however, may not expect all the values as equally likely: For example he may at least expect some coefficients to be negative or positive prior to estimation. Also, the econometric and statistical methods, may fit not only the structural relations but also the accidental effects and less important features of the data.

Furthemore, in order to estimate and forecast so many variables, a modeler has a restricted sample size and the choice of the sample period may effect the results. In a sample period there may have been some accidental or temporary effects influencing the relationships between the variables. As Todd (1984,6) puts it :

" The statistical procedure used to estimate the coefficients (OLS regression) picks values which best explain the available data, data in which the stable relationships among variables have been obscured by numerous random effects".

By BVAR approach, it is possible to incorporate the modelers prior expectations about the relative importance of variables and the expected structural relations among variables.

Finally, it can be said that, in unrestricted VAR and structural models there may be the problem of overfitting. This problem is solved by so many zero restrictions in structural models. However, in unrestricted VAR models there are no restrictions at the expense of overparametrization. BVAR models on the other hand, reduce the problem of overfitting, not by applying zero restrictions on coefficients but by controlling the data's influence on the variables.

4.2 Application of Priors to Var Models

In general the Bayesian approach to vector autoregressions is the method of assigning prior distributions on parameters (θ) which explain the model, in order to obtain the posterior distribution $\hat{\theta}$ for θ .

In Larson (1982,552) the prior distribution of a parameter θ is defined as:

"......a probability function or probability density function expressing our degree of belief about the value of θ, prior to observing a sample of a random variable y whose distribution function depends on θ".

Now, if we specify θ as the coefficients of the variables and specify a model conditional on the coefficients, we may also specify priors over θ conditional on a set of parameters (π). So that we have a prior distribution for θ(coefficients) conditional on our prior expectations namely π. We would also define this as a joint probability density function conditional on π, as:

$$p(y/\theta)q(\theta/\pi)$$

Then, as it is explained in Doan et all (1983, 4):

" We can in principle integrate p(y|θ) and q(θ|π) with respect to θ to obtain the marginal distribution for y given π, which we could call m(y|π)".

Now, we can treat m(y|π) as our model and we may use it to measure the fit of the model.

After defining the prior distribution, we can costruct the posterior distribution for θ. Posterior distribution will be the likelyhood function formed by the weighted average of the prior distribution function conditional on π.

As it is defined in Larson (1982,553):

" Posterior distribution is made up of both the subjective prior information about the parameter and the objective sample information. The posterior distribution then is used to construct an estimator of the unknown parameter".

When we come to assign Bayesian priors to our coefficients of the VAR model, firstly it is assumed that, all the coefficients of the VAR model are distributed as multivariate normal with mean $\bar{\theta}$ and variance covariance matrix Σp depending on the vector of prior parameters π [2].

Also by considering the random walk nature of the time series variables, it is assumed that $\bar{\theta}$ is equal to 'one' for the first own lag and zero for the lags of other variables. That is:

$\theta \sim N(1, \Sigma p)$ for the first own lag,
$\theta \sim N(0, \Sigma p)$ for lags of other variables.

Now, by variyng the size of the variances of the prior distributions, we may effect the posterior distribution $\hat{\theta}$. That is, if we are fairly sure about the parameters value, we choose a prior with a small variance, if we are less certain about its value we choose a prior with a larger variance. For example in our VAR model, if we specify a small variance for the lags of other variables, it means that we expect their coefficients to be close to zero and our equations will approach to a random walk model. But however, if we expect the other variables to be effective in determining the dependent variable, we assign large variances to other variables. Assigning a small variance is called as; thightening the prior, while assigning a large variance is called as; loosening the prior [3].

Furthermore, we can assign a decay parameter to the weights of the coefficients for larger lags: For example, we may expect the variables to be less effective as the lags increase or the periods get farther. So to summarize, we have three tools, namely the variances of the first own lag, variances of the other variables and a decay parameter determining the relative importance of the variables.

4.3 Application of Priors in Rats Program

For the explanations in this part we refer to Manual Rats 2.10 Large Memory Version Users' Guide (1987, Chapter 11).

The application of priors make use of the suggestions by Litterman (1979). There are some assumptions developed in assigning priors to coefficients of a model:

1. The priors for deterministic variables, (like constant and dummy variables) are assumed to be flat.

2. The distributions of priors assigned on coefficients are assumed to be independent and normal.

3. The means of prior distributions other than the first own lag are assumed to be zero.

Now, we determine, first, the mean of the prior distribution for the first own lag for each equation. Second we specify *S(i,j,l)* which is the standart deviation of the prior distribution of lag *l* of variable *j* in equation *i*:

$$S(i,j,l) = \{ \delta g(l) f(i,j)\} si/sj; \quad f(i,i) = g(1) = 1$$

δ = Overall tightness; standart deviation of the first own lag.

g(*l*) = Tightness of lag l relative to lag 1 (decay).

f(i,j) = Tightness of variable *j* in equation *i* relative to variable *i* (cross lag).

si = The standart error of the univariate autoregression on equation i.

So, we specify first the overall tightness δ i.e. the standart deviation of the first own lag. Then we specify the decay parameter. We may have two alternatives for the decay parameter:

1. $g(l) = l^{-d}$: Harmonic lagtype. For $d = 0$, there is no decay for increasing lags. As *d* gets larger we have a tighter prior for increasing lags.

2. $g(l) = d^{l-1}$: Geometric lagtype. For $d = 1$ there is no decay, and smaller values of *d* allow tighter priors.

Finally, we specify the cross lags. There are three choices in RATS for assigning cross lags. If we use a symmetric prior for cross lags, this means that we are assigning equal weight to all of the variables other than own lags and furthermore their weights may be reduced if we also substitute a decay parameter. If we use a general prior, this means that we can assign different weights to all of the variables other than own lags for each equation. Furthermore, we can also use circular type of priors for cross lags, which seperate the variables as the relatively more important ones in explaining the model (star variables) and the ones which are exogeneous to the system (circle variables)[4].

Now, to give an example, if we have:Type = symmetric, Cross lag = 0.5, Overall tightness = 0.1, Lagtype = Harmonic with decay = 2.0; then, this means that, the standart deviation of the first own lag is 0.1, there is harmonic decay with increasing lags such that d = 2.0, and lags of all other variables get half the weight of own lags (cross lag).

It can be seen that we can effect the significance and the effectivenes of all the variables in our models by assigning priors to means and standart deviations of the coefficients.

NOTES:

1. Todd (1984, 7).

2. The description of Bayesian priors are referred to Litterman (1979), Doan et all (1983), Todd (1983) in which the theoretical details, beyond the scope of this study,are developed.

3. Todd (1984,17).

4. Symmetric, general and circular type of priors are largely discussed in Rats Users' Manual 2.10 by Doan T.A. and Litterman R.B.(1987, Chapter 11).

CHAPTER V
THE MODEL, SELECTION OF DATA AND STATIONARITY ANALYSIS

5.1 The Model

The structural models were discussed and summarized in Chapter 1. In addition to that, we also present the six lag VAR representation of Hooper Morton, Dornbush Frankel and Frenkel Bilson models.

In the VAR representations of each alternative exchange rate model, we will have a system of equations. For example in the Hooper Morton model, we will have six equations defining; exchange rate, interest rate differential, differences in monetary aggregates, trade balances of the two countries and the differences in real income.

Each equation will incorporate six lags for each variable in the model and a constant. Now we present the vector autoregression model below:

$$s_t = A_{11}s_{t-1} + A_{12}s_{t-2} + \dots\dots + A_{16}s_{t-6} + A_{21}(\inf e - \inf e*)_{t-1} + \dots\dots + A_{26}(\inf e - \inf e*)_{t-6} + \dots\dots A_{31}(r - r*)_{t-1} + \dots\dots + A_{36}(r - r*)_{t-6} + A_{41}(m - m*)_{t-1} + \dots\dots + A_{46}(m - m*)_{t-6} + A_{51}(y - y*)_{t-1} + \dots\dots + A_{56}(y - y*)_{t-6} + \dots\dots + A_{61}(TB - TB*)_{t-1} + \dots\dots + \dots\dots + A_{66}(TB - TB*)_{t-6} + u1_t$$

$$(\inf e - \inf e*)_t = B_{11}s_{t-1} + \dots\dots + B_{21}(\inf e - infe*)_{t-1} + \dots\dots + \dots\dots + B_{61}(TB - TB*)_{t-1} + \dots\dots + B_{66}(TB - TB*)_{t-6} + u2_t$$

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$$(TB - TB*)_t = F_{11}s_{t-1} + \dots\dots + \dots\dots + \dots\dots F_{66}(TB - TB*)_{t-6} + u6_t \quad (1)$$

In (1), the VAR representation of Hooper Morton model is presented which utilizes the differences of trade balances of Turkey and USA in order to reduce overparametrization. By removing (TB-TB*) from (1) above, we arrive at the Dornbush Frankel model (VAR) and by removing (infe-infe*) further from (1), we get the VAR representation of Frenkel Bilson model.

5.2 Selection of Data

The models discussed above, require selection of (monthly) variables such as exchange rate, a proxy for long run inflationary expectations, short term interest rates, monatary aggragate, trade balance and income.

Firstly, the official exchange rate of CBRT (TL/$ selling rate) is used and forecasted in the model. In fact, the free market exchange rates should have been used in order to reflect the relations between the variables in the model more accurately. However, since Turkey has established the free exchange rate system in 1986, it was not possible to use free market rate as, the period beginning from 1986 would not be sufficiently long for estimation. In addition, up to 1993 11, the official rate was sufficiently close to the free market rate and it was possible to take the official rate as a reference to the free market rate.

Secondly, a decision on a proxy for the long run inflarionary expectations was necessary. By making use of the advices in Meese and Rogoff (1983,5), yearly pecentage changes in the wholesale price indices of Turkey and USA have been used for long run inflational expectations.

Third, time deposits with maturity of three moths have been used for Tukish short term interest rates and three month treasury bill rates have been used for the short term interest rates of USA.

Forth, for the selection of monetary aggregates, several monetary indicators have been considered. In the first place, M2Y for Turkish monetary aggragate and M2 for the USA monetary aggregate have been taken into account, as both include all sight and time deposits.

However, there was a problem with Turkish M2Y, as it also included foreign currency deposits which is in fact a part of the money supply of USA. But on the other hand, using M2 which includes only TL time deposits would be also misleading, as then, a seizable part of sight and time deposits would be ignored since the foreign currency deposits in Turkey is in considerable magnitude. The same problem, although less in significance, occurs with M1 since it only includes TL sight deposits. So, the following monetary indicators, which are, currency in circulation, reserv money, M1, M2 and M2Y have been experimented by their correspondances of USA monetary indicators, by analysing the insample estimation properties and forecast performances of the models. As a result, it was demostrated that by using M2Y for Turkey and M2 for USA, the in sample estimations and forecast performances of the models have been improved significantly. Also, in a period of significant currency substitution, changes in M2Y including foreign currency deposits could be effective in explaining exchange rate.

Fifth, it was mentioned before that, trade balances of both countries would be used as a proxy for current account. The reason is that, it was not possible to obtain mothly figures for the USA current account. So, the differences between exports (FOB) and imports (CIF) which were available for both countries have been used. However, for the model with Turkish foreign asset holdings only, the Turkish current account were used since it was available monthly.

Last, it was necessary to use a proxy for real GNP (national income), since it was not possible to obtain monthly GNP fiqures. For that reason, the monthly production indices for both countries have been used as a proxy for GNP.

Since a VAR model contains a considerable size of estimators and polinomial lags, it requires sufficiently large number of observations so as to prevent overparametrization. For that reason, monthly data have been used as of January 1982 to July 1993.

The reason the data is not lasting up to 1994 is that, firstly, it was not possible to find the most recent values of some US data like for example the US trade balance.

Secondly, the currency crisis which began in January 1994 would largely effect the forecast performances of the model since the relations between several markets in the economy have been ruined.

The forecast performances of the model also depends on the validity of the assumptions characterizing the three models discussed above. As the expectations, behavioral aspects, connections between the markets depending on relative yields, money demand functions have been adversly affected by the currency crisis, and speculative movements have been extended; we do not include this period in our analysis. So, our data lasts up to January 1993 which can be considered as sufficiently before crisis.

5.3 Stationarity Analysis

5.3.1 Theoretical Background

In estimating a model, firstly one should apply stationarity analysis in order to determine whether the series are deterministic or stochastic, as the appearance of nonstationarities in the data may lead to misleading results. A series is called stationary if it's mean and variance does not depend on time. A nonstationary time series data may depart from its mean and variance as time goes on. If this departure is consistently in one direction, then it can be said that the series exhibits a trend [1]. A nonstationary time series data may contain a deterministic linear trend, which can be made stationary by just detrending with a linear time trend, or it may contain a stochastic trend (that is the series exhibits a unit root) which can be made stationary by appropriate differencing.

A series with stochastic trend may become stationary by first differencing and seasonal differencing appropriate times. That is, if a series is integrated of order (d,D), then it can become stationary by first differencing d times and seasonal differencing D times (Pekka and Ilmakunnas (1990,79).

In this study, the order of integration considered is (*1,0*). That is, it is assumed that it will be enough to take the first difference of the data to make it stationary, in the case of an existence of unit root. The reason why seasonal unit roots are not considered, is that, too much differencing could be costly by complicating the analysis and reducing the explonatory power of the data.

In order to apply stationarity analysis, first a combination of the two kind of nonstationarity, i.e. stochastic and linear time trends are utilized as below [2], where $DYt = Yt - Yt\text{-}1$:

$$DYt = a + qt + bYt\text{-}1 + \Sigma DYt\text{-}i + ut \qquad ut \sim N(0,\sigma^2) \qquad (2)$$

in which, $\Sigma DYt\text{-}i$ is included for eror autocorrelation.
Here the null hypothesis for unit root is:

H0; $b = 0$; nonstationarity versus stationarity.

So, if we can not reject Ho then we conclude that there is evidence of unit root.

Now for testing for the unit root, we start from the general case and estimate equation (2) above [3]. After the estimation, we check for the unit root and the coefficients of constant and trend. The critical values computed for unit root tests can be faund in Dickey and Fuller (1976). If here, there is no unit root, but the coefficient of trend is significant then we conclude that the series exhibits a linear time trend. If however, trend is also not significant we conclude that the series is stationary. But if there is evidence of unit root with an insignificant trend, we drop it from the model and check for the unit root again (of course if constant is not significant, we drop it from the equation also). If there is still the evidence of unit root, then we conclude that the series is nonstationary and there is a unit root.

