Money Demand Estimation and Currency Substitution: Evidence from Turkey

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This thesis is dedicated to my family.

Abstract

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In this thesis, I try to represent both the long-run and short-run empirical relationships between the main Turkish macroeconomic series; the $M1$ money balances, real output and the opportunity costs variables for the period 1987Q1-2003Q3. Throughout the thesis, extended portfolio balance theory is employed and two different scenarios are considered as treating prices $I(1)$ and $I(2)$. Estimation results reveal that the long-run real money balances is a function of the real output, the interest rate spread and the exchange/depreciation rate as expected. Also, estimated signs are consistent with the theory. Besides, the significant and negative sign of the depreciation rate is also consistent with the existence of currency substitution in Turkey. Based on the long-run model, the short-run model is estimated by simultaneous equation model. Results depict that the relationship between interest rate and money, as well as inflation and money comes into picture not only in the long-run both also in the short-run.

Keywords: Money Demand, Cointegration, Currency Substitution, Error Correction Modeling, Turkey

Kısa Özet

Para talabi Tahmini ve Para İkamesi: Türkiye'den Kanıt
İlknur Zer

Bu tezde, 1987Ç1-2003Ç3 zaman diliminde Türkiye'deki temel makroekonomik seriler arasındaki ilişkiler, uzun dönem ve kısa dönemde empirik olarak incelenmiştir. Bunun için paranın *M*1 tanımı, reel üretim ve paranın alternatif maliyetleri kullanılmıştır. Tez boyunca genişletilmiş portföy teorisi baz alınıp, serileri sırasıyla *I*(1) ve *I*(2) olarak düşünen iki farklı seneryo analizi yapılmıştır. Johensan kointegasyon analizi sonuçlarına göre uzun vade para dengesinin, teoriye uygun olarak, reel üretim, faiz oran farkı ve döviz kuru/döviz kuru değer kaybı ile açıklanabildiği ortaya çıkmıştır. Buna ek olarak, döviz kuru/ döviz kuru değer kaybının tahmin edilen katsayısının negatif ve anlamlı çıkması, Türkiye'deki görülen para ikamesiyle tutarlıdır. Uzun vadedeki model baz alınarak, simultane denklem modeli kullanılarak model kısa vade için tahmin edilmiştir. Sonuçlara göre,faiz oranı ve para arzı, enflasyon ve para arzı arasında ilişkinin sadece uzun vadede olmadığı, aynı zamanda kısa vadede de etkili olduğu ortaya çıkmıştır.

Anahtar Kelimeler: Para Talebi, Kointegrasyon, Para İkamesi, Hata Düzeltme Modeli(Error Correction Modeling), Türkiye

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1. Introduction

Since empirical money demand estimations are used by monetary authorities as a major tool in designing policies to influence real and monetary balances there has been a growing interest in developing macroeconomic models including inflation dynamics, exchange rate determination and money demand stability. Some of the works on money demand stability includes currency substitution. By following the definition of Calvo and Végh (1992) I will use the term "currency substitution" as the holding of foreign currency rather than domestic currency for some of the monetary services.[1] During periods of high and variable inflation and depreciation rate of currency, the opportunity cost of holding domestic currency is high. This will lead residents to use foreign currency for savings, and even for transactions. As Turkey can be treated as a small open economy with high inflation and unstable financial sector, we expect the Turkish residents to hold foreign currencies instead of domestic ones as an alternative for investment and for liquidity purposes. It has been argued that the currency substitution makes monetary targeting more difficult for monetary authorities; hence it is the main source of domestic money demand instabilities.

In this thesis, the hypothesis of the existence of stationary long-run money demand function in terms of currency substitution is tested by using the multivariate cointegration technique introduced by Johansen (1988) and Johansen and Juselius (1990). Main Turkish macroeconomics series for the period 1987Q1-2003Q3 has been used. An error correction model (ECM) is developed to study both short run and long run dynamic properties of the model.

[1] Note that, dollarization is defined as the denomination of assets in a foreign currency rather than the in the domestic currency.

Empirical evidence on currency substitution in the literature has been usually provided by estimating a money demand equation augmented by an exchange rate variable.[2] In addition to a variable that reflects the level of transactions in the economy, such as real income, another variable that represents the opportunity cost of holding money, such as the interest rate earned on other assets or the level of inflation should be included.

Akcay et al. (1997) focus on the estimation of the demand for domestic money in Turkey in the spirit of the portfolio balance model and test the presence of dollarization and its effects on exchange rate volatility. They use EGARCH-M model to model the exchange rate movements. Estimated expected depreciation is an evidence of dollarization. They also assert that the higher levels of dollarization lead to higher volatility of exchange rate.

Bahmani-Oskooee and Techaratanachai (2001) examine the currency substitution in Thailand by using *M*2 money balances using cointegration analysis. They find that the devaluation of the Thai bath will result in a decline in money balances.

Prock et al. (2003) investigate the extent of currency substitution in Argentina, Brazil and Mexico using a vector error correction (VEC) model. By using the link between *M*1 money balances and exchange rates - used to define currency substitution- they conclude that currency substitution occurs to a greater extent in Argentina and Brazil than Mexico.

Selcuk (2003) provides empirical evidence for currency substitution in seven emerging market economies in European periphery, including Turkey, by employing GMM estimation approach under money-in-the-utility-function framework. The study indicates that foreign currencies are strong substitutes for domestic currency in producing liquidity services for all of the countries. Circiv (2003) models the empirical relationship between the broader

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[2] See Akcay et al. (1997), Bahmani-Oskooee et al. (2001), Prock et al. (2003), Circiv (2003), and Chaisrisawatsuk et al. (2004).

definition of money, real income, inflation, interest rates, and expected depreciation rate for the period 1987-1999. The results from the cointegration analysis reveal that the long-run demand for real balances depends upon real income, on the its own interest rate, interest rates on government securities, inflation and expected exchange rates. The coefficient of the expected exchange rate variable found to be negative and significant, which indicates existence of currency substitution in Turkey.

Chaisrisawatsuk et al. (2004) study the issue of independent monetary policy and the stability of the domestic money demand function in the presence of currency substitution and capital mobility in five Asian economies using cointegration analysis. The results suggest that capital mobility and currency substitution are significant factors in the domestic money demand equations for Indonesia, Korea, Malaysia, Singapore, and Thailand.

The thesis is organized as follows; in Section 2, the main macroeconomic developments in Turkey are introduced. In Section 3, a cursory look on the currency substitution in Turkey is given. Money demand theory and arguments on variable selection are introduced in Section 4. Section 5 explains the statistical model, the data, and gives the preliminary empirical analysis. Since there is not a certain conclusion on the integration order of the variables used, two scenarios will be employed. Section 6 and Section 7 present the $I(1)$ and $I(2)$ scenarios respectively. The economic and statistical models are reconstructed, and the empirical findings for both long-run and short-run are reported for both scenarios. Section 8 concludes. Data issues are given at Appendix A. Unrestricted model results are presented in Appendix B.

2. Macroeconomic Developments in Turkey

During the last three decades the Turkish economy has experienced periods of high economic growth as well as severe economic crises. During these fluctuations, both internal economic conditions and external economic events played an important role.

Due to the developments in the world economy and the internal economic environment, the Turkish economy has been subject to inflation and low level of growth in GNP until 1980. In this period the Turkish economy can be summarized as having a restrictive monetary policy, negative real interest rates, contraction on real monetary aggregates, overvaluation of and severe shortage in foreign exchange and a high inflation rate. Therefore, at January 1980, a substantial stabilization and structural adjustment program was announced in order to gradually liberalize the economy, that is to integrate the domestic financial system with the international markets. Several reforms have been carried out including financial sector reforms and liberalization of capital account. The Turkish financial system was changed as a result of these reforms.

At the initial period of the 1980 reform program inflation was reduced to around 30 percent. In May 1981, the fixed exchange rate regime has been abandoned. Between the period of 1980-1982, the growth rate of GNP declined and the economy entered the recession with a high inflation rate. Both high real interest rates and high rates of depreciation of Turkish Lira resulted in a sizeable increase in the demand for money. A major step towards liberalizing the foreign exchange regime was taken in December 1983. Commercial banks were allowed to engage in foreign exchange operations and transactions in proportion to their foreign exchange liabilities. Finally, banks were allowed to open foreign currency deposit accounts to residents, and restrictions on foreign travel and investment from abroad were greatly loosened and simplified. The Turkish economy had experienced relatively higher and stable growth rates between 1984 and 1987. In 1987, Istanbul Stock Exchange has been established.