If however there is evidence of unit root with a significant trend, we again check for the significance of unit root, from ordinary t tables. If ordinary t tables do not indicate a unit root, then we conclude that the series exhibits a time trend. If however, there still the evidence of unit root in normal t tables, then we have a mixed case and the result is inconclusive.

5.3.2 Conclusion of Unit Root Tests

Unit root tests have been applied for all the variables in the model. In estimating the structural models we used the trade balances of Turkey and USA in Hooper Morton model. However, in estimating the VAR representation of the Hooper Morton model, in order to eliminate the overparametrization problem we assumed that the coefficients of the trade balances of two countries are equal. That is we utilized the difference of trade balances of Turkey and USA.

So, for the VAR approach, unit root test was applied to the difference of the trade balances, and for the structural model unit root tests were applied to trade balances seperately. Furthermore, we also applied unit root test to Turkish current account for the Hooper Morton model which incorporates only the Turkish current account. Variables are summarized as follows:

FX = logarithm of TL/$ selling rate; **DWPI** = difference between wholesale price indices of Turkey and USA; **DINT** = difference between the short term interest rates of Turkey and USA; **DM2Y** = difference between the logarithm of monetary aggregates of Turkey and USA; **DPROD** = difference between the logarithm of monthly production indices of Turkey and USA; **DTBAL** = difference between the trade balance of Turkey and USA, **USTBAL** = trade balance of USA; **TTBAL** = Turkish trade balance; **CABT** = current account balance of Tukey.

Now in the tables presented below: *DYt:* Represent the first difference of the dependent variable, *C* present constant, *T* present the linear time trend and *Yt-1* present the first lag of the dependent variable as in equation (2). The values in table are the respective coefficients of variables and the values in paranthesis are the respective critical values computed for unit root tests [4].

Table 5.3.2.1 Unit Root Tests (General Case)

DY(t)	C	T	Y(t-1)
FX	1.68 (3.09)	1.62 (2.79)	-1.54 (-3.43)
DWPI	1.49 (3.09)	1.66 (2.79)	-2.10 (-3.43)
DINT	2.05 (3.09)	2.28 (2.79)	-2.48 (-3.43)
DM2Y	1.61 (3.09)	1.52 (2.79)	-1.06 (-3.43)
DPROD	-0.94 (-3.09)	2.71 (2.79)	-2.42 (-3.43)
DTBAL	3.48* (3.09)	-2.36 (-2.79)	-2.66 (-3.43)
USTBAL	-2.85 (-3.09)	1.11 (2.79)	-2.72 (-3.43)
TTBAL	-0.28 (-3.09)	-3.04* (-2.79)	-3.27 (-3.43)
CABT	-0.015 (-3.09)	-0.987 (-2.79)	-3.48* (-3.43)
(*) Significant at %5 significance level			

In Table 5.3.2.1, the most general case, it is seen that except for CABT there is evidence of unit root since at the %5 significance level, since the coefficients of *Yt-1*'s are not significantly different from zero (if we refer to equation (1) the null hypothesis, H0:b = 0 can not be rejected). Also except TTBAL none of the variables exhibits a linear time trend. Current account balance of Tukey (CABT) is stationary. For Turkish trade balance (TTBAL) there is evidence of unit root but also trend is significant. So we check for the evidence of unit root from ordinary t table: Since the critical value is (-1.96) at %5 significance, we say that there is a linear time trend in TTBAL.

Table 5.3.2.2 Unit Root Tests (Without Trend)

DY(t)	C	Y(t-1)
FX	0.63 (2.53)	1.03 (-2.88)
DWPI	1.37 (2.53)	-1.34 (-2.88)
DINT	1.25 (2.53)	-1.06 (-2.88)
DM2Y	6.33* (2.53)	3.95 (-2.88)
DPROD	0.86 (2.53)	0.66 (-2.88)
DTBAL	2.57* (2.53)	-2.38 (-2.88)
USTBAL	-2.61* (-2.53)	-2.61 (-2.88)
(*) Significant at %5 significance level		

For the remainig variables, we drop the time trend and check for the existence of unit root again. The results are presented in Table 5.3.2.2. It is seen that there is evidence of unit root in all the variables in Table 5.3.2.2, since the null hypothesis of unit root can not be rejected. Furthermore, removing the constants which are not significant does not change the result also.

So, we conclude that CABT is stationary, there is linear time trend in TTBAL, and there is unit root in all the other variables. Then, while estimating; the level of CABT and TTBAL will be used and furthermore the first difference of other variables will be utilized in order to make them stationary. Finally a linear time trend will be added to the model when the Turkish trade balance (TTBAL) and the trade balance of United States are used seperately.

NOTES

1. For the details of unit root and stationary analysis we reference to Dickey and Fuller (1981), Blake (1991), Dolado et all (1990), Engle and Yoo (1987), Engle and Granger (1987).

2.Çalışır et all (1992,2)

3. The procedure of applying the test is demonstrated in detail in Dolado and Jenkinson (1987,13).

4. Fuller (1976) Table 8.5.2.

CHAPTER VI

IN SAMPLE ESTIMATION PROPERTIES AND DIAGNOSTIC TESTS

In Chapter 5 we summarized our models and applied stationary analysis to the data which will be used in the estimation of models. Our estimation period is from 1983-2 to 1993-6 with monthly data. Here now, we will represent the in sample estimation properties of the structural models under discussion and their VAR representation. We will use the first differences of the data which have unit roots and we will insert a time trend where the time series data indicate a linear deterministic time trend.

6.1 Estimation Results of the Structural Models

Firstly, we present the in sample estimation properties and diagnostic tests for the structural models [1]. In all the models, two polinomial lags for each variable is added to in order to include longer time adjustments for the models. In Table 6.1.1A, the estimation results of Hooper Morton model is shown.

Table 6.1.1A Estimation Results:

Hooper Morton Model

VARIABLE	LEVEL		LAG 1		LAG 2	
	COEFF.	't' VAL.	COEFF.	't' VAL.	COEFF.	't' VAL.
FX	-	-	0.12	1.27	0.21	2.44*
DWPI	0.59E-03	1.08	0.15E-02	2.72*	0.76E-03	1.38
DINT	-0.9E-03	-1.35	0.12E-02	1.84	-0.87E-03	-1.32
DM2Y	0.18	2.18*	0.08	0.95	-0.2	-2.79*
DPROD	0.32E-03	0.01	-0.05	-1.93	-0.06	-2.34*
USTBAL	0.01E-05	2.18*	0.18E-05	1.8	-	-
TTBAL	0.1E-04	0.98	-0.1E-04	-1.04	-	-
CONSTANT	0.01	2.4*				
TREND	0.7E-04	0.74				
* 't' value is 1.96 for five percent significance						

Now in the Table 6.1.1A above, the second lag of both US and Turkish trade balances are deleted in order to improve the diagnostic tests. Also since there is deterministic trend in TTBAL, a trend component appears in the model.

When we examine the table, it is seen that the first lag of the difference between inflational expectations of both countries (DWPI), the level of and the second lag of the differences of monetary aggregates

(DM2Y), and the second lag of exchange rate (FX) are highly significant. Also the second lag of the relative industrial production indices (DPROD) is significant. However, the other variables namely the interest rate differential (DINT) and the trade balance of Turkey (TTBAL, USTBAL) are highly insignificant. Furthermore, the coefficient of USTBAL although significant, is the reverse of what is expected. According to the Hooper Morton model, a deficit in Turkish trade balance (as a proxy for current account deficit) is expected to depreciate the exchange rate and the US trade deficit is expected to appreciate the foreign exchange. Also, although not significant, the level of interest rate differential appreciates the exchange rate (TL/$) as expected. Also when we remove the polinomial lags and reestimate, the current level of interest rate differential becomes highly significant.

We also applied diagnostic tests to our models. In the context of the diagnostic tests, we analysed the existence of error autocorrelation measured by lagrange multiplier statistic (error autocorrelation is removed in all the models by including the necessary polinomial lags), normality of the disturbance terms (which is measured by Chi-square statistics), hetoroscedasticity (measured by F-test), and ommited variables (measured by LM reset test). The results of the diagnostic tests for Hooper Morton model are presented in Table 6.1.1B. The model passes all the diagnostic tests presented in Table 6.1.1B.

Table 6.1.1B Diagnostic Tests:

Hooper Morton Model

NORMALITY	HETEROSCEDASTICITY	LM RESET TEST
Chi-square(2) = 1.963 %5 significance = 5.99	F(38,64) = 0.6498 significance lev. = 0.9229	F(1,102) = 2.368 significance lev. = 0.1270

As assumed in Chapter 2, we do not expect the TL/$ exchange rate to be effected by the US Trade balance. So, we also estimate the Hooper Morton model with only the Turkish current account. The results of the estimation and test statistics are presented in Table 6.1.2A and 6.1.2B.

Table 6.1.2A Estimation Results:

Hooper Morton Model with CABT

VARIABLE	LEVEL		LAG 1		LAG 2	
	COEFF.	't' VAL.	COEFF.	't' VAL.	COEFF.	't' VAL.
FX	-	-	0.12	1.24	0.17	1.96*
DWPI	0.71E-03	1.29	0.15E-02	2.73*	0.81E-03	1.42
DINT	-0.72E-03	-1.04	0.12E-02	1.79	-0.76E-03	-1.09
DM2Y	0.23	2.94*	0.09	1.17	-0.16	-2.33*
DPROD	-0.01E-03	-0.5	-0.06	-2.18	-0.07	-2.59*
CABT	0.19E-05	0.19	0.18E-05	1.8	-	-
CONSTANT	0.02	2.94*	-	-	-	-
* 't' value is 1.96 for five percent significance						

Table 6.1.2B Diagnostic Tests:

Hooper Morton Model with CABT

NORMALITY	HETEROSCEDASTICITY	LM RESET TEST
Chi-square = 2.945 5% significance = 5.99	F(32,73) = 0.9837 Significance lev. = 0.5061	F(1,105) = 0.725 Significance lev. = 0.3963

From Tables 6.1.2A and 6.1.2B above, we see that the current account deficit of Turkey is also not significant, but, its coefficient is positive as expected.

Again similar to the Hooper Morton model with relative trade balances, the coefficients of the first lag of DWPI, the level and second lag of DM2Y and the second lag of exchange rate are significant.

Furthermore the first and second lag of DPROD are significant which appreciates the exchange rate. However, the signs of the coefficients of the secod lag of M2Y and the first lag of interest rate differential are the reverse of what is expected.

When we examine diagnostic tests, it is seen from Table 6.1.2B, that the model passes all the tests for the normality of disturbances, hetoroscedasticity and LM test for omited variables.

Table 6.1.3A Estimation Results:

Dornbush Frankel Model

VARIABLE	LEVEL		LAG 1		LAG 2	
	COEFF.	't' VAL.	COEFF.	't' VAL.	COEFF.	't' VAL.
FX	-	-	0.12	1.25	0.17	1.98*
DWPI	0.71E-03	1.3	0.16E-02	2.79*	0.8E-03	1.43
DINT	-0.72E-03	-1.04	0.12E-02	1.83	-0.73E-03	-1.09
DM2Y	0.23	3.0*	0.09	1.2	-0.16	-2.34*
DPROD	-0.01E-03	-0.5	-0.06	-2.19	-0.07	-2.64*
CONSTANT	0.02	3.05*	-	-	-	-
* 't' value is 1.96 for five percent significance						

Table 6.1.3B Diagnostic Tests:

Dornbush Frankel Model

NORMALITY	HETEROSCEDASTICITY	LM RESET TEST
Chi-square = 2.945 5% significance = 5.99	F(32,73) = 0.9837 Significance lev. = 0.5061	F(1,105) = 0.725 Significance lev. = 0.3963

In Table 6.1.3A it is seen that, the coefficients of the Dornbush Frankel model are very similar to the Hooper Morton model; as removig the insignificant current account balance of Turkey does not effect the results. From Table 6.1.3B, it can be seen that, the Dornbush Frankel model also passes all the diagnostic tests. After the sticky price version models, we estimate the Frenkel Bilson model which assumes that prices are flexible in the short run and PPP holds continuously.

The estimation results of Frenkel Bilson model and test statistics are in Table 6.1.4A and 6.1.4B respectively:

Table 6.1.4A Estimation Results:

Frenkel Bilson Model

VARIABLE	LEVEL		LAG 1		LAG 2	
	COEFF.	't' VAL.	COEFF.	't' VAL.	COEFF.	't' VAL.
FX	-	-	0.2	2.21*	0.12	1.39
DINT	-0.21E-03	-0.31	0.19E-02	2.87*	-0.89E-03	-1.38
DM2Y	0.14	2.16*	0.04	0.58	-0.16	-2.45*
DPROD	-0.01E-03	-0.4	-0.07	-2.43	-0.08	-2.99*
CONSTANT	0.02	3.96*	-	-	-	-
* 't' value is 1.96 for five percent significance						

Table 6.1.4B Diagnostic Tests:

Frenkel Bilson Model

NORMALITY	HETEROSCEDASTICITY	LM RESET TEST
Chi-square = 2.974 5% significance = 5.99	F(22,100) = 1.6048 Significance lev. = 0.0601	F(1,122) = 1.191 Significance lev. = 0.2772

Here, from Table 6.1.4B it is seen that leaving out the difference of inflational expectations which was significant in the Dornbush Frankel model, worsenes the diagnostic tests.

However, now in the Frenkel Bilson model, the first lag of the interst rate differential becomes significant. Under the assumption of flexible prices, and the validity of purchasing power parity in the short run; an increase in the short term interest rate differential is expected to depreciate the exchange rate by effecting prices and real money demand. The results of the other coefficients are very similar to the Dornbush Frankel model: The second lag of the differences in production indices appreciates, while the level of the relative money supplies and the first lag of exchange rate depreciates the exchange rate. Frenkel Bilson model however, hardly passes all the test statistics (Table 6.1.4B).

From all the structural models we see that, the variables which effect the exchange rate are the differences in inflational expectations, differences in money supply and the second lag of foreign exchange.

6.2 Estimation Results of VAR models

We also estimate the VAR representation of structural models discussed in 6.1, with six lags [2]. Since there are so much variables (37 for the Hooper Morton model for example), we will only present the 'F' tests for the significance of all lags for each variable. That is, we test the hypothesis H0: *Bj1 = Bj2 =.........= Bj6 = 0*, in which *Bji* present the *i*th lag of variable *j*. Furthermore, we will also present the coefficients and the 't' values of the variables which are significant at five percent significance.

In Tables 6.2.1A and 6.2.1B, estimation results and test statistics of the Hooper Morton VAR model is shown. To overcome overparametrization we utilize differences of the trade balances of Turkey and USA rather than using them seperately.

Table 6.2.1A Estimation Results:

Hooper Morton Model (VAR)

SIGNIFICANCE OF ALL LAGS			COEFFICIENTS AND 't' VALUES		
VARIABLES	F STAT.	SIGNIFICANCE	VARIABLES	COEFF.	't' VALUE'
FX	0.63	0.7	DWPI(t-1)	0.19E-02	3.15
DM2Y	1.07	0.39	DINT(t-1)	0.18E-02	2.3
DWPI	2.31	0.04	DINT(t-3)	0.16E-02	2.14
DINT	1.9	0.09	DINT(T-5)	0.16E-02	2.04
DPROD	0.8	0.57	DM2Y(T-2)	-0.18	-1.96
DTBAL	0.81	0.56	CONSTANT	0.04	4.03
* 't' value is 1.96 for five percent significance					

Table 6.2.1B Diagnostic Tests:

Hooper Morton Model (VAR)

NORMALITY	HETEROSCEDASTICITY	LM RESET TEST
Chi-square = 1.555	F(39,70) = 1.04	F(1,94) = 2.408
5% significance = 5.99	Significance lev. = 0.4346	Significance lev. = 0.1241

In the Tables 6.2.1A and 6.2.1B estimation results and the diagnostic tests for the exchange rate equation is presented. Since a VAR model is composed of a system of equations, besides the equation of exchange rate, we also have equations for the other variables (as there is no distinction of exogeneous and endogeneous variables). For example in Hooper Morton model we have five more equations. Here only the results of the exchange rate equation is persented but the the estimation results of the other equations are given in Appendix1.

As it is seen in the estimation results of Hooper Morton model (Table 6.2.1A), except the lags of inflation differential, the lags of other variables are not significant. The lags of interest rate differential is now significant at 9% percent significance level, and furthermore the first, third and fifth lags of this variable are highly significant.

However, the coefficient of the lags of interest rate differentials are positive implying that the lags of interest rate differential depreciates the exchange rate. According to the Dornbush overshooting hypothesis, the current short term interest differential, appreciates the exchange rate in the short run but in the long run prices become flexible and exchange rate depreciates.

In all of the structural models discussed above, although not significant, the level of the interest rate differential appreciates the exchange rate. Furthermore when we remove the polinomial lags in the structural models, then the level of interest rate differential becomes significant and appreciates the exchange rate. Here, in the context of Hooper Morton and Dornbush Frankel models, we may suspect that the short run may be infact smaller than one month for Turkey; as an increase in the current interest rate differential appreciates the exchange rate while the first lag depreciates the echange rate.

Furthermore, the lags of the difference of Turkish and US monetary aggregates, whose first lag were significant in the structural version becomes highly insignificant. However, still the second lag of DM2Y is significant and its coefficient is the reverse of what is expected. In addition to that, the lags of foreign exchange is also insignificant which is not an expected result. Besides, the difference of trade balances is insignificant implying that Hooper Morton model does not improve up on the Dornbush

Frankel model. Finally, in diagnostic tests there is no problem of autocorrelation and the model passes all tests presented in Table 6.2.1B.

Since we estimated the Hooper Morton model with Turkish current account, estimation results of the VAR representation is also utilized.

Table 6.2.2A Estimation Results:

Hooper Morton Model with CABT (VAR)

SIGNIFICANCE OF ALL LAGS			COEFFICIENTS AND 't' VALUES		
VARIABLES	F STAT.	SIGNIFICANCE	VARIABLES	COEFF.	't' VALUE'
FX	0.69	0.66	DWPI(t-1)	0.2E-02	3.11
DM2Y	0.93	0.48	DINT(t-1)	0.18E-02	2.24
DWPI	2.18	0.05	DINT(t-3)	0.17E-02	2.05
DINT	1.97	0.07	DINT(T-5)	0.16E-02	1.92
DPROD	0.64	0.7	CONSTANT	0.03	3.37
CABT	0.07	0.99			
* 't' value is 1.96 for five percent significance					

Table 6.2.2B Diagnostic Tests:

Hooper Morton Model with CABT (VAR)

NORMALITY	HETEROSCEDASTICITY	LM RESET TEST
Chi-square = 0.428 5% significance = 5.99	F(39,58) = 0.9261 Significance lev. = 0.5951	F(1,81) = 0.407 Significance lev. = 0.5253

The estimation results of Hooper Morton model with Turkish current account (Table 6.2.2A) is similar to the version with the differences of trade balances, except that the significance of interest rate differential is improved further and the second lag of DM2Y, which had a negative and unexpected sign, is now insignificant. Consequently, the Hooper Morton model indicates that exchange rate is not effected by the foreign asset holdings of residents which is presented by the current account in the model. However, interest rate differential and inflational expectations play an important role. Also in the model there is no autocorrelation.

In the next step the current account balance is removed and the Dornbush Frankel model is estimated.

Table 6.2.3A Estimation Results:

Dornbush Frankel Model (VAR)

SIGNIFICANCE OF ALL LAGS			COEFFICIENTS AND 't' VALUES		
VARIABLES	F STAT.	SIGNIFICANCE	VARIABLES	COEFF.	't' VALUE'
FX	0.76	0.6	DWPI(t-1)	0.19E-02	3.33
DM2Y	1.12	0.35	DINT(t-1)	0.18E-02	2.36
DWPI	2.58	0.02	DINT(t-3)	0.16E-02	2.21
DINT	2.22	0.05	DINT(T-5)	0.15E-02	2.03
DPROD	0.75	0.61	CONSTANT	0.04	4.11
* 't' value is 1.96 for five percent significance					

Table 6.2.3B Diagnostic Tests:

Dornbush Frankel Model (VAR)

NORMALITY	HETEROSCEDASTICITY	LM RESET TEST
Chi-square = 0.96 5% significance = 5.99	F(39,58) = 1.116 Significance lev. = 0.3472	F(1,87) = 0.183 Significance lev. = 0.6702

Dornbush Frankel model improves up on the Hooper Morton model in the sense that, the significance of all the variables in the model are improved. Specifically, the significance of the difference between inflational expectations and interest rate differential is improved significantly. Furthermore there are no problems of autocorrelation and the test statistics are satisfactory.

Here, as argued in Hooper Morton model, we see that, the lags of interest rate differential depreciates the exchange rate while the current level in the structural version (although not significant) appreciates the exchange rate. Furthermore, when we remove the polinomial lags, the current level of interest rate differential becomes highly significant appreciating the exchange rate.

Finally, we estimate the Frenkel Bilson model which assumes continuous purchasing power parity under flexible prices in the short run.

Table 6.2.4A Estimation Results:

Frenkel Bilson Model (VAR)

SIGNIFICANCE OF ALL LAGS			COEFFICIENTS AND 't' VALUES		
VARIABLES	**F STAT.**	**SIGNIFICANCE**	**VARIABLES**	**COEFF.**	**'t' VALUE'**
FX	1.27	0.27	**FX(t-1)**	0.21	1.98
DM2Y	1.8	0.1	**DINT(t-1)**	0.21E-02	2.81
DINT	1.93	0.08	**DM2Y(t-2)**	-0.23	-2.65
DPROD	1.14	0.34	**DM2Y(t-5)**	0.16	1.96
			CONSTANT	0.28	3.35
* 't' value is 1.96 for five percent significance					

Table 6.2.4B Diagnostic Tests:

Frenkel Bilson Model (VAR)

NORMALITY	HETEROSCEDASTICITY	LM RESET TEST
Chi-square = 6.506* 5% significance = 5.99 2.5% significance = 7.38	F(39,70) = 0.9251 Significance lev. = 0.5973	F(1,105) = 1.758 Significance lev. = 0.1877

Removing the inflational expectations and estimating the Frenkel Bilson model reduces the significance of interest rate differential (Table 6.2.4A), but however the significance of other variables are improved significantly. Now the first lag of foreign exchange, the second and fifth lags of the difference between monetary aggregates are significant. Also, as in the other models, the first and fifth lags of of interest rate differential are significant in explaining the model. When we examine the diagnostic test results, it is seen that the diagnostic tests are worsened significantly because of leaving out a significant variable. The LM reset test is reduced and the model can not pass the test for the normality of residuals at 5% significance level. However, the model passes normality test for 2.5% significance level.

In the structural version of Frenkel Bilson model, although not significant, the sign of the coefficient of interest rate differential is the reverse of what is expected: The current level of interest rate differential appreciates the exchange rate. Also as argued in the other models, when we leave out the polinomial lags, the level of interest rate differential becomes significant appreciating the exchange rate in the Frenkel Bilson model.

One property common in both the Dornbush Frankel model and the Frenkel Bilson model is that, in both models the current level of exchange rate differential appreciates and their lags depreciates the exchange rate. So by combining the estimation results of the structural and VAR models, we can argue that, the increase in the current level of interest rate differential appreciates the exchange rate by inducing capital inflow as in Dornbush Frankel model. But in a very small period of time prices become sensitive with the effect of inflational expectations (in Turkey there is a significant inflational environment so that inflational expectations become an important factor for determinig exchange rate and the relations in the whole economy). Consequently, a reduction in the money demand occurs depreciating the exchange rate. So that's why the forecasts of the Hooper Morton model, Dornbush Frankel model and the Frenkel Bilson model will not deviate from each other significantly. Hooper Morton model will not deviate from the Dornbush Frankel model much, as the coefficients of trade balances and the current account are highly insignificant. Also the VAR representations of Dornbush Frankel and the Frenkel Bilson models will not generate very different forecasts as increases in the lags of the interest rate differential will depreciate the exchange rate in both models.

NOTES

1. For applying the in sample estimations and diagnostic tests of the alternative models, the statistical program by Hendry D.F. (1989), called PC Give was utilized.

2. The six lags have been selected after several trials and the examination of the significance of variables in all the models.

CHAPTER VII

FORECASTING THE ALTERNATIVE EXCHANGE RATE MODELS

After the estimation results, we present the out of sample forecast performances of the alternative structural models and their VAR representations for the period 1991-1 to 1993-7 (1993-1 to 1993-6 for structural models). In this context, we compare the one-step ahead forecasts of the structural models and the unrestricted VAR models. Furthermore, by introducing Bayesian priors we will discuss whether or not the forecasts of the unrestricted VAR models are improved by Bayesian approach to VAR models (BVAR models). Finally, we will also introduce the three step ahead forecasts of the Bayesian VAR models to analyse the forecast performances of the alternative exchange rate models for a longer forecast horizon.

7.1 Forecasts of Structural Models

Firstly, in Tables 7.1.1 to 7.1.3 we present the one step ahead exchange rate (TL/$ selling rate) forecasts of the structural models with their actual values for the period 1993-1 to 1993-6.

Table 7.1.1 Forecasts of Exchange Rate:

Hooper Morton Model with CABT

MONTHS	ACTUAL VALUE	FORECAST	DIFFERENCE	% ERROR
1993-1	8,832	8,865	-33	0.37
1993-2	9,204	9,061	143	1.55
1993-3	9,470	9,512	-42	0.44
1993-4	9,669	9,751	-82	0.85
1993-5	10,144	9,759	385	3.79
1993-6	10,882	10,423	459	4.22

In forecasting the Hooper Morton model, we use the Turkish current account only, since the estimation results indicate that this model improves up on the Hooper Morton model with the relative trade balances.

Table 7.1.2 Forecasts of Exchange Rate:

Dornbush Frankel Model

MONTHS	ACTUAL VALUE	FORECAST	DIFFERENCE	% ERROR
1993-1	8,832	8,893	-61	0.69
1993-2	9,204	9,077	127	1.38
1993-3	9,470	9,561	-91	0.96
1993-4	9,669	9,843	-174	-1.8
1993-5	10,144	9,859	285	2.81
1993-6	10,882	10,490	392	-3.6

Table 7.1.3 Forecasts of Exchange Rate:

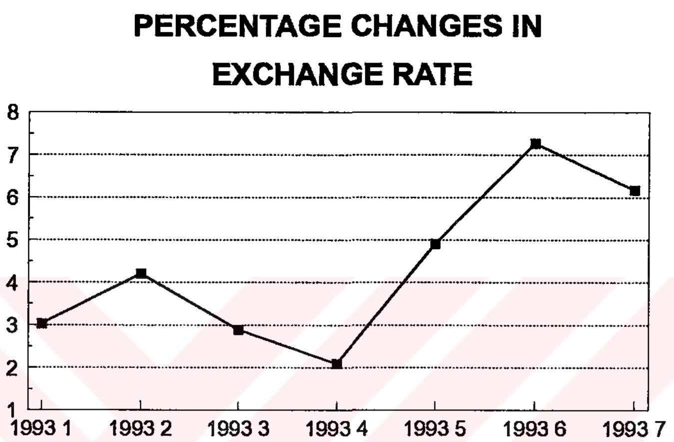
Frenkel Bilson Model

MONTHS	ACTUAL VALUE	FORECAST	DIFFERENCE	% ERROR
1993-1	8,832	8,930	-98	1.11
1993-2	9,204	9,190	14	0.15
1993-3	9,470	9,589	-119	1.26
1993-4	9,669	9,814	-145	-1.5
1993-5	10,144	9,833	311	3.07
1993-6	10,882	10,424	458	4.21

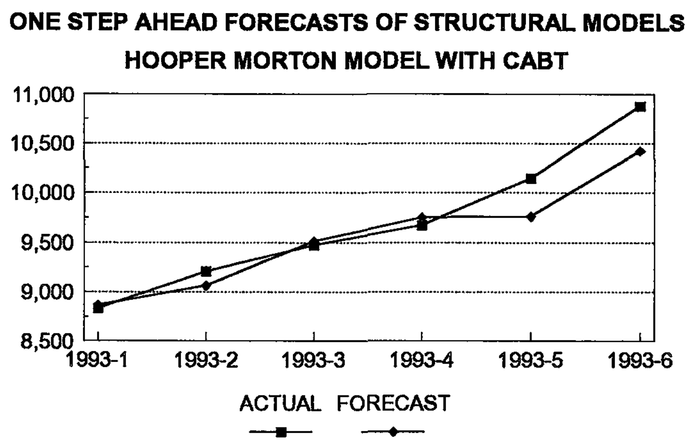
When we examine the Tables 7.1.1 to 7.1.3, it is seen that for the periods 1993-5 and 1993-6 all the of the models generate poor forecasts. Also in all the models, exchange rate forecasts are higher than the actual level for the period 1993-3 and 1993-4, while the exchange rate forecasts are lower than the actual level for the periods 1993-5 and 1993-6.