Throughout the period, positive real interest rates remained at low levels and the Turkish lira appreciated. These developments brought about a decline in the demand for money. However, inflationary pressures continued. Between 1988 and 1993 it fluctuated around 70 percent. Due to the instability in financial markets, the rate of growth of real GNP fell down sharply between 1988 and 1989. Real interest rates were generally negative and this caused a decline in the real money demand. In 1989, the transaction costs associated with acquiring foreign balances has been reduced. Therefore, portfolio changes become more responsive to the changes in relative returns on assets. Moreover, residents were allowed to invest abroad in cash up to US $5 million, or its equivalent in other currencies, through banks and special financial institutions. Residents in Turkey were allowed to secure foreign credits abroad in cash or in kind, provided that they used banks or special financial institutions as intermediaries. The widening of the possibilities of obtaining foreign balances may have increased the potential for currency substitution (OECD, 1994). On February 25, 1990 restrictions on foreign exchange were removed to a great extend. This development was considered as a step toward the convertibility of Turkish currency.

One of the currency crises was in April 1994. Celasun (1998) argues that huge requirements for public sector borrowing in 1993 and early 1994, combined with major policy errors in financing the deficit, led to the currency crash. As a result of interventions to control interest rates and Treasury borrowing at the same time, the market for domestic borrowing almost disappeared, the government turned to monetization for financing, and the value of the over appreciated Turkish lira plummeted. As a result of Turkey's currency crisis in 1994, output fell 6 percent, inflation rose to three-digit levels, the Central Bank lost half of its reserves, and the exchange rate (against the U.S. dollar) depreciated by more than half in the first three months of the year. A stand-by agreement with IMF and the re-functioning of the domestic debt market helped to reduce the strength of the crises, and inflation started to decline. After 1995 it fluctuated around 75 percent per annum (Circiv, 2003).

In August 1999, the economy suffered from the negative macroeconomic impacts of the Marmara earthquake. In December 1999, an exchange-rate-based stabilization program for 2000-2002 has been announced. The program was supplemented by fiscal adjustment and structural reform and was supported by IMF. After the announcement of the "Disinflation Program", a recovery was observed in the economic activities in Turkey. The recession experienced in the Turkish economy during 1999 also played an important role in this development. A sharp drop in real interest rates are observed because of the removal of uncertainties in the exchange rate with the adaptation of the program, the implementation of fiscal measures, and the improvement in Treasury's external borrowings. Falling interest rates created a wealth effect and caused a sharp rise in consumer credits. This in turn led to an increase in consumption expenditures. In addition to the decline in interest rates, the delayed consumption expenditures of 1999 were realized in 2000, thus contributing to GNP growth and an increase in imports. At the end of 2000, CPI and WPI inflation were realized as 39.0 percent and 32.7 percent respectively, and were brought down to the lowest levels of last 14 years (see Serdendecti (2001) for details). However, at November 2000 and February 2001, political infighting triggered two successive banking and currency crises. The crises have been attributed to a number of reasons, which include a fragile banking system and weaknesses in the structural fiscal adjustment (OECD 2002).

Alper (2001) points out three unfavorable external developments in 2000; hiking federal funds rate by 100 basis points in US, increasing oil price, and increasing the strength of the U.S. dollar vis-à-vis the euro. Those could have affected the success of the stabilization program. However, he argues that not the external factors, but the internal ones were the "crucial" source of the liquidity crisis in Turkey. The internal factors are given by: (1) unsuccessful government policies in maintaining the stream of good news and sustaining capital inflows, (2) not enough backing of the program by the IMF in terms of providing enough insurance against exchange rate risk, and (3) the "no sterilization" rule, which may be a "design flaw" in the program since it initially led to interest rate undershooting (see Alper (2001) for details).

The overnight interest rates rose exponentially to 5000%, and there had been a rapid depreciation of Turkish lira. Finally, at the end of February 2001, implementation of the new economic program started and the exchange rate was left to float.

The shift to the floating exchange rates at the end of February 2001 led to an increase in production costs and in public sector prices in March, and in turn the exchange rate depreciated in the course of 2000. Therefore, March inflation was realized at 6.1 percent in CPI and 10.1 percent in WPI. The price adjustments in public sector continued in April and CPI and WPI inflation were realized at 10.3 and 14.4, respectively.

In recent years, the Turkish economy is experiencing a recovery from the 2000-2001 crises, which correspond to one of the four deepest economic crisis episodes after 1950. During last year, inflationary expectations in the country are changing in a positive direction so inflation rate based on CPI for December 2004 has been calculated by 9.32% although the official target was 12%. Besides disinflation, the Turkish economy is also subject to high growth rates.

Hence, high levels of inflation and instability in the financial sector were some of the main economic problems for Turkey. Due to these adverse levels of inflation and considerable amount of the openness of the country, Turkish residents have been holding a considerable portion of their financial wealth in Euros (German mark before) or US dollars. In addition, foreign currency was held even for transactions purposes. This substitution of foreign currency for domestic currency would decline the domestic money holdings and could cause an economic slowdown and further worsen the impact of the economic crises.

3. A Brief Look on the Currency Substitution in Turkey

As argued in Section 2, high and variable levels of inflation, depreciation of the exchange rate and instability in the financial sector were some of the main economic problems for Turkey. During such a period, commercial banks were allowed to open foreign currency deposit accounts by 1983. Because of those effects, what we expect is to see the substitution of Turkish Lira with the foreign currencies.

The share of the foreign exchange deposits in *M2Y*,[3] which might be argued as an indicator of currency substitution, is graphed at the first panel of Figure 1. Similarly, the ratio of *M2Y/M2* presented as a second panel and finally the foreign exchange deposits in US (billion) dollars is presented at the third panel.

[3] M2Y=M2+FX Deposits, where M2=Currency in Circulation+Demand Deposits+Time Deposits

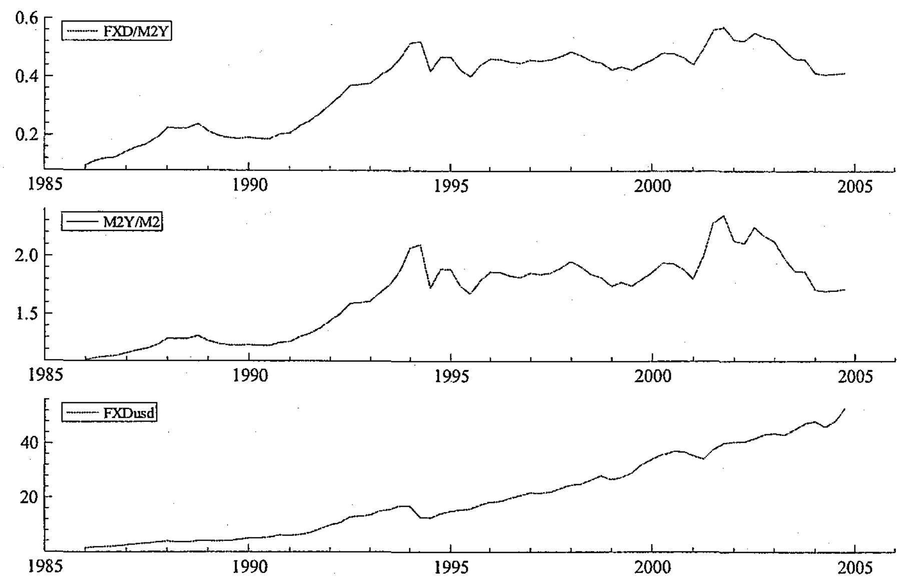

Figure 1: Some Indicators of Currency Substitution

As we can see from the first two panels, the degree of the currency substitution increased almost exponentially up to 1994 and has a spike at the second quarter of 1994. Because of the economic agents' confidence in the exchange rate based stabilization program, announced at the end of 1999, not only the FX deposits in USD terms but also the share of the FX deposits of M2Y started to decrease at 2000. However following the currency crises, FXD/M2Y has reached its peak in the fourth quarter of 2001 and follows a downward trend both in 2003 and 2004.