The reason can be seen from Graph 7.1.1, which represents the percentage changes in the actual level of exchange rate for the period 1993-1 to 1993-7. For 1993-3 and 1993-4 there are sharp reductions in the percentage increases of exchange rate and all the models forecast exchange rate values which are significantly higher than the actual level. Similarly, after 1993-4 there is a sharp increase in the % changes of exchange rate which can not be captured by any of the models.

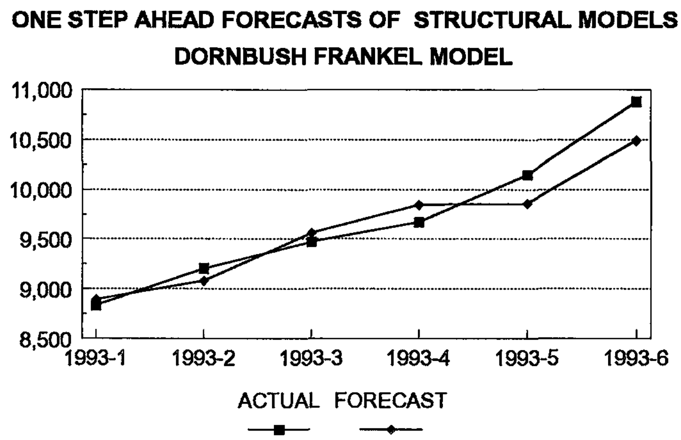
In the graphs 7.1.2 to 7.1.4, the trend in the one step ahead forecasts of exchange rate generated by the three alternative structural exchange models can be seen. The forecasts are fitted together with the actual levels of exchange rate, in order to present the forecast performances more clearly.



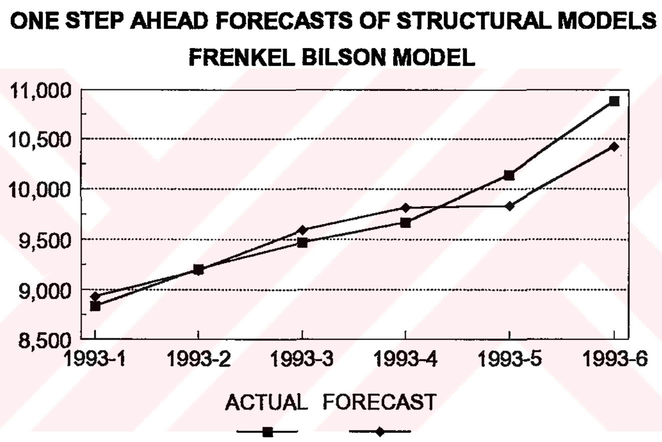
GRAPH 7.1.1



GRAPH 7.1.2



GRAPH 7.1.3



GRAPH 7.1.4

We can see that the forecasts of all the models are similar to each other, and except for 1993-5 and 1993-6 all the models produce fairly good forecasts. Specifically, for periods 1993-1, 1993-3 and 1993-4 the Hooper Morton model improves up on the other two. For periods 1993-4 and 1993-5 the Dornbush Frankel model improves up on the other two and finally for 1993-2 the Frenkel Bilson model produces improved forecasts. Also except for the period 1993-4 the forecasts of Dornbush Frankel model are fairly close to Hooper Morton model.

7.2 One Step Ahead Forecasts: Unrestricted VAR Models

Now in order to see whether using VAR approach improves the forecasts of exchange rate, we first forecast the unrestricted VAR (UVAR) representations of structural models. Secondly, in the next section, by applying prior restrictions we will compute the forecasts of the Bayesian approach to our VAR models (BVAR).

In comparing the alternative VAR models, we will make use of forecast performance statistics. The statistics which will be used to compare forecast performances will be the Theil's U statistic which is the ratio of root mean square error (RMS) to the root mean square error of the naive forecast of no change in the dependent variable. Formula of theTheil's U statistic and the root mean square statistic are presented in Litterman (1979,37) as:

$$\text{Theil's U statistic} = [\Sigma_{t\in Tk}(Ft_{(t+k)} - A_{(t+k)})^2 / \Sigma_{t\in Tk}(A_{(t)} - A_{(t+k)})^2]^{1/2} \qquad (1)$$

$$\text{RMS Error} = [\Sigma_{t\in Tk}(Ft_{(t+k)} - A_{(t+k)})^2 / Lk]^{1/2} \qquad (2)$$

Here, T_k is the set of t's in the forecast period of k step ahead forecasts. L_k is the number of elements in T_k. $F_t(t+k)$ is the k step ahead forecasts made at time t, while $A(t+k)$ is the actual value at $t+k$.

In the Bayesian approach, as will be explained in the next section, the procedure will be to minimize the Theil's U statistic by assigning several different priors to the models.

Now, we present the forecasting results of the alternative unrestricted VAR models (UVAR) in Tables 7.2.1 to 7.2.3, for the period 1993-3 to 1993-7.

Table 7.2.1 Forecasts of Exchange Rate: Hooper Morton Model (UVAR)

MONTHS	ACTUAL VALUE	FORECAST	DIFFERENCE	% ERROR	THEIL U * 100
1993-1	8,832	8,835	-3	0.03	104.9
1993-2	9,204	9,226	-22	0.24	99.65
1993-3	9,470	9,386	84	0.89	108.5
1993-4	9,669	9,772	-103	1.07	127.4
1993-5	10,144	9,602	542	5.34	79.49
1993-6	10,882	10,344	538	4.94	161.4
1993-7	11,555	11,456	99	0.86	190.5

When we compare the VAR representation of Hooper Morton model (Table 7.2.1) with the structural version (Table 7.1.1), it is seen that for the periods 1993-1 and 1993-2 the VAR model strictly improves up on the structural model, while for all the other periods the VAR model generates poorer forecasts than the structural representation.

So, it can be said that the unrestricted VAR model does not improve up on the structural model in terms of out of sample forecasting performance. We also have forecasts for 1993-7 in the VAR model. The forecast performance in 1993-7 improves significantly. The reason may be that, the sharp increases in exchange rate in the periods 1993-5 and 1993-6 (Graph 7.1.1) have been captured by the model in period 1993-7.

Table 7.2.2 Forecasts of Exchange Rate: Dornbush Frankel Model (UVAR)

MONTHS	ACTUAL VALUE	FORECAST	DIFFERENCE	% ERROR	THEIL U * 100
1993-1	8,832	8,841	-9	0.1	87.19
1993-2	9,204	92,248	-44	0.48	86.1
1993-3	9,470	9,447	-23	0.24	93.44
1993-4	9,669	9,813	-144	1.49	109.8
1993-5	10,144	9,711	433	4.27	77.53
1993-6	10,882	10,406	476	4.37	
1993-7	11,555	11,401	154	1.33	161.29

Now, when the forecasts of Dornbush Frankel unrestricted VAR (UVAR) model is (Table 7.2.2) compared with the UVAR representation of Hooper Morton model (Table 7.2.1), for the period 1993-3, 1993-5 and 1993-6, the Dornbush Frankel UVAR model improves up on the Hooper Morton UVAR model. Besides, although the forecasts of other periods are poorer then the Hooper Morton UVAR model; as the forecast errors are small and forecasts are close, we can say that Dornbush Frankel UVAR model is not worser than and in fact slightly improves up on the Hooper Morton UVAR model for the other periods.

Moreover, the forecast performance statistics are improved significantly in the Dornbush Frankel UVAR model. However, the same problem as in the Hooper Morton UVAR model occurs in the Dornbush Frankel UVAR model in the sense that; for period 1993-5, athough forecast performance is poor, the Theil's U statistic is significantly low. The reason is that, since the Theil's U statistic makes use of the forecast performances of the past periods, and since the forecast performances of the prieods 1993-1 to 1993-4 are highly satisfactory, the Theil U statistic reduces significantly.

When we compare the Dornbush Frankel UVAR model, whith the structural version; for the period 1993-1 to 1993-4 the Dornbush Frankel UVAR model strictly improves up on the structural version. However, for 1993-5 and 1993-6 the structural version produces much improved forecasts. Finally, we present the one step ahead forecasts of the unrestricted VAR (UVAR) approach to Frenkel Bilson model in Table 7.2.3

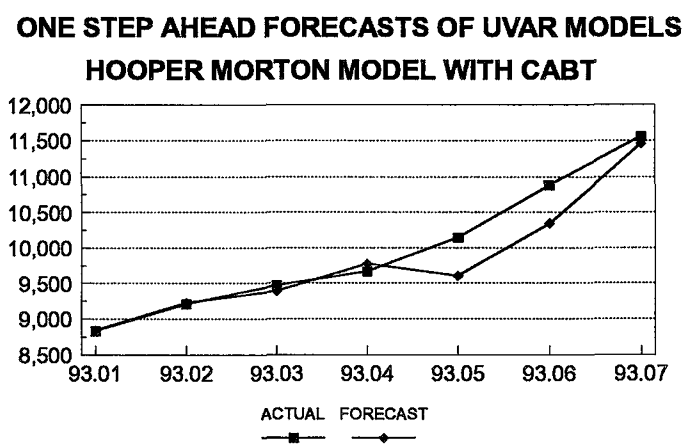
Table 7.2.3 Forecasts of Exchange Rate:

Frenkel Bilson Model (UVAR)

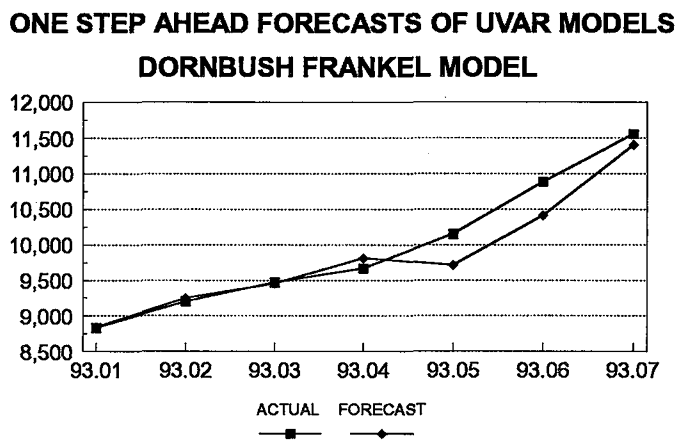
MONTHS	ACTUAL VALUE	FORECAST	DIFFERENCE	% ERROR	THEIL U * 100
1993-1	8,832	8,913	-81	0.92	86.57
1993-2	9,204	9,092	112	1.22	91.5
1993-3	9,470	9,402	68	0.72	84.66
1993-4	9,669	9,733	-64	0.66	119.3
1993-5	10,144	9,694	456	4.49	85.9
1993-6	10,882	10,348	534	4.91	136.7
1993-7	11,555	11,397	158	1.37	175.5

The comparison of Frenkel Bilson UVAR model with the Dornbush Frankel UVAR model, indicates that the Frenkel Bilson UVAR model generates poorer forecasts than the Dornbush Frankel UVAR model except for the period 1993-4. The reason may be attributed to the fact that, removing the inflational expectations from the Dornbush Frankel UVAR model leads to smaller forecasts in the Frenkel Bilson UVAR model (except for 1993-1). Also, as the Dornbush Frankel model overestimates the exchange rate for the period 1993-4, removing inflational expectations, leads to the reduction of the exchange rate forecast for this period and improves the forecast in Frenkel Bilson UVAR model. However, the Frenkel Bilson UVAR model generates much better forecasts than the Hooper Morton UVAR model for period 1993-4 to 1993-6. When we compare the structural version of Frenkel Bilson model (Table 7.1.2) with the unrestricted VAR representation, it is seen that for 1993-1, 1993-3 and 1993-4 the UVAR approach produces better forecasts than the structural version. However, for 1993-5 and 1993-6 the forecasts of structural version strictly improves up on the VAR representation. We can say that, generally, Frenkel Bilson UVAR model generates a satisfactory trend for exchange rate for period 1993-1 to 1993-4, but then the forecasts become worser.

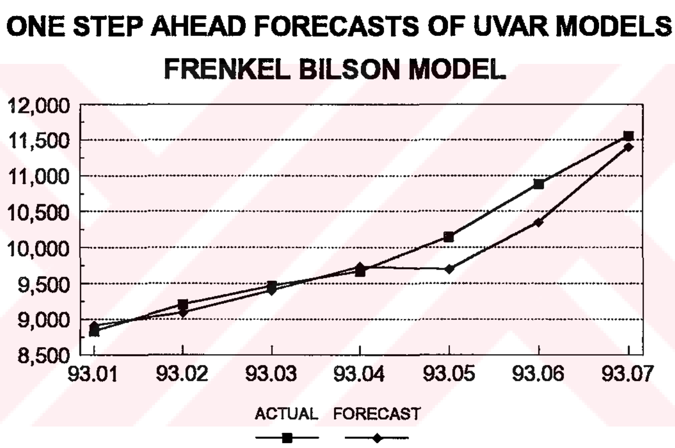
In Graphs 7.2.1 to 7.2.3, the exchange rate forecasts of three alternative unrestricted VAR models are presented.



GRAPH 7.2.1



GRAPH 7.2.2



GRAPH 7.2.3

When we compare Graphs 7.2.1 to 7.2.3 with Graphs 7.1.2 to 7.2.4, we see that the VAR representation of the structural models in general produce satisfactory forecasts and represent a close trend with the actual levels for 1993-1 to 1993-4. However, the VAR representations can not capture the significantly high increases in the exchange rate for 1993-5 and 1993-6. So we can say that the structural models strictly improves up on the

VAR representations for 1993-5 and 1993-6. Furthermore, although the forecats of both the structural models and VAR representations do not differ much from each other, we can say that, the UVAR representations in general slightly improves up on the structural models for 1993-1 to 1993-4. However, as a final word, it can not be said that the VAR models improve up on the structural models in our examples.