In numbers, the ratio of FX deposits to $M2Y$ that was hovering below 50%, surged to almost 60% level after the twin crises in November 2000 and February 2001. Then it started to decline again, falling to 54% as of end-2002 and 46% as of end-2003. As of end 2004, the ratio slipped further to 42%.

Increases in US dollar holdings, graphed at the last panel of Figure 1, may reflect either an increased demand for all monetary assets, or a substitution out of lira-dominated assets into dollar dominated assets at a given level of total monetary holdings.

Figure 2 plots the three different monetary aggregates for the given period, evaluated at real Turkish liras. *M*1 includes currency in circulation and demand deposits, *M*3 includes *M*2 as well as all lira public deposits. Following Kamin and Ericsson (2003),[4] I will also define "all monetary assets" as *M*3 and the dollar- denominated bank deposits converted to real lira terms. Moreover, since the scale of narrow money is smaller, to make the interpretation easier, I put the scale for the *M*1 on the right axis at Figure 3.

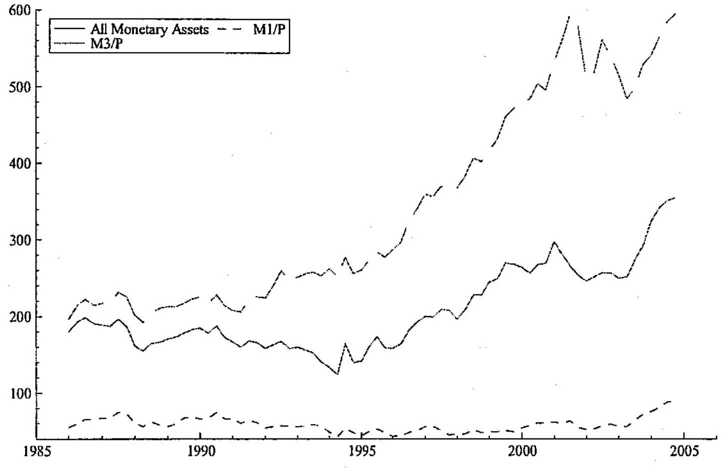

Figure 2: Real Holdings of Narrow money (M1/P), broad money (M3/P), and all monetary assets ([M3/P]+FX deposits($bn)*E/P) (trillion TL)

Figure 2 is consistent with the argument of the currency substitution, in the sense that a shift from lira-denominated assets to dollar-denominated assets clearly took place for the period 1990Q2-1994Q2, because while the local currency denominated assets has a decreasing trend, we have an increasing trend for the quantity of total financial assets.[5] Note that we also have a decreasing trend for the real M1 balances, which may be an indication of the shift of away from Turkish lira to dollars even for the transaction

[4] Here note that, although one needs to include both dollar currency and deposit holdings to have the complete figure of the "all monetary assets", such data is not available.

[5] The increase in the all monetary assets is 16% and the decrease for local-denominated ones is calculated as 30%.

purposes. However for the period 1994Q3-2000Q4, what we see is the increase of the local currency denominated assets, a zigzag shape for the $M1$ real balances as well as an increase in the overall financial assets. That is, there is not a clear evidence for the currency substitution, despite the indications by the other measures of the currency substitution presented at Figure 1. As the graph depicts, for the period 2001Q1-2002Q1, there is an evidence of currency substitution. The local currency denominated assets have a pike at 2001Q1 and started to decrease up to 2001Q3, whereas the overall quantity of financial asset holdings were increasing for that period. After that, both started to decrease until 2002Q1, but again the local currency holdings decreased much more than the overall assets.[6] The changes in the narrow money holdings are not clear, probably due to the lack of information of the dollar currency holdings. Then the reverse currency substitution started to take place.

Finally note that the spike at 2001 in the "all monetary assets" may be due to the real depreciation of the Turkish lira at the crisis period.

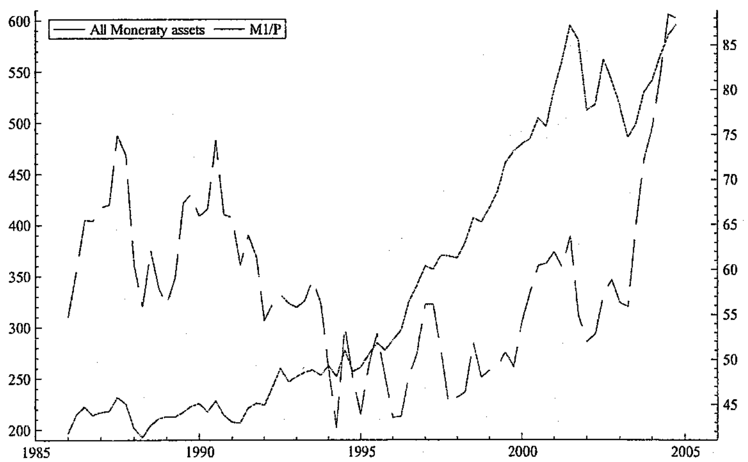

Figure 3

[6] The percentage decrease for the lira-denominated assets was 7.5%, whereas it is calculated as 2.3% for the overall assets.

4. Money Demand Theory, Variable Selection

The simple money demand function states that the demand for money depends upon a variable that reflects the level of transactions in the economy, such as real income and another variable that represents the opportunity cost of holding money, such as the interest rate earned on other assets and/or the level of inflation.

Following the discussion above, the extended portfolio balance theory of money demand function will be employed in this thesis. To estimate a meaningful money demand function, the choice of an appropriate monetary aggregate is complicated. Either a broad or a narrow definition of money can be used as the monetary variable. In the Turkish literature, different definitions of money are used in order to determine the long-run equation for money demand. Circiv (2003) used $M3$ definition of money; Akcay et al. (1997) focused on the $M1$ definition of money as a proxy for currency substitution; Akıncı (2004) uses even the narrower definition of money, namely currency issued by CB to estimate a stable money demand function for Turkey; Selcuk (2003) adopts money-in-the-utility function framework and uses $M2$ definition of money to conclude the existence of currency substitution in different countries in European periphery. Generally it may be argued that a narrow definition of money (like monetary base or $M1$) tends to be more flexible and reactive to market operations. Narrow money can have a close relationship with prices and interest rate policies since it can easily be influenced by economic variables, however it cannot always be adequate to capture all the information related to the financial system. A broader definition of money, such as $M2$ or $M2X$ or $M3$, on the other hand, can comprise a wider range of the financial system, however it may be less sensitive to the changes in the economy. This thesis adopts the definition of currency substitution used by Akcay et al. (1997) and Calvo and Vegh (1992) focusing on the $M1$ definition of money to test for currency substitution[7].

To proxy the transactions, either Gross National Product (GNP) or Gross Domestic Product (GDP) can be used. In some studies, Industrial Production Index (IPI) is also used because of the nonavailability of the higher frequency data. Here, GDP is used in order to proxy the transactions. Since the amount transactions are proportional to income, the demand for money is expected to be directly proportional to income.

Measuring the rate of return and the opportunity cost of holding money is also important. Returns on monetary aggregates and on alternative assets have to be considered. 3-month interest rates on deposits is thought to be the nominal return on money and its sign on the money demand equation is expected to be positive. On the other hand, yields on government securities, i.e. 3-month Treasury bill interest rate is used to proxy the return on other assets. Following Felmingham et al. (2001), and Doornik et al. (1998) I will use the interest rate spread that is the spread between the return on bonds and money to capture the opportunity cost of money directly.

Not only the relationship between the price level and money demand, but also the relationship between the inflation rate and money holdings has been studied widely. As noted in Section 2, Turkish economy is subject to high level of prices and variability in prices, so price level or inflation becomes an important determinant of money demand. For the economies suffering from high inflation, it is better to include rate of inflation and the rate of exchange rate because goods and foreign assets can be substituted for domestic currency (Abel et al. (1979)). An increase in the expected inflation rate would lead to a decrease in money demand because the opportunity cost of holding money increases.

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[7] I also tried to work with $M2$ definition of money, however the cointegration results were not satisfactory.