Among the UVAR representations, although in general the trend in the forecasts are not much different from each other, both Dornbush Frankel UVAR model and the Hooper Morton UVAR models improve up on the Frenkel Bilson UVAR model in capturing the trend of exchange rate. Also during the period 1993-1 to 1993-4 Hooper Morton UVAR model improves up on Dornbush Frankel UVAR model. But during the period 1993-5 and 1993-6 the revers occurs.

7.3 One Step Ahead Forecasts: Bayesian VAR Models

After the discussion of unrestricted VAR approaches to structural models, we will discuss whether imposing prior restrictions on the coefficients of the variables improves the forecasting performance of the models. In applying Bayesian priors (discussed in Chapter 4), we will firstly assign a prior for the standart deviation of the first own lag (overall tightness). Then we will assign a weight for the cross lags of other variables.

That is, we will assign a weight for the lags of other variables in the model. Finally, we will assign a decay parameter which indicates tighter priors as the lags of the variables increase. So, as the lags increase the coefficients of the variables will be forced to zero.

" Litterman's results have shown that a reasonable procedure is to set the tightness parameter on the order of 0.1 or 0.2. As the number of variables in the system increase, the prior is made tighter on variables other than own lags." (Todd and Litterman (1987)).

So we will also set the overall tightness (standart deviation of the first own lag) on the order of 0.1 or 0.2 and we will assign a harmonic decay paramater for the increasing lags. Also in assigning cross lags, we will use a general lagtype which enables to specify a seperate weight for each variable in each equation. For example in Chapter 6 we examined that in Dornbush Frankel model, both the inflational expectations and interest rate differential were significant in explaining the exchange rate (Table 6.2.3A). So in determinig priors for the Dornbush Frankel model, we will assign a higher weight for these variables. That is, we will assign loose priors to these variables as we do not expect their coefficients to be close to zero. Also we will assign thighter priors for the insignificant variables. Then, after several experiments of forecasting with several priors, we choose the prior that minimizes the Theil's U statistic which is used as an indicator of forecast performance. Now we firstly present the forecast results of the Bayesian VAR representation (BVAR) of Hooper Morton model with CABT.

Table 7.3.1 Forecasts of Exchange Rate:

Hooper Morton Model (BVAR)

MONTHS	ACTUAL VALUE	FORECAST	DIFFERENCE	% ERROR	THEIL U * 100
1993-1	8,832	8,804	28	0.32	69.44
1993-2	9,204	9,266	-62	0.67	73.81
1993-3	9,470	9,493	-23	0.24	67.2
1993-4	9,669	9,724	-55	0.57	76.12
1993-5	10,144	9,944	200	1.97	21.66
1993-6	10,882	10,581	301	2.77	54
1993-7	11,555	11,531	24	0.21	84.66

When we compare the UVAR (Table 7.2.1) and Bayesian VAR approaches (BVAR) (Table 7.3.1) to Hooper Morton model of exchange rate, it is seen that the forecasts of the BVAR approach strictly improves up on the unrestricted VAR approach both in terms of forecasts and forecast performance statistics. In fact, although the forecasts of Hooper Morton UVAR model is better than the forecasts of Hooper Morton BVAR model for the period 1993-1 and 1993-2, the improvement is neglicible and its clear that imposing prior expectations strictly improves the forecasting performance of the model. Also, the pecentage errors of forecasts for the period 1993-5 and 1993-6 which were 5.3 and 4.9 respectively in Hooper Morton UVAR model is reduced to 1.97 and 2.77 in Hooper Morton BVAR model. When we compare the Bayesian representation of the Hooper Morton model with the structural version, it is seen that the Bayesian approach strictly improves up on the structural version.

In the BVAR approach the Theil's U statistic is very low (0.2166) for the period 1993-5 although the forecast performance is reduced, as was the case in the UVAR approach. The reduction in the Theil's U statistic is more serious in the BVAR approach, since the forecast performances of the previous periods are significantly improved up on the UVAR representation. In fact the forecast performances of BVAR approach is almost near perfect for the period 1993-1 to 1993-4. At the same time the exchange rate forecast in 1993-5 is poor, as the model incorporating lags can not reflect the significant increase in the exchange rate for this period.

However, the forecast of BVAR approach in 1993-5, is significantly improved up on the UVAR represantation. We saw that for the forecasting period 1993-5, among the UVAR models, the Dornbush Frankel UVAR model was the best and the Frenkel bilson UVAR model was the worst. So, by assigning a higher weight for the coefficient of interest rate differential and assigning a low weight for the coefficient of current account deficit we obtain improved forecasts in BVAR approach for the period 1993-5. But, since none of the BVAR approaches (as will be seen) can reduce the forecast error significantly for the period 1993-5, we can argue that, there may have been some other factors effecting the exchange rate in 1993-5, which is not included in the alternative models of exchange rate. However, in period 1993-7 the Hooper Morton BVAR model captures the increases in exchange rate. The results of the one step ahead forecasts of Dornbush Frankel model with Bayesian priors are presented in Table 7.3.2

Table 7.3.2 Forecasts of Exchange Rate:

Dornbush Frankel Model (BVAR)

MONTHS	ACTUAL VALUE	FORECAST	DIFFERENCE	% ERROR	THEIL U * 100
1993-1	8,832	8,830	2	0.02	72.82
1993-2	9,204	9,244	-40	0.44	76.29
1993-3	9,470	9,495	-25	0.26	67.43
1993-4	9,669	9,723	-54	0.56	76.3
1993-5	10,144	9,958	186	1.83	23.39
1993-6	10,882	10,582	300	2.76	53.07
1993-7	11,555	11,526	29	0.25	85.09

When we compare the forecasts of unrstricted VAR representation of the Dornbush Frankel model (Table 7.2.2) with the BVAR representation (Table7.3.2), clearly the Bayesian approach strictly improves up on both the UVAR approach and the structural approach (Table 7.1.3). Furthermore, the Dornbush Frankel BVAR model strictly improves up on the Hooper Morton BVAR model. In the BVAR approach of forecasting, the forecasts are improved because of the reason that, the BVAR model permits the variables to effect the model only when the data suggests that they should. Furthermore, the effectivenes of variables may change in each period and the Bayesian approach can be used to capture those differences. For example, in most periods of forecast range, the prior which minimizes the Theil's U statistic differ from each other. Finally we present the one step ahead forecasts of the Frenkel Bilson BVAR model (Table7.3.3).

Table 7.3.3 Forecasts of Exchange Rate:

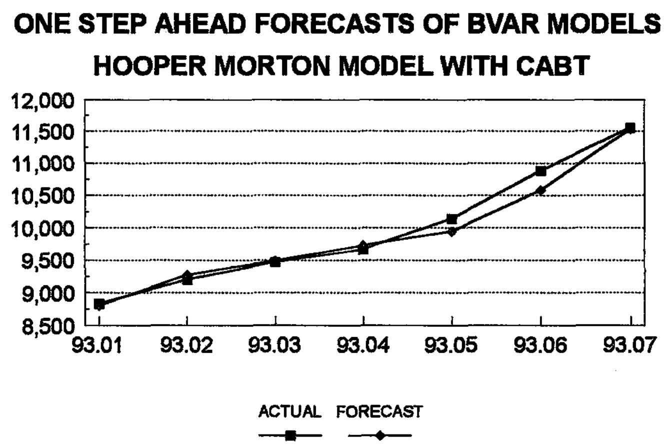
Frenkel Bilson Model (BVAR)

MONTHS	ACTUAL VALUE	FORECAST	DIFFERENCE	% ERROR	THEIL U * 100
1993-1	8,832	8,858	-26	0.29	79.25
1993-2	9,204	9,095	111	1.21	84.19
1993-3	9,470	9,516	-46	0.49	88.35
1993-4	9,669	9,709	40	0.41	88.55
1993-5	10,144	9,941	203	2	41.43
1993-6	10,882	10,534	348	3.2	63.68
1993-7	11,555	11,487	68	0.59	98.22

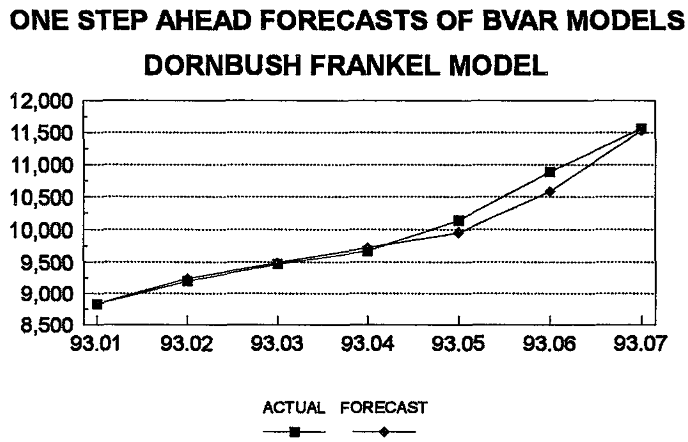
UVAR representation. Also except for the period 1993-2, again the Frenkel Bilson BVAR model strictly improves up on the structural version (Table 6.1.4). However, Frenkel Bilson BVAR model does not improve up on neither the Hooper Morton BVAR model nor the Dornbush Frankel BVAR model.

Among the three models of BVAR approach, the Frenkel Bilson BVAR model is the worse. In fact, although the Dornbush Frankel BVAR model slightly improves up on the Hooper Morton BVAR model, as current account deficit of Turkey is highly insignificant in Hooper Morton model, the forecasting performances of both models come closer to each other.

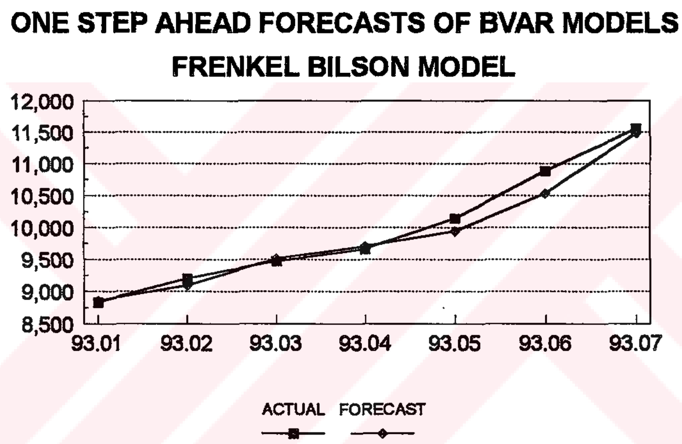
In Graphs 7.3.1 to 7.3.3, we present one step ahead exchange rate forecasts of the three alternative BVAR models with the actual values.



GRAPH 7.3.1



GRAPH 7.3.2



GRAPH 7.3.3

From the Graphs 7.3.1 to 7.3.3 we see that, for the period 1993-5 and 1993-6 the percentage errors of the forecasts have been reduced significantly in all the models of Bayesian representation. That is, the high differences in the forecasts and actual values in both the structural models and UVAR models for periods 1993-5 and 1993-6 have been significantly reduced by the BVAR approach.

The forecasts of BVAR approach, for all the models, strictly improves up on both the unrestricted VAR representations and the structural models. To summarize, although we can not say that the unrestricted VAR representations improve up on the structural models, we can say that the BVAR approach to structural models produce much better and improved forecasts then the structural models. An important note is that, in fact, we are estimating and forecasting the official exchange rate, for which the Central Bank behaviour plays an important role especially for our period of estimation. The Central Bank, if posesses a strong reserve of foreign exchange, can effect the value of exchange rate by buying and selling in the money market. So, the Central Bank can eliminate the short run bubles or speculative increases in exchange rate and then the behaviour of exchange rate becomes relatively predictable. Then, good forecasts in exchange rate may also be Central Bank factor smoothening the trend in exchange rate.

7.4 Three Step Ahead Forecasts: Bayesian VAR Models

We demonstrated that, BVAR models of exchange rate improves the one step ahead forecasts of exchange rate significantly. In order to analyse wheather BVAR models can generate good forecasts in a longer time horizon, we also present the three step ahead forecasts (three step ahead indicates three months) of the Bayesian representation of our three alternative models in Tables 7.4.1, 7.4.2 and 7.4.3 respectively.

Table 7.4.1 Three Step Ahead Forecasts of Exchange Rate: Hooper Morton Model (BVAR)

MONTHS	ACTUAL VALUE	FORECAST	DIFFERENCE	% ERROR	THEIL U * 100
1993-1	8,832	8,901	-69	0.78	62.5
1993-2	9,204	9,136	68	0.74	59.23
1993-3	9,470	9,499	-29	0.31	55.09
1993-4	9,669	9,848	-193	2	58.59
1993-5	10,144	9,980	164	1.62	44.9
1993-6	10,882	10,461	421	3.87	58.52
1993-7	11,555	11,242	313	2.71	76.81

Table 7.4.2 Three Step Ahead Forecasts of Exchange Rate: Dornbush Frankel Model (BVAR)

MONTHS	ACTUAL VALUE	FORECAST	DIFFERENCE	% ERROR	THEIL U * 100
1993-1	8,832	8,909	-77	0.87	65.79
1993-2	9,204	9,137	67	0.73	59.44
1993-3	9,470	9,496	-26	0.27	55.43
1993-4	9,669	9,848	-179	1.85	58.8
1993-5	10,144	9,978	166	1.64	45.02
1993-6	10,882	10,458	424	3.9	59.03
1993-7	11,555	11,235	320	2.77	77.19

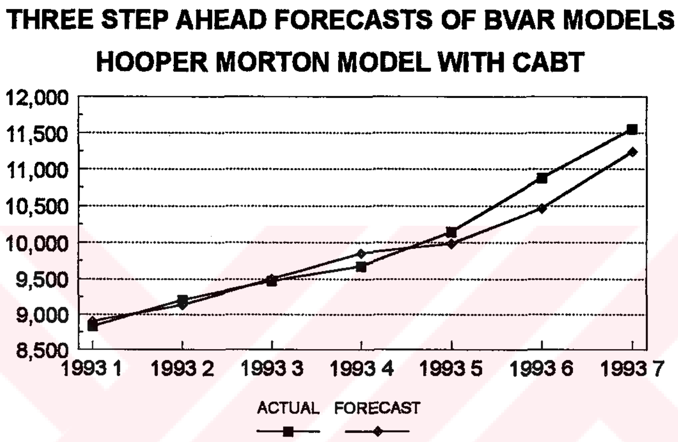
Table 7.4.3 Three Step Ahead Forecasts of Exchange Rate: Frenkel Bilson Model (BVAR)

MONTHS	ACTUAL VALUE	FORECAST	DIFFERENCE	% ERROR	THEIL U * 100
1993-1	8,832	8,890	68	0.77	65.43
1993-2	9,204	9,142	62	0.67	61.3
1993-3	9,470	9,508	-38	0.4	59.31
1993-4	9,669	9,776	-107	1.11	59.67
1993-5	10,144	9,984	160	1.58	40.68
1993-6	10,882	10,453	429	3.94	47.99
1993-7	11,555	11,221	334	2.89	73.91

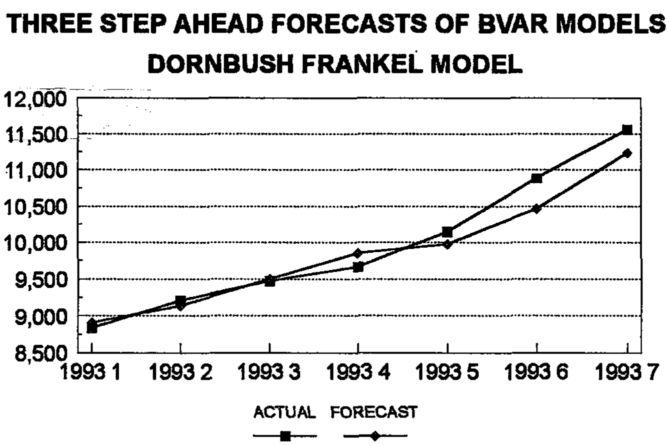
When we examine the Tables 7.4.1 to 7.4.3 it is seen that, for the period 1993-1 to 1993-5 the forecasts of Frenkel Bilson BVAR model is improved up on the other two. But for the period 1993-6 and 1993-7 Hooper Morton model generates better forecasts.