Since foreign currency denominated assets forms an appropriate investment alternative for the countries experience high inflation and economic instability, expected exchange rate could be included in the demand equation to capture the opportunity cost of holding domestic money. To define currency substitution, the link between exchange rates and money demand has been used in the literature. Prock et al. (2003) and Bahmani-Oskooee et al. (2001) use the coeffecient of nominal effective exchange rate in the $M1$ and $M2$ money demand functions respectively to figure out currency substitution. On the other hand, Chaisrisawatsuk et al.(2004) and Circiv (2003) predict that the evidence of currency substitution is given by the coefficient of the expected depreciation rate of the domestic currency. According to the currency substitution literature, when the exchange rate is expected to depreciate, the expected return from holding foreign money increases, and the demand for domestic currency falls (as individuals substitute foreign money for domestic currency). That is why; the expected exchange rate is included in the model in order to investigate the currency substitution.

5. Formulation of the Statistical Problem

In order to investigate the empirical relationship between money, income, price level, interest rates, and exchange rate, vector autoregression (VAR) analysis is employed. The objective is to find an empirically well-behaved specification as the starting point for cointegration analysis. The statistical model and the data will be given below. Furthermore, the preliminary empirical analyses are presented.

5.1. The Statistical Model

The VAR model of order k with p endogenous variables is given by

$$x_t = \Pi_1 x_{t-1} + \ldots + \Pi_k x_{t-k} + \varphi D_t + \mu + \varepsilon_t, \qquad t = 1,\ldots T \qquad (1)$$

Where x_t is the $px1$ vector of variables observed at time t $\Pi_1, \Pi_2, \ldots, \Pi_k$ are pxp matrices of parameters and D_t is a vector of deterministic terms and ε_t is the $px1$ vector i.i.d. Gaussian innovations, i. $\varepsilon_t \sim N(0,\Omega)$.

An error correction representation of the $VAR(k)$ model is then

$$\Delta x_t = \Pi x_{t-1} + \sum \Gamma_i \Delta x_{t-i} + \varphi D_t + \sum \mu_i + \varepsilon_t, \qquad t = 1,\ldots T \qquad (2)$$

with $\Pi = -(I - \Pi_1 - \ldots - \Pi_k)$ and $\Gamma_i = -\Pi_2$

5.2. The Data

The data used in the analysis are quarterly and seasonally unadjusted, time series over 1987:1 to 2003:3 on m, p, y, e, R_b, and R_m for Turkey.

M	nominal *M1*
P	the consumer price index at *2000* prices
Y	real GDP, at *2000* factor costs
E	nominal market exchange rate Turkish Lira per US Dollar
R_b	compound three-month Treasury bill rate
R_m	three-month interest rates on deposits
R_s	$R_b - R_m$

Data series, sources and the graphical representation of the transformed series used in the cointegration analysis are presented at Table A1, Figures A1 and A2 in Appendix A.

5.3. Preliminary Empirical Analysis

By looking at the graphical representation of the transformed series in levels, one can conclude that all of the series, except the interest rate differential exhibit positive trend and all series appear to be nonstationary at levels. There is a clear seasonality effect in real output. Besides, we expect some seasonality in price and money series, although they are not that clear from the graphs.[8]

The price index, exchange rate and money have very smooth graphs indication of $I(2)$ behavior. Interest rates, output and real money seem to be mean reverting in the first differences.

When we look at the first differences of the Turkish nominal series, we can clearly see the spikes. Generally speaking spikes at 1994 and also at the beginning of 2001 is due to the currency crises of 1994 and 2000&2001. Besides, the level shifts occurred, possibly because of the crises, especially at the price and exchange rate series can be seen. Those shifts may be an evidence of policy changes in the economy. After 2001 crises, the exchange rate policy has been swiched to the floating regime and some kind of official inflation targeting has been started. However, exact policy changes did not occur after 1994 crises, but the effects of the crises were not transitory.

In addition, the spikes at the beginning of the data may be due to the interest rate intervention during 1988-89 periods. After 2001, there is an appreciation of Turkish Lira and clear decrease inflation, and interest rates, may be the help of the stand-by agreements made with IMF.

Note that the interest rate spread is positive at all the periods except 2000. This is mainly because of the liquidity problems at the banking system. The last panels of Figure A4 and Figure A5 give the real money in level and first differences respectively. The growth rate of real money exhibits a typical $I(0)$ behavior, implying the level is $I(1)$.

[8] Formal seasonality tests have been applied for series by using X-12 ARIMA method. Seasonality of real output, price series and money are accepted by all of the tests.

Cointegration analysis requires all of the variables to be integrated of order 1, hence the degree of integratedness of the series is checked by formal unit root tests, however a certain conclusion cannot be reached. Augmented Dickey Fuller, and Phillips Perron unit root tests conclude that the price level and money are $I(1)$, however Elliot-Rotenberg-Stock Point Optimal Test results suggests that the series are $I(2)$. Whether the inflation should be treated as $I(1)$ or $I(0)$ has been subject to much debate. Inflation being $I(1)$ with a nonzero mean, corresponds to prices to be $I(2)$ with linear trends. That is,

$$p_t = \sum_{s=1}^{t} \pi_s + p_0 = \sum_{s=1}^{t} \sum_{i=1}^{s} \varepsilon_i + \pi_0 t + p_0 \tag{3}$$

Treating inflation as $I(1)$, is consistent with accepting the inflationary shocks strongly persistent. However, there are several papers in the literature that shows that in the presence of trend and/or structural changes, both long memory and nonstationarity will lead to the rejection of the of the null of short memory, that is the series is $I(0)$ (see for details Giraitis (2001), Kontonikas (2004)).

That is why, I will present two different scenarios, treating price level and money demand as $I(1)$ and $I(2)$ respectively.

6. The I(1) Scenario

In this section, I will treat the money, price and exchange rate series as $I(1)$. The economic and the statistical model are presented. The expected long run relations based on the theory will follow up. The statistical properties of the model are checked. Finally the long-run and short-run model estimates are given.

6.1. The Economic Model

The equilibrium in the money market occurs when money demand equals money supply. That is;

$$M/P=L(R,Y^r)$$

Where, Y denotes for transactions and R denotes the return on money. In accordance with foregoing, the set of variables in the money balance equation should be extended so as to capture all costs of holding money. More specifically, exchange rate and the return on other assets have to be included in the money balance equation. Hence the extended money demand function based on the portfolio theory of money demand can be written as,

$$M/P=L(R_m, R_b, Y^r, E)$$

or, in the log-linear form,

$$m_t = \beta_0 + \beta_1 p_t + \beta_2 y^r{}_t + \beta_3 R_{S_t} + \beta_4 e_t + \varepsilon_t \qquad (4)$$

where m is the logarithm of nominal money, p is the logarithm of the price level, y^r is the logarithm real income, R_S is the interest rate spread,[9] e is the logarithm of the exchange rate.[10] The expected signs of the coefficients are $\beta_1 < 0, \beta_2 > 0, \beta_3 < 0$, $\beta_4 < 0$. That is, whenever income increases, we expect the demand for real balances also increases. On the other hand, money demand is supposed to be inversely related to the price level and the interest rate spread. The increase in the exchange rate, in other words the depreciation of the currency, would lead to a decrease in the money holdings because of the opportunity cost of holding domestic currency will increase. Hence β_4 is expected to be negative.

[9] In order to be consistent for the scales of the variables, interest rate spread is calculated as follows: $R_S=R_b/400-R_m/400$

[10] Exchange rate will be defined as the Turkish Lira per US dollars (TL/\$), hence an increase indicates the depreciation of Turkish Lira.

6.2. The Statistical Model

The representation of the vector process becomes[11]

$$\begin{pmatrix} m_t \\ e_t \\ p_t \\ y^r{}_t \\ R_{S_t} \end{pmatrix} = \begin{pmatrix} c_{11} & d_{12} \\ c_{21} & d_{22} \\ c_{31} & d_{32} \\ 0 & d_{42} \\ 0 & d_{52} \end{pmatrix} \begin{pmatrix} \sum u_{1t} \\ \sum u_{2t} \end{pmatrix} + \begin{pmatrix} g_1 \\ g_2 \\ g_3 \\ g_4 \\ 0 \end{pmatrix} t + stat.comp. \tag{5}$$

where, $\sum u_{1t}$ denotes once cumulated nominal shocks, and $\sum u_{2t}$ denotes once cumulated real shocks. The trend component, t, is present in the model because all of the level series, other than the interest rate spread exhibits positive trend. Note that there is no twice cumulated nominal shocks (see the $I(2)$ scenario presented in Section 7.2. for details).