Generally, the three step ahead forecasts of Bayesian VAR models generate satisfactory forecasts. In generating the three step ahead forecasts, it is clear that the forecasts of other variables in the model are also forecasted and reinserted into the model in each step. The success of the forecasts also depend on wheather or not the other variables in the model can be estimated satisfactorily. The estimation results and diagnostic tests of other equations in the VAR system are presented in Appendix 1.

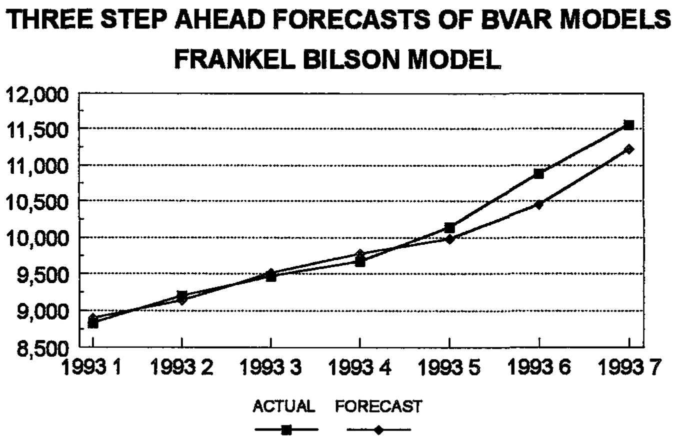
It was seen in the estimation results of other equations in the VAR model, there were some problems with the diagnostic tests and especially with the normality of the residuals. These problems seemed more strongly in the equation for the relative wholesale price index. So, the results of the three step ahead forecasts should be treated with caution.



GRAPH 7.4.1



GRAPH 7.4.2



GRAPH 7.4.3

When we examine the Graphs 7.4.1 to 7.4.3 and compare them with the one step ahead forecasts of structural and unrestricted VAR representations of alternative models; the three step ahead forecasts of BVAR models, generates fairly good forecasts, The three step ahead forecasts of Frenkel Bilson BVAR model in general improves up on both the one step ahead forecasts of structural model and the unrestricted VAR model. Although the three step ahead forecasts of Dornbush Frankel BVAR model can not strictly improve up on the one step ahead forecasts of unrestricted version, it produces much better forecasts for 1993-5 and 1993-6. The same argument is also valid for the three step ahead forecasts of Hooper Morton BVAR model. However, both the three step ahead forecasts of Hooper Morton BVAR and the Dornbush Frankel BVAR model generates forecasts generally close to one step ahead forecasts of both the structural and the unrestricted VAR representations. Consequently, we see that in general the three step ahead BVAR models produce satisfactory forecasts in capturing the trend in exchange rate and they also produce close forecasts to structural models, three months earlier than the latter.

7.5 Dornbush Frankel Model with a Currency Substitution Factor (CSF):

As mentioned before, in out estimation models we used the monetary aggregate M2Y for Turkey, which includes the foreign exchange deposits of the residents. Clearly, we should have been using a monetary aggregate which only includes domestic components. However, there were problems with the diagnostic tests of the estimations utilizing all the other monetary aggregates.

In order to overcome this systematic problem, we divided the monetary aggregate M2Y of Turkey to its components as domestic M2 and the foreign exchange deposits. Monetary aggregate M2 includes currency in circulation, TL sight deposits and TL time deposits. Then we used the difference of Turkish monetary aggregate M2 and the corresponding American monetary aggregate (M2 of USA) which we call DM2. Then we also included an indicator of currency substitution for Turkey seperately into the Dornbush Frankel model since it was the best due to the estimation results. The currency substitution factor was the ratio of foreign exchange deposits to monetary aggregate M2 of Turkey. According to our stationarity analysis there was unit root in DM2 and there was a deterministic trend in the currency substitution factor. We faund out that the estimation results were not better than the initial Dornbush Frankel model and there were problems with the diagnostic tests. Furthermore the out of sample forecasts of this model were not satisfactory. So, we do not present the forecasts of this model but we are presenting the estimation results and diagnostic tests in Tables 7.5.1A and 7.5.1B.

Table 7.5.1A Estimation results of Structural Models: Dornbush Frankel Model with Currency Substitution Factor (CSF)

VARIABLE	LEVEL		LAG 1		LAG 2	
	COEFF.	't' VAL.	COEFF.	't' VAL.	COEFF.	't' VAL.
FX	-	-	0.12	1.18	0.13	1.38
DINT	-0.53E-03	-0.73	0.11E-02	1.56	-0.73E-03	-1.01
DWPI	0.43E-03	0.76	0.14E-02	2.52*	0.9E-03	1.56
DM2	0.05	0.82	0.09	1.21	-0.18	-0.28
DPROD	-0.02	-0.78	-0.06	-2.01*	-0.06	-2.0*
CSF	0.16	1.7	0.7E-03	0.01	-0.14	-1.45
TREND	-0.5E-04	-0.36	-	-	-	-
CONSTANT	0.02	3.36*	-	-	-	-
* 't' value is 1.96 for five percent significance						

Table 7.5.1B Diagnostic Tests: Dornbush Frankel Model with Currency Substitution Factor

NORMALITY	HETEROSCEDASTICITY	LM RESET TEST
Chi-square = 8.184*	F(36,67) = 1.359	F(1,103) = 0.186
5% Significance = 5.99	Significance lev. = 0.1380	Significance lev. = 0.6671

As it is seen from the tables, dividing M2Y to its components and including a currency substitution factor worsenes the estimation results of the Dornbush Frankel model significantly. Also, there is a problem with the normality of the residuals. Furthermore since we use the ratio of foreign currency deposits to M2 as the currency substitution factor, there may also be a problem of multicollinearity worsening the estimation results. In this case we do not further represent the forecasting results of this model.

However, there is still the problem of finding the appropriate monetary aggregate and an indicator for the high level of currency substitution in Turkey.

CHAPTER VIII

CONCLUSION

8.1 Summary of Estimation Results and Forecast Performances of the Models

We compared three structural models and their VAR representations in terms of their in sample estimation properties and out of sample forecasting performances. One other aspect of this study was to investigate, whether or not Bayesian approach to forecasting can improve the forecast performances for the short period forecast horizons.

If was faund that, in the estimation of structural models with two polinomial lags, the Hooper Morton model which is a synthesis of the portfolio balance approach and monetary approach, did not improve the estimation of exchange rate up on the other alternative models. The reason was the insignificance of the trade balances of two countries in consideration. Here we may argue that, the reason for the insignificance of trade balances in determining exchange rate can be the use of monthly data. Trade balance may be a determinant of exchange rate in the long run, but with a monthly data the adjustment period may be short for the trade balance factor (as a proxy for the current account) to effect exchange rate. Furthermore as, we assumed that it would also not be logical to expect Turkey to lend USA for the US current account deficit; we estimated the Hooper Morton model with Turkish current account only. However, the results were still not improved. So as a result, we concluded that there was not much difference between the estimation results of the Dornbush Frankel model and the Hooper Morton model.

In the Dornbush Frankel model we faund out that, either the level or one of the polinomial lags of each variable except the interest rate differential were significant in explaining the exchange rate. Also, although not significant the coefficient of the level of interest rate differential were negative, while the coefficient of the first lag was positive, meaning that, at the current level an increase in the interest rate differential would appreciate but in the next period it would depreciate the exchange rate.

Removing the inflational expectations, and estimating Frenkel Bilson flexible price monetary model, produced inferior results in terms of diagnostic tests. However, now the first lag of the interest differential was significant and positive.

When we estimated the six lag VAR representations of the three exchange rate models, it was faund out that the difference between Dornbush Frankel model and the Hooper Morton model was not significant. In both models, the first, third and fifth lags of the interest rate differential, and the first lag of the inflational expectations were highly significant. The estimation results of the VAR representation of Frenkel Bilson model did not improve up on the others since moving out a significant variable (i.e. inflational expectations) disturbed the results and diagnostic tests.

One problem with all the structural models was that; although the coefficient of the difference between monetary aggregates were significant and positive, the second lag of this variable was negative meaning that an increase in the money supply would appreciate the exchange rate. This could happen only if an increase in the money supply is sterilized by the Central Bank with some lag, through open market operations and increasing interest rates significantly. However, in VAR representations of both the Hooper Morton model and the Dornbush Frankel model, lags of the differences between monetary aggregates were insignificant. So we could in general argue that the Dornbush Frankel model were more satisfactory than the other two and the Dornbush overshooting hypothesis coud work in a significantly short period of time; since current level of exchange rate would appreciate but its first lag woud depreciate the exchange rate.

In comparing the one step ahead forecast performances of the structural models for the period 1993-1 to 1993-6; the first point was that, the forecasting perormances of all the structural models were similar and the forecasts were rather satisfactory up to period 1993-5. Also the comparison with the VAR representations indicated that, results were not much different and neither the structural models, nor the VAR representations could produce improved results up on the other. However, it was clear that the Bayesian representations of the models produced forecasts which strictly improved the forecasting performances. Furthermore the three step ahead forecasts of the Bayesian models were also satisfactory.

A final note is that, when we estimated the structural models without polinomial lags (results not reported in this study), it was faund that the performance of structural models were inferior than the VAR model both in terms of estimation results and in terms of forecasts. This shows the importance of adjustment mechanism in the exchange rate models.

8.2 Exchange Rate: Discussions in Economic Literature

We estimated and forecasted three altenative approaches to exchange rate which have been discussed widely in the economic literature. Now we will summarise the results and discussions developed concerning the three approaches we used specifically to estimate the exchange rate [1].

Firstly in the flexible price monetary approach to exchange rate, Frankel (1976) estimated a version of the flexible price monetary approach for DM/$ rate which we used in our estimation (equation (5) in section 2.2.1.1A of Chapter 2). However, in his model Frankel used expectations of exchange rate instead of interest rate differential reflecting inflational expectations. Further since his estimation was started over 1920-3, he expected that the German hyperinflation would dominate the model. Also he assumed that UIP would be zero meaning that expected change in exchange rate would be equal to the forward premium. So, the model he estimated was as follows: In log form

$$s_t = a + bmg_t + cfp_t + e_t \qquad (1)$$

Where *mg* is the German money supply and *fp* is the forward premium. The results were supporting the flexible price monetary approach.

However, since the period of estimation was a special case, Bilson (1978) estimated the Frankel's model for the period Jan 1972- April 1976: But he did not assume equal coefficient for the real income variable. So Bilson estimated:

$$s_t = (m - m*)_t + by_t + cy*_t + dfp_t + e_t \qquad (2)$$

In this model, Bilson faund out the presence of multicollinearity and autocorrelation. So, Bilson suggested that there might be a problem of model misspecification. Then he added a partial adjustment scheme for the exchange rate and a first order autoregressive for the error term. However, the results still did not support the flexible price monetary model. Finally, by changing the estimation technique and using Theil-Goldberger mixed estimation procedure which makes use of priors; he could develop results supporting the flexible price monetary approach.

In estimating the exchange rate, the researcher mostly faces a simultaneity problem: For example if the monetary authorities intervene in the foreign exchange market and the effect of this intervention on the money supply is not sterilized, then the relative money supply term may be correlated with the error term. In order to overcome the simultaneity problem between exchange rate and the relative money supply, Dornbush (1979) formed the dependent variable of the flexible price monetary model as: $(s-(m-m^*))$. However, the only significant variable was the relative income and there was still the problem of autocorrelation.

The reason may be the lack of dynamics. The money market may not continuously be in equilibrium and partial adjustment terms may be necessary.

So, Dornbush (1976) added a partial adjustment scheme and also improved the specification of the money demand function by introducing a long term interest differential term as an opportunity cost variable.

$$\begin{aligned} s_t = (m - m*)_t + a(s - m + m*)_{t-1} + b(y - y*)_t \\ +c(r - r*)_t + d(r_L - r*_L)_t + e_t \end{aligned} \qquad (3)$$

The results were improved but the relative income and short term interet rate differential were not significant.

In the flexible price monetary models, the problem of autocorrelation appeared significantly and furthemore few authors have considered the simultaneity problem which mostly appeared in the exchange rate equations. So the results developed concerning flexible price monetary model were that: Although the results supported this approach, the problem of simultaneity and autucorrelation indicated that the flexible price monetary model could be misspecified or the dynamics of the model could be inadequate in the sense of lag structure.

Frankel (1979) estimated the real interest differential formulation (RID) which is a variant of the sticky price monetary model, as the purchasing power parity holds only in the long run. The model he estimated is similar to the sticky price monetary model estimated here, which is defined in section 2.2.1.2A equation (15) of Chapter 2. One difference is that, Frankel, in the estimation of RID formulation, used long term interest rate differential as the deteminant of inflational expectations. However in this study, previous 12 month inflation rates were used as a proxy for inflational expectations. Frankel's results were improved over the flexible price monetary model in the sense that all variables were correctly signed and statistically significant. The estimation period for the Frankel's DM/$ exchange rate model was July 1974 to February 1978.