Hence, money, exchange rate, and prices can be rewritten as,

$$\begin{aligned} m_t &= c_{11}\sum u_{1t} + d_{12}\sum u_{2t} + g_1 t + stat.comp. \\ e_t &= c_{21}\sum u_{1t} + d_{22}\sum u_{2t} + g_2 t + stat.comp. \\ p_t &= c_{31}\sum u_{1t} + d_{32}\sum u_{2t} + g_3 t + stat.comp. \end{aligned}$$

6.3. Expected Long-Run Relations, Some Theoretical Background

The trilogy of open capital markets states that the pegged exchange rate regime and the autonomous monetary policy are inconsistent for the liberalized economies. As argued in Section 2, although the pegged, at least the managed floating exchange rate regime has been used up to 1994, and an exchange-rate-based stabilization program was in place for 2000, after 2001, the floating exchange rate regime has been implemented. Hence the trilogy of

[11] see Juselius(2004) for details

open capital markets is not the fact in Turkish economy for the period under consideration.[12] This would indicate that I can locate a money demand function that is endogenous in the system. It is plausible to explain the real money instead of nominal one since I am using real output in my model. Hence testing the long-run stationarity of the real money balances in terms of opportunity costs (the exchange rate and the interest rate spread) as well as income is subject to consideration. That is,

$$(m_t - p_t) + a_1 y^r{}_t + a_2 e_t + a_3 R_{S_t} \sim I(0) \qquad (6)$$

Besides, it is also consistent with monetarists to check whether the inverse velocity forms a cointegration relation with the opportunity costs of money. i.e. by imposing a restriction on the real output, we can have,

$$(m_t - p_t - y^r{}_t) + \alpha_1 e_t + \alpha_2 R_{S_t} \sim I(0) \qquad (7)$$

To express the equations (6) and (7) as money demand equations, signs for the opportunity costs should be positive. Otherwise, it can be interpreted as a policy function.

Between the given series, one might also expect to find a long-run relation which explains the output gap. What we expect is the reaction of the output to the interest rate spread, even in the long-run.[13] That is;

$$(y^r{}_t - b_1 trend) + b_2 R_{S_t} \sim I(0) \qquad (8)$$

[12] One has to cautious with the interpretation here. It has been argued by many, including Levy-Yeyati and Sturzenegger (2003) that a country's stated exchange rate regime, that is, de jure exchange rate regime, and its implemented exchange rate policies, that is, de facto exchange rate regime do not coincide at all times due to various reasons such as the "fear of floating" (see Calvo and Reinhard (2002)). Although the Turkish monetary authorities claim that the lira is floating, the regime might be closer to a managed float. However, Ardic & Selcuk (2005) argue that between March 2001-October 2003, the Central Bank of the Republic of Turkey has conducted policies that are in line with free float.

[13] See for instance Estralla et al. (1991). They find that a 1% increase in the spread between the long-term and short-term rates will lead to 1% growth in output a year later.

6.4. Length Determination and the Construction of the Model

To test the validity of the lag length,I perform two tests; the likelihood ratio test and information criteria. Table 1 reports the likelihood ratio (LR) tests where I start with *k*=4 and check whether it is feasible to reduce the number of lags.

Table 1: LR Test for Lag Determination

Lag Deletions	*F*-Statistics (p-Value)
k=4→k=3	F(35,99)=1.0604[0.3992]
k=4→k=2	F(70,113)=1.0471[0.4088]
k=4→k=1	F(105,117)=1.2859[0.0927]
k=3→k=2	F(35,128)=1.0233[0.4456]
k=3→k=1	F(70,146)=1.3834[0.0520]
k=2→k=1	F(35,158)=1.7492[0.0111]*

Although reducing the lag from 3 to 1 and 4 to 1 are borderline accepted, likelihood ratio test results generate the evidence of the optimal lag length as 2, because reducing the lag from 2 to 1 is rejected.

Table 2 reports the Akaike, the Schwartz and the Hannan-Quinn information criteria.

Table 2: Information Criteria for Lag Determination

	SBC	*HQ*	*AIC*
k=4	-12.489	-16.204	-18.612
k=3	-13.454	-16.446	-18.386
k=2	-14.722	-16.992	**-18.464**
k=1	**-15.647**	**-17.195**	-18.198

Information criteria give conflicting results.

Second lag length allows for different short-run effects within the statistical model while the first lag only allows for adjustment towards long-run equilibrium. Hence based on the test results and purpose of the study, k=2 is chosen. Hence equation 2 can be rewritten for the VAR(2) model is as follows;

$$\Delta x_t = \Gamma \Delta x_{t-1} + \alpha\beta' \tilde{x}_{t-1} + \phi D_t + \mu + \varepsilon_t \tag{9}$$

That is,

$$\begin{pmatrix} \Delta m_t \\ \Delta y^r{}_t \\ \Delta e_t \\ \Delta p_t \\ \Delta R_{S_t} \end{pmatrix} = \Gamma \begin{pmatrix} \Delta m_{t-1} \\ \Delta y^r{}_{t-1} \\ \Delta e_{t-1} \\ \Delta p_{t-1} \\ \Delta R_{S_{t-1}} \end{pmatrix} + \Pi \begin{pmatrix} m_{t-1} \\ y^r{}_{t-1} \\ e_{t-1} \\ p_{t-1} \\ R_{S_{t-1}} \\ D_S 94_{t-1} \\ D_S 00_{t-1} \\ trend \end{pmatrix} + \phi D_t + \mu + \varepsilon_t, \qquad t = 1,...,T, \;\; \varepsilon_t \sim N(0,\Omega) \tag{10}$$

D_t contains the seasonal dummies and a blip dummy, namely D_p01. Besides, we have two shift dummies and trend included in the cointegration space. Trend is included because all of the series except the interest rate spread has trending behavior. The shift dummies are used to capture the effects of the two currency crises held in 1994 and 2000 &2001. Allowing those dummies to be in the cointegration space means allowing for the broken trends, ie. level shifts.[14] It can be argued that the permanent effects of the currency crises can be captured in this way.

The dummies are defined as;

D_s94_t =1 for t=1994:2,...,2003:3, and 0 otherwise.

[14] See for instance Lutkepohl et al. (1998). They model the demand for M3 in the Unified Germany by taking account the structural break at 1990 because of German unification. Felmingham et al. (2001) use also a shift dummy to capture the 1991 deep recession in Australia.

$D_s00_t = 1$ for t=2000:4,...,2003:3, and 0 otherwise.

$D_p01_t = 1$ for t=2001:2, and 0 otherwise.

The unrestricted model estimates are given in Appendix B. From the long-run estimates one can see that all of the variables, including trend and shift dummies are significant at least for one of the variables. Estimated short-run parameters are also given in Table B2 in Appendix B. The results depict that the seasonal dummies are highly significant for real output. Besides, the blip dummy is highly significant for the exchange rate and the price level with t-values 5.2842 and 5.5112 respectively. Finally, an examination of the results shows that the shift dummies are significant not only in the long-run, but also in the short-run (i.e. their lags) especially for the interest rate spread, the exchange rate and the price series.

6.5. Misspecification Tests

In order to check whether the estimated model is well-specified, it is essential to test for potential autocorrelation, normality and ARCH effects. Table 3 presents the specification tests for the unrestricted VAR model with dummies.

Table 3: Specification tests for the unrestricted VAR(2) model with dummies

Multivariate Tests:						
Residual Autocorrelations:						
		LM_1:	$\chi^2(25)$=	23.7356	p.val.	0.535
		LM_4:	$\chi^2(25)$=	36.1736	p.val.	0.069
Normality:						
		LM:	$\chi^2(10)$=	11.9264	p.val.	0.290
Univariate Tests						
		m	*e*	*p*	*Y*	*Rs*
ARCH 1-4:	$F(4,35)$=	0.19448 [0.9396]	1.0532 [0.3941]	0.79085 [0.5391]	0.25955 [0.9018]	0.42646 [0.7885]
AR 1-4:	$F(4,39)$=	0.83999 [0.5083]	0.82418 [0.5178]	0.89494 [0.4762]	1.4909 [0.2237]	0.77246 [0.5498]
Jarq.Bera:	$\chi^2(2)$=	1.1132 [0.5732]	7.4897 [0.0236]*	0.9965 [0.6076]	0.2048 [0.9026]	2.9817 [0.2252]
Skewness		-0.0445	0.1115	0.2212	-0.0974	0.3429
Kurtosis		3.1980	4.2269	2.5321	2.8391	3.5727
Std. Deviation		0.0412	0.0422	0.0185	0.0310	0.0233

The null of no autocorrelation cannot be rejected not only for all of the variables univaritely, but also as a vector test. Testing for normality is done by testing each of the system residual series, and the univariate tests are based on the skewness and kurtosis estimates of the residuals with small sample corrections. Besides a minor problem for the exchange rate series, the model also passed from the normality tests. Note that the nonnormality of the exchange rate is mainly because of the excess kurtosis.

6.6. Rank Determination

The cointegration rank divides the data into *r* relations (equilibrium errors) towards which the process is adjusting and *p-r* relations which are pushing the process. Hence the choice of r would influence all subsequent econometric analysis and might be crucial for whether we accept or reject our prior economic hypothesis (see Juselius (2003) for details). As argued in Section 6.3. we expect at least two cointegration relations based on the economic theory. Besides, the rank of the system has been checked by the formal trace test.[15] The *LR* test, so called the trace test, for cointegration rank r is given by,

$$\tau(p-r) = -2\ln Q(H_r/H_p) = T\sum_{i=r+1}^{p}\ln(1-\hat{\lambda}_i) \tag{11}$$

Table 4 gives the results.

Table 4: The trace test, the eigenvalue roots and the 5 largest modulus of the model

p-r	r	λ_r	$\tau(p\text{-}r)$	$\tau^*(p\text{-}r)$ (Brt. Cor.)	$C^{sim}_{.95}$	r=5	r=4	r=3	r=2	r=1
5	0	0.5936	157.5116	133.7085	110.0590	0.9001	1.0000	1.0000	1.0000	1.0000
4	1	0.4762	98.9809	83.7373	81.6344	0.7523	0.9593	1.0000	1.0000	1.0000
3	2	0.3954	56.9480	28.5680	56.8961	0.7523	0.3446	0.9516	1.0000	1.0000
2	3	0.2279	24.2413	13.9063	35.9443	0.3367	0.3446	0.3900	0.9622	1.0000
1	4	0.1080	7.4266	4.3896	18.1119	0.3367	0.4638	0.3900	0.0816	0.7342

Asymptotic distributions depend on whether there is a constant and/or trend in the VAR model and whether they are restricted or not. Hence the usual trace test results take into account this deterministic component of the model. However, other deterministic components, such as the intervention dummies, are also likely to influence the shape of the distribution and hence asymptotic results (for details see Juselius (2003)). Since I am using shift dummies in my analysis, the 95% critical values are obtained by a simulation program runs in CATS supplied by H. B. Nielsen. Based on the trace test results, the cointegration rank

[15] For discussions on maximum eigenvalue test, see for instance Lütkepohl et al. (2001).

3 is borderline accepted. However, the small sample Barlett corrections test results (see Johansen (2002) for details) indicates that the cointegration rank is 2.

Johansen (2002) finds that the power of the trace test can be very low for relevant alternative hypotheses in the neighborhood of the unit circle, hence when assessing the appropriateness of the asymptotic tables to determine the cointegration rank, one need to consider not only the sample size, but also the short-run dynamics. Hence Juselius (2003) advises to use as much as additional information as possible. That is why, I also use the roots of the companion matrix to determine the rank. If the r^{th}+1 cointegration vector is nonstationary and even included in the model, then the largest characteristic root will be close to the unit circle. Hence a correct choice of the cointegrating rank would correspond to the largest unrestricted root not being very close to the unit circle. We have 0.9516 for rank 3 and 0.9622 for rank 2, quite similar and unfortunately close to unity.[16]

The unrestricted VAR results for all five α and β vectors are given in Appendix B. When we look at the significance of the adjustment coefficients for the third relation, we can see that the adjustment coefficients $\alpha_{3,1}$, $\alpha_{3,3}$, $\alpha_{3,4}$ are quite significant indicate the equilibrium correcting behavior of money, price level and output. Thus, a choice of rank three would be consistent with the short-run dynamic properties of the system.

The recursive graphs of the trace test statistics is given below.

[16] Note that the examination of the roots also gives a signal of I(2)ness. Because the roots are jumping.

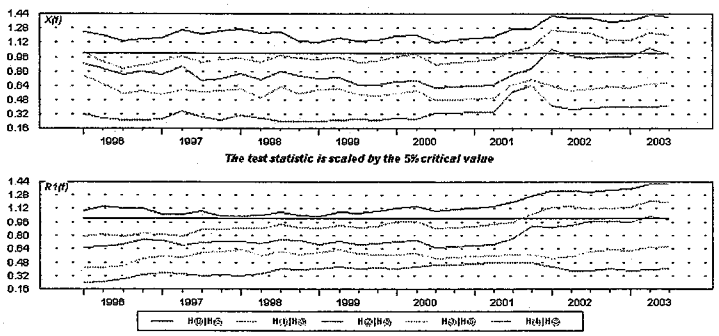


Figure 4: Recursively Estimated Trace Test

Upper panel of Figure 4 is based on the recursive estimation of the full model, whereas the lower panel is based on the '*R*-form'. By the '*R*-form' we mean the concentrated cointegrated VAR model where the short-run dynamics and dummy variables have been concentrated out. When the sample size is small, making the analysis based on the full model can lead to problems in inference from the graphs. So that, in general, the concentrated model is preferred. The recursive graphs of the trace test can provide an information of whether the cointegration relations are reasonably constant or not. If α_i and β_i are reasonably constant, then eigenvalue, λ_i, will also be constant and $-t_l\ln(1-\lambda_i)$ will grow linearly (see Juselius (2003) for details). The lower panel clearly indicates that the first three lines have trends hence the cointegration rank is three.

To sum up, I choose rank as three.

6.7. Recursive Tests of Constancy

Although the model passed the misspecification tests, we also need to exclude the possibility that the model suffers from parameter non-constancy. We can check this using a number of diagnostic tests. There are two versions of those tests. One version depends on the general ECM modeling. The other one depends on the '*R*-form' model which has been the concentrated modeling described above. Instabilities of the short run parameters may affect the recursive graphs of the first representation. However those effects are averaged at the concentrated model, that is why the focus will be on the '*R*-form' (see Juselius(2003) Chapter 9).

Figure 5 represents the recursively calculated log-likelihood test. It is a general test for constancy of all parameters. Like Chow structural break test, it is based on the residuals. The graph indicates that the calculated log-likelihood lies within the 95% confidence bands for period 1996:4-2003:3.

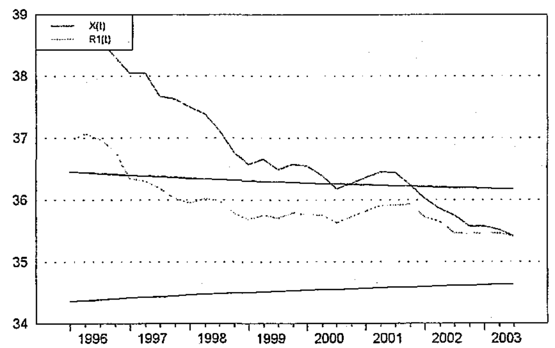
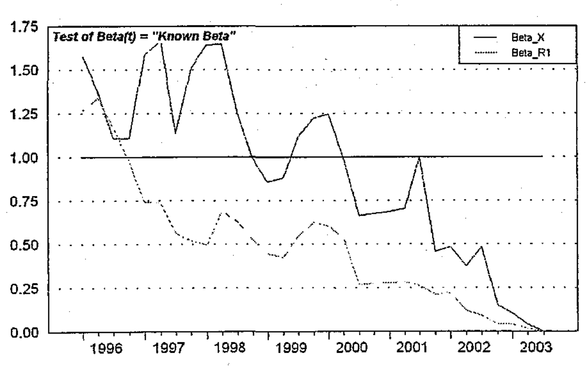