When the estimation period is extended after 1980, then the in sample estimation results of both the flexible price monetary model and the RID model have poor explanatory power, few coefficients are correctly signed and error autucorrelation appears as a problem. For example the relative money supplies generally have a negative sign indicating that an increase in the money supply leads to appreciation. This was also the case for our structural models in the sense that, while the sign of the coefficient of current relative money supplies was correct, the coefficient of the second lag of relative money supplies was negative. Haynes and Stone (1981) argued that this may be because of subtractive constraints used in monetary approach which may lead to biased estimates. One other reason might be the instability of money demand functions.

Frankel (1982) stressed the importance of the wealth effect of current account which were not included in monetary approach and gained importance after 1980. So, Frankel estimated a model including wealth and removing the subtraction constraints on income and interest rate. The results were satisfactory and the explanatory power of the model was good.

In the portfolio balance approach to exchange rate, exchange rate is not determined by money market conditions only, but also conditions in the bond markets. Branson (1977) estimated a version of portfolio balance approach for DM/$ rate, for the period August 1971 to December 1976; which is represented in section 2.2.2A equation (20) of Chapter 2. Branson faund results which were supportive for for portfolio balance approach by estimating the model by OLS and 2SLS. However, there was a problem of first degree autocorrelation indicating that there might be some unexplained shocks reducing the effectiveness of portfolio balance model.

Bisignano and Hoover (1982) critisized the use of cumulative current accounts for foreign bonds arguing that bilateral data for foreign assets must be used for a reliable representation of portfolio balance model and also they included domestic non traded bonds of two countries in their model. The results were improved showing that domestic nontraded assets should be included in exchange rate models of portfolio balance approach.

Many researchers have attempted to combine features of portfolio balance model and monetary model. The derivation of the synthesis of monetary approach and portfolio balance approach was presented in section 2.2.2B equation (25) of Chapter 2. Several versions of this equation have been estimated by Isard (1980), Hacce and Townend (1981), Hooper and Morton (1982). In the estimation results of Hooper Morton model, firstly there was no autocorrelation and coefficient representing the news about the current account was significant. Generally the results of the synthesis was improved over simple monetary and portfolio balance models. Hacce and Townend included an oil price term and estimated with monthly data. Results were inferior to Hooper Morton estimation, and there was the existance of autocorrelation.

The out of sample forecast performances may also be an indicator to test the validity of econometric models. In this context Meese and Rogoff (1983) forecasted a representative of flexible price model, sticky price monetary model, and their synthesis. These three equations were used in this study as a representative of three structural approaches, and summarised in section three of Chapter 2. Meesse and Rogoff compared the forecasting performances of these models with the forecasating performances of random walk, forward rate, univariate and VAR models. The result was that, none of the models were improved up on the random walk model in terms of forecast performances [2].

After Meese and Rogoff, there has been several attempts to test wheather or not structural models can outperform the random walk model. For example Woo (1985) and Finn (1986) estimated versions of the rational expectations form of flexible price monetary model. Furthermore, they added a partial adjustment term for money demand. Finn's results indicated that forecast performances of the structural model was neither superior nor inferior than the random walk model. However, Woo faund that the random walk model was improved up on. Also, Somanath (1986) forecasted various asset reduced form equations for DM/$ rate with the addition of partial adjustment terms for money demand. His results outperformed the Results of Meese and Rogoff. Hogan (1986) with quarterly data for Australian-US dollar rate, compared the forecast performances of; structural exchange rate models with a static specification of money demand versus dynamic specification, forward rate, random walk, ARIMA and purchasing power parity models. The results indicated that for a forecast horizon of one quarter, forward rate results were the best. However, according to Hogan's results the sticky price monetary model with a dynamic specification of money demand and UIP static monetary model outperformed the random walk model.

Finally, there has also been some attempts to forecast ecxhange rate with time-varying parameter models [3]. The results were also strictly improved over the random walk model.

We can conclude that, attemps for estimating and forecasting exchange rate models have been widened in the last decade and the results indicate that although the prediction of exchange rate is a rather difficult process, the developments have been challenging in this area.

NOTES

1. The emprical exchange rate models and the results developed are widely discussed in MacDonald and Taylor (1991, 178-205). Here, in general, we summarized the discussions in MacDonald and Taylor in order to compare our conclusions with the ones developed in the literature.

2. Meese and Rogoff developed possible explanations why their structural models failed to improve up on the random walk model. These were mainly the possibility of sampling error, simultaneous equation bias, structural instability and misspecification of the money demand functions. These discussions can be faund in great detail in Meese and Rogoff (1983).

3. For example Wolff (1987), Schinasi and Swamy (1987) estimated exchange rate models with time varying parameters.

REFERENCES

Allen, H., Henry, B. and Pesaran B.,1991. ***"Exchange Rate Equations"***, Bank of England Discussion Papers, No.37, pp.1-13.

Bilson, J.F.O., 1978. ***"Rational Expectations and the Exchange Rate"***. In The Economics of Exchange Rates, ed. J.A. Frankel and H.G. Johnson. Reading, MA: Addison-Wesley, pp.75-96.

Bilson, J.F.O., 1979. ***"Recent Developments in Monetary Models of Exchange Rate Determination"***, IMF Staff Papers, No.26, pp.201-223.

Bisignano, J. and Hoover, K., 1982. ***"Some Suggested Improvements to a simple Portfolio Balance model of Exchange Rate Determinetion with Special Reference to the UD Dollar/ Canadian Dollar Rate"***, Weltwirtschaftliches Archiv, No.119, pp.19-37.

Blake, N.S., 1991. ***"Modelling Trends in Macroeconomic Time Series"***, Economic Review, May 1991, pp.19-31.

Boughton, J.M., 1987. ***"Tests of the Performance of Reduced-Form Exchange Rate Models"***, Journal of International Economics, Vol.23, pp.41-56.

Branson, W.H., 1977. ***"Asset Markets and the Relative Prices in Exchange Rate Determination"***, Reprint series 98, Institute for International Economic Studies.

Branson, W.H., Halttunen, H. and Masson, P., 1979. ***"Exchange Rates in the Short Run"***, European Economic Review, Vol.10, pp.395-402.

Brunner, K., Meltzer, A.H., 1979. ***"Policies for Employment, Prices and Exchange Rates"***. In Policies for Employment, Prices and Exchange Rates, ed. K. Brunner , and A.H. Meltzer, Carnegie-Rochester Conference 11, pp.1-7.

Champbell, J.Y. and Perron, P., 1991. ***"Pitfalls and Opportunities: What Macroeconomists Should Know About Unit Roots"***, NBER Macroeconomics Annual 1991, Vol.6, pp.141-219. Cambridge.

Charemza, W.W., and Deadman, D.F., 1992. New Directions in Econometric Practice, Edward Algar Publishing Ltd., England.

Clements, M.P. and Mizon, G.E., May 1990 (Revised September 1990). ***"Empirical Analysis of Macroeconomic Time Series: VAR and Structural Models"***, paper prepared for International Seminar on Macroeconomics, sponsored by the European Economic Association, the National Bureau of Economic Research and La Maison des Sciences de l'Homme. Hosted by the Institut fur Volkswirtschaftslehre und Statistic, Universitat Mannheim, June 19-20, 1990. Available on request.

Cornell, B., 1977. ***"Spot Rates, Forward rates and Exchange Market Efficiency"***, Journal of Financial Economics, Vol.5, pp.55-65.

Dickey, D.A. and Fuller W.A., 1981. ***"Likelihood Ratio Statistics for Autoregressive Time Series With a Unit Root"***, Econometrica, Vol.49, No.4, pp.1057-1085.

Diebold, F.X. and Nerlove, M., 1988. ***"Unit Roots in Economic Time Series: A Selective Survey"***, Finance and Economics Discussion Series, No.49, Division of Research and Statistics, Federal Reserve Board. Washington D.C.

Doan, T. and Litterman, R.B., 1987. Manual Rats 2.10 Large Memory Version User's Guide, VAR Econometrics Inc., Evanston, IL 60201.

Doan, T., Litterman, R.B., and Sims, C., Sept 1983. ***"Forecasting and Conditional projection Using Realistic Prior Distributions"***, NBER Working Paper Series, No.1202, Cambridge.

Dolado, J.J., and Jenkinson, T., 1987. ***"Cointegration: A Survey of Recent Developments"***, Applied Economics Discussion Paper No.39. University of Oxford.

Dolado, J.J., and Jenkinson, T., 1990. ***"Cointegration and Unit Roots"***, Journal of Economic Surveys, Vol.4, No.3, pp.249-273.

Dornbusch, R., 1976. ***"Expectations and Exchange Rate Dynamics"***, Journal of Political Economy, Vol.84, No.6, pp.1161-1176.

Dornbusch, R., 1979. ***"Monetary Policy Under Exchange Rate Flexibility"***, In Managed Exchange Rate Flexibility, Federal Reserve Bank of Boston, Conference Series No.20, pp.90-126.

Engle, R., and Granger, G. 1987. ***"Cointegration and Error Correction: Representation, Estimation and Testing"***, Econometrica, Vol.55, pp.251-276.

Engle, R., and Yoo, S., 1987. ***"Forecasting and Testing in Cointegrated Systems"***, Journal of Econometrics, Vol.35, pp.143-159.

Finn, M.G., 1986. ***"Forecasting the Exchange Rate: A Monetary or Random Walk Phenomenon"***, Journal of International Money and Finance, Vol.5, pp.181-220.

Frenkel, J.A., 1976. ***"A Monetary Approach to Exchange Rate: Doctrinal Aspects and Emprical Evidence"***, Scandinavian Journal of Economics, Vol.78, No.2, pp.200-224.

Frankel, J.A., 1979. ***"On the Mark: A Theory of Floating Exchange Rates Based on Real Interest Rate Differentials"***, American Economic Review, Vol.69, pp.610-622.

Frankel, J.A., 1982. ***"The Mystery of multiplying Marks: A Modification of the Monetary Model"***, Review of Econometrics and Statistics, Vol.64, pp.515-519.

Frankel, J.A., 1983. ***"Monetary and Portfolio Balance Models of Exchange Rate Determination"***. In Economic Interdependence and Flexible Exchange Rates , ed. J.S. Bhandari, and B.H. Putnam. MA: MIT Press, Cambridge.

Frenkel, J.A., 1981. ***"Flexible Exchange Rates, Prices and the Role of 'News': Lessons From the 1970s"***, Journal of Political Economy, Vol.89, No.4, pp.665-705.

Fuller, W., 1976. Introduction to Statistical Time Series, John Wiley and Sons, N.Y.

Granger, C., 1981. ***"Some Properties of Time Series Data and Their Use in Econometric Model Specification"***, Journal of Econometrics, Vol.28, pp.121-130.

Hacce, G. and Townend, J., 1981. ***"Exchange Rates and Monetary Policy: Modelling Sterling's Effective Exchange Rate, 1972-80"***. In The money Supply and the Exchange Rate, ed. W.A. Eltis and P.J.N. Sinclair. Oxford University Press, Oxford.

Haynes, S.E. and Stone, J.A., 1981. ***"On the Mark: Comment"***, American Economic Review, Vol.71, pp.1060-1067.

Hendry, D.F., 1989. PC-GIVE: An Interactive Econometric Modelling System, Institute of Economics and Statistics, Version 6.1, University of Oxford, Oxford.

Hogan, I.H., 1986. ***"A Comparison of Alternative Exchange Rate Forecasting Models"***, The Economic Record, Vol.51, pp.215-223.

Hooper, P., and Morton, J.E., 1982. ***"Fluctuations in the Dollar: A Model of Nominal and Real Exchange Rate Determination"***, Journal of International Money and Finance, Vol.1, pp.39-56.

Ilmakunnas, P., 1990. ***"Testing the Order of Differencing in Quarterly Data: An Elastration of the Testing Sequence"***, Oxford Bulletin of Economics and Statistics, Vol.52, No.1, pp.79-88.

Isard, P., 1978. ***"The Process of Exchange-Rate Determination: A Survey of Popular Views and Recent Models"***, Princeton Studies in International Finance, No.42, Princeton.

Isard, P., 1980. ***"Expected and Unexpected Changes in Exchange Rates: The Roles of Relative Price Levels, Balance of Payments Factors, Interest Rates and Risk"***, International Finance discussion discussion Papers, No.156.

Kouri, Pentti, J.K., 1976. ***"The Exchange Rate and the Balance of Payments in the Short Run and in the Long Run: A Monetary Approach"***, The Scandinavian Journal of Economics, Vol.78, pp.280-304.

Larson, H.J.,1982. Introduction to Probability Theory and Statistical Inference, Third edition, John Wiley and Sons, N.Y.

Larsen, R.J., and Marx, M.L., 1986. An Introduction to Mathematical Statistics and Its Applications, Prectice-Hall International Ed., New Jersey.

Litterman, R.B., 1979. ***"Techniques of Forecasting Using Vector Autoregressions"***, Working paper No.115, Federal Reserve Bank of Minneapolis.

Litterman, R.B., 1981. ***"A Bayesian Procedure for Forecasting With Vector Autoregressions"***, MIT Working Paper.

Meese, R., 1990. ***"Currency Fluctuations in the Bretton Woods Era"***, Journal of Economic Perspectives, Vol.4, No.1, pp.117-134.

Meese, R., and Rogoff, K., 1983. ***"Empirical Exchange Rate Models of the Seventies: Do They Fit Out Of Sample?"***, Journal of International Economics, Vol.14, pp3-24.

MacDonald, R., and Taylor, M.P., 1991.***"Exchange Rate Economics"***. In Surveys in Monetary Economics Vol:1, ed. Christopher J. Green, David T. Llewellyn. Basil Blackwell, Oxford.

Maddala, G. S., 1988. Introduction to Econometrics, Macmillian Publishing Company, New York.

Murphy, R.G., and Duyne, C.V., 1980. ***"Asset Market Approaches to Exchange Rate Determination: A Comparative Analysis"***, Weltwirtschaftliches Archiv (Review of World Economics), Heft: 4, Band:116, pp.629-657.

Mussa, M. 1979. . ***"Emprical Regularities in the Behaviour of Exchange Rates and Theories of the Foreign Exchange Rate Markets"***. In Policies for Employment, Prices and Exchange Rates, ed. K. Brunner , and A.H. Meltzer, Carnegie-Rochester Conference 11, pp.1-7.

Schinasi, G.J, 1987. ***"The Out of Sample Forecasting Performance of Exchange Rate Models When Coefficients are Allowed to Change"***, International Finance discussion Papers, No.301.

Sims, C.A., 1980. ***"Macroeconomics and Reality"***, Econometrica, Vol.48, pp.1-48.

Stein, J.L., 1992. ***"Fundamental Determinants of Exchange Rates"***, Journal of International and Comparative Economics, Vol.1, pp.125-162.

Todd, R.M., 1984. ***"Improving Economic Forecasting With Bayesian Vector Autoregression"***, Research Paper, Federal Reserve Bank of Minneapolis.

Wold, H., 1954. A Study in the Analysis of Stationary Time Series, (second edtion), Almquist and Witsell, Stockholm.

Wolff, C.P., 1987. ***"Forward Foreign Exchange Rates, Expected Spot Rates, and Premia: A Single Extraction Approach"***, Journal of Finance, Vol.42, pp.395-406.

Woo, W.T., 1985. ***" The Monetary Approach to Exchange Rate Determination Under Rational Expectations "***, Journal of International Economics, Vol.18, pp.1-16.

APPENDIX 1

SIGNIFICANCE AND DIAGNOSTIC TESTS OF EQUATIONS OTHER THAN THE EXCHANGE RATE EQUATIONS

Since the VAR models are composed of system of equations, we also present the estimation results of the equations other than the exchange rate equations which have been presented in the sixth chapter. The reason for this necessity is that, in the three step ahead forecasts of VAR models, each equation produces the one step ahead forecasts of its dependent variable. then these forecasts are incorporated into the VAR model to produce the two step ahead forecasts. Similarly each equation produces the two step ahead forecasts of its dependent variable. finally these two step ahead forecasts are used to determine the three step ahead forecasts of the VAR model and specifically exchange rate. It should be clear that in one step ahead forecasts of exchange rate we do not need to use the results of other equations.

Also in the three step ahead forecasts, the estimation results of other equations in the VAR system are also be used to determine geometric type priors of cross lags (mentioned in chapter three), in producing forecasts of Bayesian VAR models.

So we present the estimation results and diagnostic tests of the equations other than the exchange rate equation for the Hooper Morton (VAR) model, Hooper morton (VAR) model incorporating the Turkish current account, Dornbusch Frankel (VAR) model and the Frenkel Bilson (VAR) model. We do not present the estimation results for the Dornbusch Frankel model incorporating the currency substitution factor since we did not produce the three step ahead forecasts of this model.

Table A.1.1 Estimation Results:

Hooper Morton Model (VAR), Dependent Variable DM2Y

SIGNIFICANCE OF ALL LAGS		
VARIABLES	F STATISTIC	SIGNIFICANCE
FX	1.74	0.12
DM2Y	1.1	0.37
DWPI	0.41	0.87
DINT	0.5	0.8
DPROD	2.02	0.07
DTBAL	1.38	0.23
DIAGNOSTIC TESTS		
NORMALITY	HETEROSCEDASTICITY	LM RESET TEST
Chi-square = 0.848 5% significance = 5.99	F(39,58) = 0.8014 Significance lev. = 0.7649	F(1,81) = 2.219 Significance lev. = 0.1402

Table A.1.2 Estimation Results:

Hooper Morton Model (VAR), Dependent Variable DWPI

SIGNIFICANCE OF ALL LAGS		
VARIABLES	F STATISTIC	SIGNIFICANCE
FX	1.09	0.44
DM2Y	0.5	0.8
DWPI	1.37	0.24
DINT	1.9	0.09
DPROD	0.78	0.58
DTBAL	0.55	0.77
DIAGNOSTIC TESTS		
NORMALITY	HETEROSCEDASTICITY	LM RESET TEST
Chi-square = 6.824*	F(39,58) = 0.8135	F(1,81) = 2.737
2.5% significance = 7.38	Significance lev. = 0.7507	Significance lev. = 0.1019

Table A.1.3 Estimation Results:

Hooper Morton Model (VAR), Dependent Variable DINT

SIGNIFICANCE OF ALL LAGS		
VARIABLES	F STATISTIC	SIGNIFICANCE
FX	2.34	0.04
DM2Y	0.93	0.47
DWPI	1.6	0.15
DINT	1.26	0.28
DPROD	0.29	0.94
DTBAL	1.56	0.17
DIAGNOSTIC TESTS		
NORMALITY	HETEROSCEDASTICITY	LM RESET TEST
Chi-square = 635.9*	F(39,58) = 0.4069	F(1,81) = 134.815*
5% significance = 5.99	Significance lev. = 0.9982	Significance lev. = 0.00

Table A.1.4 Estimation Results:

Hooper Morton Model (VAR), Dependent Variable DPROD

SIGNIFICANCE OF ALL LAGS		
VARIABLES	**F STATISTIC**	**SIGNIFICANCE**
FX	0.91	0.8
DM2Y	2.1	0.06
DWPI	1.16	0.33
DINT	0.6	0.73
DPROD	6.6	0
DTBAL	1.78	0.11
DIAGNOSTIC TESTS		
NORMALITY	**HETEROSCEDASTICITY**	**LM RESET TEST**
Chi-square = 2.071 5% significance = 5.99	F(39,58) = 1.0427 Significance lev. = 0.4359	F(1,81) = 6.258* Significance lev. = 0.014

Table A.1.5 Estimation Results:

Hooper Morton Model (VAR), Dependent Variable DTBAL

SIGNIFICANCE OF ALL LAGS		
VARIABLES	**F STATISTIC**	**SIGNIFICANCE**
FX	2.49	0.03
DM2Y	0.96	0.45
DWPI	1.63	0.14
DINT	1.52	0.18
DPROD	2.72	0.02
DTBAL	11.82	0
DIAGNOSTIC TESTS		
NORMALITY	**HETEROSCEDASTICITY**	**LM RESET TEST**
Chi-square = 1.605 5% significance = 5.99	F(39,58) = 0.3760 Significance lev. = 0.9992	F(1,81) = 0.022 Significance lev. = 0.8828

Table A.2.1 Estimation Results:

Hooper Morton Model (VAR) with CABT, Dependent Variable DM2Y

SIGNIFICANCE OF ALL LAGS		
VARIABLES	**F STATISTIC**	**SIGNIFICANCE**
FX	1.57	0.17
DM2Y	1.32	0.25
DWPI	0.31	0.93
DINT	0.84	0.54
DPROD	2.29	0.04
CABT	1.27	0.28
DIAGNOSTIC TESTS		
NORMALITY	**HETEROSCEDASTICITY**	**LM RESET TEST**
Chi-square = 2.416 5% significance = 5.99	F(39,58) = 0.9938 Significance lev. = 0.5011	F(1,81) = 1.726 Significance lev. = 0.1926

Table A.2.2 Estimation Results:

Hooper Morton Model (VAR) with CABT, Dependent Variable DWPI

SIGNIFICANCE OF ALL LAGS		
VARIABLES	**F STATISTIC**	**SIGNIFICANCE**
FX	0.88	0.51
DM2Y	0.51	0.79
DWPI	1.61	0.16
DINT	2.05	0.07
DPROD	0.81	0.56
CABT	1.72	0.13
DIAGNOSTIC TESTS		
NORMALITY	**HETEROSCEDASTICITY**	**LM RESET TEST**
Chi-square = 5.693 5% significance = 5.99	F(39,58) = 0.6824 Significance lev. = 0.8961	F(1,81) = 0.457 Significance lev. = 0.50

Table A.2.3 Estimation Results: Hooper Morton Model (VAR) with CABT, Dependent Variable DINT

SIGNIFICANCE OF ALL LAGS		
VARIABLES	**F STATISTIC**	**SIGNIFICANCE**
FX	2.07	0.06
DM2Y	0.66	0.68
DWPI	1.49	0.19
DINT	1.28	0.27
DPROD	0.42	0.87
CABT	0.43	0.85
DIAGNOSTIC TESTS		
NORMALITY	**HETEROSCEDASTICITY**	**LM RESET TEST**
Chi-square = 1038.36*	F(39,58) = 0.7701	F(1,81) = 91.487*
5% significance = 5.99	Significance lev. = 0.8050	Significance lev. = 0.00

Table A.2.4 Estimation Results: Hooper Morton Model (VAR) with CABT, Dependent Variable DPROD

SIGNIFICANCE OF ALL LAGS		
Variable	**F STATISTIC**	**SIGNIFICANCE**
FX	1.03	0.41
DM2Y	2.33	0.04
DWPI	1.33	0.25
DINT	0.79	0.58
DPROD	7.44	0
CABT	2.81	0.02
DIAGNOSTIC TESTS		
NORMALITY	**HETEROSCEDASTICITY**	**LM RESET TEST**
Chi-square = 2.480	F(39,58) = 1.1758	F(1,81) = 8.466*
5% significance = 5.99	Significance lev. = 0.2837	Significance lev. = 0.005

Table A.2.5 Estimation Results: Hooper Morton Model (VAR) with CABT, Dependent Variable CABT

SIGNIFICANCE OF ALL LAGS		
Variable	**F STATISTIC**	**SIGNIFICANCE**
FX	0.46	0.83
DM2Y	2.03	0.07
DWPI	1.29	0.27
DINT	0.96	0.45
DPROD	1.26	0.28
CABT	7.63	0
DIAGNOSTIC TESTS		
NORMALITY	**HETEROSCEDASTICITY**	**LM RESET TEST**
Chi-square = 2.840 5% significance = 5.99	F(39,58) = 1.1758 Significance lev. = 0.2837	F(1,81) = 8.466 Significance lev. = 0.0047

Table A.3.1 Estimation Results: Dornbush Frankel Model (VAR) Dependent Variable DM2Y

SIGNIFICANCE OF ALL LAGS		
VARIABLES	**F STATISTIC**	**SIGNIFICANCE**
FX	1.74	0.12
DM2Y	1.58	0.16
DWPI	0.37	0.89
DINT	0.61	0.72
DPROD	2.34	0.04
DIAGNOSTIC TESTS		
NORMALITY	**HETEROSCEDASTICITY**	**LM RESET TEST**
Chi-square = 3.28 5% significance = 5.99	F(39,58) = 1.6342* Significance lev. = 0.044	F(1,87) = 2.079 Significance lev. = 0.1529

Table A.3.2 Estimation Results: Dornbush Frankel Model (VAR)

Dependent Variable DWPI

SIGNIFICANCE OF ALL LAGS		
VARIABLES	**F STATISTIC**	**SIGNIFICANCE**
FX	0.9	0.5
DM2Y	0.72	0.64
DWPI	1.62	0.15
DINT	1.94	0.08
DPROD	1.2	0.31
DIAGNOSTIC TESTS		
NORMALITY	**HETEROSCEDASTICITY**	**LM RESET TEST**
Chi-square = 11.761* 5% significance = 5.99	F(39,58) = 0.9534 Significance lev. = 0.5567	F(1,87) = 1.193 Significance lev. = 0.2778

Table A.3.3 Estimation Results: Dornbush Frankel Model (VAR),

Dependent Variable DINT

SIGNIFICANCE OF ALL LAGS		
VARIABLES	**F STATISTIC**	**SIGNIFICANCE**
FX	2.56	0.02
DM2Y	0.75	0.61
DWPI	1.38	0.23
DINT	1.15	0.34
DPROD	0.64	0.69
DIAGNOSTIC TESTS		
NORMALITY	**HETEROSCEDASTICITY**	**LM RESET TEST**
Chi-square = 1303* 5% significance = 5.99	F(39,58) = 0.4262 Significance lev. = 0.9971	F(1,87) = 81.34* Significance lev. = 0.0

Table A.3.4 Estimation Results: Dornbush Frankel Model (VAR)

Dependent Variable DPROD

SIGNIFICANCE OF ALL LAGS		
VARIABLES	**F STATISTIC**	**SIGNIFICANCE**
FX	1.05	0.39
DM2Y	2.08	0.06
DWPI	1.11	0.36
DINT	0.52	0.79
DPROD	0.65	0
DIAGNOSTIC TESTS		
NORMALITY	**HETEROSCEDASTICITY**	**LM RESET TEST**
Chi-square = 1.247 5% significance = 5.99	F(39,58) = 0.6846 Significance lev. = 0.8941	F(1,87) = 5.8* Significance lev. = 0.02

Table A.4.1 Estimation Results: Frenkel Bilson Model (VAR)

Dependent Variable DM2Y

SIGNIFICANCE OF ALL LAGS		
VARIABLES	**F STATISTIC**	**SIGNIFICANCE**
FX	0.67	0.14
DM2Y	1.76	0.11
DINT	0.68	0.67
DPROD	2.35	0.04
DIAGNOSTIC TESTS		
NORMALITY	**HETEROSCEDASTICITY**	**LM RESET TEST**
Chi-square = 1.01 5% significance = 5.99	F(39,70) = 1.0502 Significance lev. = 0.4208	F(1,105) = 8.667* Significance lev. = 0.004

Table A.4.2 Estimation Results: Frenkel Bilson Model (VAR)

Dependent Variable DINT

SIGNIFICANCE OF ALL LAGS		
VARIABLES	F STATISTIC	SIGNIFICANCE
FX	4.12	0
DM2Y	0.7	0.65
DINT	1.76	0.11
DPROD	0.93	0.48
DIAGNOSTIC TESTS**		
NORMALITY	HETEROSCEDASTICITY	LM RESET TEST
Chi-square = 2036.4 5% significance = 5.99	F(39,70) = 0.4324 Significance lev. = 0.9973	F(1,105) = 40.573* Significance lev. = 0.00
**Existance of twelfth degree autocorrelation.		

Table A.4.3 Estimation Results: Frenkel Bilson Model (VAR)

Dependent Variable DPROD

SIGNIFICANCE OF ALL LAGS		
VARIABLES	F STATISTIC	SIGNIFICANCE
FX	1.3	0.26
DM2Y	2	0.07
DINT	0.38	0.9
DPROD	6.53	0
DIAGNOSTIC TESTS		
NORMALITY	HETEROSCEDASTICITY	LM RESET TEST
Chi-square = 0.629 5% significance = 5.99	F(39,70) = 0.6759 Significance lev. = 0.9074	F(1,105) = 6.035* Significance lev. = 0.02