Figure 5: Recursively Calculated Log-Likelihood

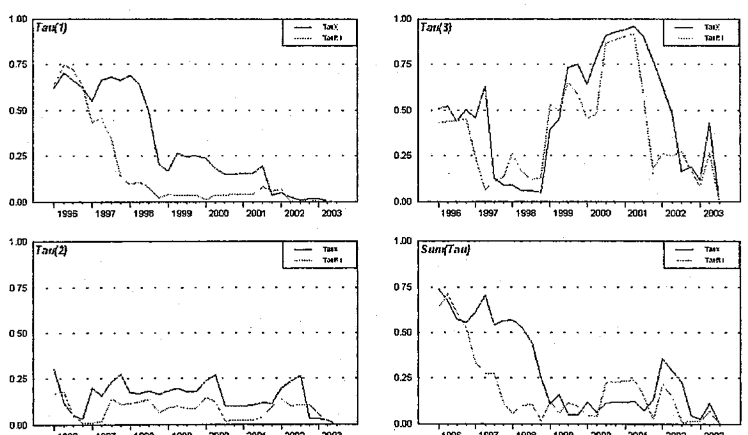


The test statistic is scaled by the 5% critical value

Figure 6: Test of Beta

The second test, namely the test of beta, tests whether the estimated beta based on the base sample is likely to remain constant when the period is extended. In this test, the β is estimated for a given sample (whole period in this case) and the period is expanding recursively. Note that the test is scaled by the %5 critical level. Hence, a value higher than 1.0 indicates instability. As shown in Figure 6, we only have some problems at the very beginning of the sample.

Since we can write $diag(\hat{\lambda}_1,...,\hat{\lambda}_r) = \hat{\beta}' S_{10} S^{-1}_{00} S_{01} \hat{\beta} = \hat{\alpha}' S^{-1}_{00} \hat{\alpha}$, where, $S_{ij} = T^{-1} \sum_t R_{it} R'_{jt}$ and the concentrated model is given by, $R_{0t} = \alpha\beta' R_{1t} + \varepsilon_t$, the stabilities of both α and β implies the stabilities of the eigenvalues λ. Therefore, the recursively calculated fluctuation test of the eigenvalues, given at Figure 7, measures the stability of the eigenvalues for each of the three cointegrating relationships. It provides clear evidence that the estimated eigenvalues stay within the lowest of the upper bands and the highest of the lower bands for all periods. The overall test in the bottom right panel also does not reject constancy for any value of t.[17]



The test statistic is scaled by the 5% critical value

Figure 7: Fluctuation Test of the Eigenvalues

Hence, we can conclude that our model also passed from the parameter constancy and it is statistically well specified and thus is a valid basis for the cointegration analysis.

[17] Note that τ_1, τ_2 and τ_3 represent the first, second and third cointegration relations respectively.

6.8. Testing Simple Hypotheses on α and β

The next step is to test simple hypotheses on α and β. Table 5 shows the test results for long run variable exclusion, stationarity and weak exogenity for the chosen rank, 3.

Table 5: Testing Simple Hypotheses on α and β

	Test for long-run exclusion	Test for stationarity	Test for weak exogenity
m	$\chi^2(3)$=29.0913 [0.0000]	$\chi^2(5)$=27.7535[0.0000]	$\chi^2(3)$=14.8671 [0.0019]
e	$\chi^2(3)$=9.2882[0.0257]	$\chi^2(5)$=27.2505[0.0001]	$\chi^2(3)$=12.3656[0.0062]
p	$\chi^2(3)$=16.0898[0.0011]	$\chi^2(5)$=27.8463[0.0000]	$\chi^2(3)$=21.5948[0.0001]
y	$\chi^2(3)$=13.5642[0.0036]	$\chi^2(5)$=28.5457[0.0000]	$\chi^2(3)$=12.5935[0.0056]
Rs	$\chi^2(3)$=35.2685[0.0000]	$\chi^2(5)$=24.8407[0.0001]	$\chi^2(3)$=25.4556[0.0000]
D_s94	$\chi^2(3)$=12.0161[0.0073]		
D_s00	$\chi^2(3)$=8.0120[0.0458]		
trend	$\chi^2(3)$=1.6211[0.6546]		

First, we conduct the null hypothesis that any given endogenous variable can be excluded from the three steady state relations, hence the variable is not needed in the cointegration space. The test for exclusion also supports the significance of the shift dummies in the long-run relations. However, it generates evidence suggesting that the restricted trend is not needed and can be omitted from the long-run relations. However, as the graphs indicate, all of the series except the interest rate spread are trended. Some caution is needed here because the potential collinearity between the variables might biasing the results. That is why, I will continue on using the statistical model given by equation (10).

Test for stationarity, without including the trend and shift dummies, is significant for all variables. That is, non of the variables are $I(0)$. Finally the test for weak exogenity, that is hypothesizing a variable has influenced the long-run stochastic path of the other variables while has no influence on them, is reported. Results suggest that none of the variables are weakly exogenous. This means that, I can reach a possible money demand equation from the system as argued in the third part.

6.8. Long-Run Identification

Our task is to impose relevant restrictions on the coefficients to achieve economically meaningful relations. To achieve exact identification, one needs to impose at least r-1 restrictions on each of the cointegration relations. Hence in my model, for r=3, I have to impose at least two restrictions. Formally,

$$rank(R'_1\beta_1, R'_1\beta_2, R'_1\beta_3) \geq 2$$
$$rank(R'_2\beta_1, R'_2\beta_2, R'_2\beta_3) \geq 2$$
$$rank(R'_3\beta_1, R'_3\beta_2, R'_3\beta_3) \geq 2$$

where, R_i denotes the $p_1 x m_i$ (m_i being the number of restrictions) restriction matrix. Note that the cointegrating relations are assumed to satisfy the restrictions $R'_i\beta_i = 0$. The system is exactly identified if the rank condition holds with equality and $m_i = r-1$. Similarly, overidentified if it is identified and rank $R'_i\beta_i > r-1$ and $m_i > r-1$ for at least one i (Johansen 1996).

Following the arguments in Section 6.3., I first check the stationarity of money velocity, that is money, prices and income have common movements. The stationarity of the velocity with shift dummies and trend is strongly rejected by $\chi^2(12)$=78.3168 with a p-value of 0.0000. Therefore more realistic assumptions of velocity are taken into consideration. I consider the cases where the interest rate spread and also the exchange rate are cointegrating with the velocity. i.e.

$$(m_t - p_t - y_t) + b_1 R_{S_t} + b_2 e_t \sim I(0) \tag{12}$$

If $b_1 > 0$, then (12) can be interpreted as a money demand equation because it means that when the opportunity cost of holding money increases, holdings decrease. The expected sign of b_2 is again positive as argued before.

Second, given the series, I try to reach an equation for the output gap. Finally the stationarity of the interest rate spread is taken into consideration. The β vector can be written as;

$$\beta' = \begin{pmatrix} 0 & 0 & 0 & 1 & \beta_{16} & 0 & 0 & \beta_{18} \\ 1 & \beta_{22} & -1 & -1 & \beta_{26} & \beta_{27} & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & \beta_{37} & \beta_{38} & 0 \end{pmatrix}$$

Table 6 reports identified long-run structure.

Table 6: Identified Long-Run Structure (t-values in brackets)

	M	e	p	y	R_S	D_s94	D_s00	$trend$
β'_1	0.0000 [0.0000]	0.0000 [0.0000]	0.0000 [0.0000]	1.0000 [0.0000]	0.4928 [3.0697]	0.0000 [0.0000]	0.0000 [0.0000]	-0.0102 [-25.9072]
β'_2	1.0000 [0.0000]	0.1423 [12.4868]	-1.0000 [0.0000]	-1.0000 [0.0000]	1.1183 [3.3561]	-0.1644 [-2.8047]	0.0000 [0.0000]	0.0000 [0.0000]
β'_3	0.0000 [0.0000]	0.0000 [0.0000]	0.0000 [0.0000]	0.0000 [0.0000]	1.0000 [0.0000]	-0.0288 [-2.2311]	-0.1095 [-6.4688]	0.0000 [0.0000]

Loadings: α_i (t-values in brackets)

	α_1	α_2	α_3
Δm	-0.7402 [-3.9121]	-0.3572 [-4.2862]	0.2583 [1.6858]
Δe	0.5085 [2.5135]	0.0723 [0.8110]	0.2378 [1.4516]
Δp	0.3033 [3.3909]	0.0850 [2.1578]	0.1792 [2.4746]
Δy	-0.6030 [-4.2521]	-0.0589 [-0.9432]	0.4055 [3.5312]
ΔR_s	0.1102 [0.9706]	-0.1274 [-2.5482]	-0.4719 [-5.1329]

The corresponding LR statistic for the over identification restriction is $\chi^2(8)=9.7936$ has a p-value of 0.2798.

The first cointegration relation corresponds to an output gap equation in which the output gap, the excess demand for goods and services, is reacting to the interest rate spread. That is (t-values given in parentheses),

$$y_t - \underset{(-25.9072)}{0.0102}\, trend = -\underset{(-3.0697)}{0.4928}\, R_{S_t} \tag{13}$$

If the interest rate spread increases, we expect capital flight into the country which in turn booms the economy. Looking at the adjustment coefficient α_{14}, we observe that the output rate is highly reacting to the output adjustment equation, as we would expect.[18]

The second cointegration vector shows the ratio of money to output (inverse velocity) is negatively related to the interest rate spread, and the exchange rate. Also the shift dummy, D_s94, is significant. As argued before, the interest rate spread captures the opportunity cost of holding money, and has a negative sign as expected. The coefficient of the exchange rate supports the currency substitution hypothesis outlined in Section 4, i.e. using the existence of a link between the exchange rate and money might be interpreted as an evidence of currency substitution. The coefficient is negative and highly significant. That is, whenever the Turkish residents expect the depreciation of the exchange rate they reduce the holdings of Turkish lira. Formally,

$$(m-p-y)_t = -\underset{(-12.4868)}{0.1423}\, e_t - \underset{(-3.3561)}{1.1183}\, R_{S_t} + \underset{(2.8047)}{0.1644}\, D_s 94_t \tag{14}$$

Comparing with Akıncı (2004), one can say the extent of the opportunity cost of holding $M1$ is higher than the opportunity cost of holding currency issued, as expected. Bahmani-Oskooee et al. (2001) use $M2$ balances to investigate the currency substitution in Thailand and the estimated coefficient of the exchange rate indicates a greater extent of the substitution in Thailand for the given period.

[18] This can be argued as the mimicing the weak exogenity test results.

The high coefficient on the interest rate spread can be explained as a risk premium. That is, in order for people to hold Turkish Lira as an asset, the risk of inflation and currency depreciation must be compensated for. Moreover, the semi-elasticity of the interest rate spread is higher than the exchange rate elasticity. That is, for the given period, the changes in the interest rate may affect money more than the changes in the exchange rate.

The first term in the α_2 vector, presented in Table 6, measures the speed of short run response to disequilibrium in money. It has the adjustment coefficient of -0.3572, which implies that lagged excess money induces smaller holdings of current money. Accordingly, we can say that there is a positive adjustment by inflation rate to excess money, that is excess money will lead to higher rates of inflation.

The third cointegration relation predicts that the interest rate spread is stationary when the structural break of the Turkish economy is taken into consideration, that is, the spread is stationary around a nonconstant mean, i.e. when we allow for a changing risk premium, although it is nonstationary by its own.

$$R_{S_t} = \underset{(2.2311)}{0.0288} D_s 94_t + \underset{(5.1329)}{0.1095} D_s 00_t \tag{15}$$

6.10. Short-Run Identification

Although the long-run covariance matrix of cointegrating relations was not the part of the identification problem, the residual covariance matrix plays a crucial role in the short-run identification. In the VAR model current effects are not explicitly modeled but are left in the residuals. Hence, large off-diagonal elements of the covariance matrix might be a sign of significant current effects between the system variables. That is why, the purpose is to obtain a short run model in which the structural error terms are uncorrelated so that they correspond to estimated shocks and they are unique.

In order to identify the short run structure, given βs are superconsistent, the identified cointegrating relations are treated to be fixed at their estimated values, i.e. $\beta' x_t$ is treated as predetermined stationary relations (see Juselius (2003) for details). On the other hand, the adjustment coefficients, α_i are unrestricted. Given the lagged values and the identified long-run structure, the aim is to impose some identifying restrictions on the contemporaneous matrix A_0. Multiplying the equation (9) by A_0, we have,

$$\begin{aligned} &A_0 \Delta x_t = A_0 \Gamma \Delta x_{t-1} + A_0 \alpha \hat{\beta}^{LR} x_{t-1} + A_0 \phi D_t + A_0 \mu_0 + A_0 \varepsilon_t, \\ &\varepsilon_t \sim N_5(0, \Sigma) \end{aligned} \tag{16}$$

or equivalently,

$$\begin{aligned} &A_0 \Delta x_t = A_1 \Delta x_{t-1} + \alpha \hat{\beta}^{LR} x_{t-1} + D_t + \hat{\phi} \mu_0 + v_t, \\ &v_t \sim N_5(0, \Omega) \end{aligned} \tag{17}$$

The identification of the simultaneous short-run structure requires at least p-1 restrictions on each equation, that is $p(p\text{-}1)$ restrictions on (17) which requires a significant number of restrictions. The estimations are done by using simultaneous equation model framework and the insignificant ones are deleted in order to gain some degrees of freedom and reach the parsimonious model. Note that seasonal dummies are kept as unrestricted in the model since they are not subject of interest.

Table 7 reports the results of the parsimonious VAR. The null hypothesis of all the chosen parameters are restricted to zero is tested by LR-test of overdentifiying restrictions. The corresponding test statistics is $\chi^2(35)$=45.393 and the null is not rejected by a p-value of 0.1122.

Table 7: Parsimonious VAR

	Δm_t	Δe_t	Δp_t	Δy^r_t	ΔRs_t
Δm_{t-1}	0.358 [3.85]	0	0	0	0
Δe_{t-1}	0	0	0	0	0
Δp_t	0	0	0.202 [2.68]	0	0.225 [2.45]
Δy^r_{t-1}	0	0	0	0	0
ΔRs_{t-1}	0.577 [5.16]	0	0	0	0
$ecm1_{t-1}$	-0.528 [-3.80]	0.531 [4.50]	0.293 [5.55]	-0.399 [-4.17]	0
$ecm2_{t-1}$	-0.367 [-5.29]	0	0	0	-0.175 [-5.92]
$ecm3_{t-1}$	0	0	0	0.314 [4.30]	-0.495 [-8.99]
D_p01_t	0	0.325 [5.19]	0.105 [3.92]	0	0.063 [3.92]
ΔD_s94_t	0	0.507 [8.10]	0.218 [8.16]	-0.133 [-3.66]	0.297 [11.7]
ΔD_s00_t	0	0	0	0	-0.157 [-6.59]
constant	5.17 [4.93]	-2.06 [-4.29]	-1.10 [-5.17]	1.628 [4.20]	1.386 [5.83]
Ω correlation of structural residuals (standard deviation on diagonal)					
Δm_t	0.049				
Δe_t	-0.193	0.061			
Δp_t	-0.101	**0.354**	0.026		
Δy^r_t	0.114	-0.158	-0.120	0.035	
ΔRs_t	**-0.580**	0.261	0.256	0.067	0.029

$$ecm1_t = y_t - \underset{(-25.9072)}{0.0102}\,trend + \underset{(3.0697)}{0.4928}\,R_{S_t}$$

$$ecm2_t = (m-p-y)_t + \underset{(12.4868)}{0.1423}\,e_t + \underset{(3.3561)}{1.1183}\,R_{S_t} - \underset{(-2.8047)}{0.1644}\,D_s94_t$$

$$ecm3_t = R_{S_t} - \underset{(-2.2311)}{0.0288}\,D_s94_t - \underset{(-5.1329)}{0.1095}\,D_s00_t$$

Table 8 below presents various tests of misspecification.

Table 8: Specification tests for the parsimonious model

Multivariate Tests:					
Residual Autocorrelations:					
		$F(100,165)=$	1.3061	p.val.	0.065
Normality:					
		$\chi^2(10)=$	12.653	p.val.	0.244
Univariate Tests					
	Δm	Δe	Δp	Δy	ΔR_S
ARCH 1-4: $F(4,49)=$	0.3606 [0.8354]	2.2070 [0.0819]	2.2059 [0.0820]	0.7513 [0.5619]	0.18592 [0.9446]
AR 1-4: $F(4,46)=$	2.4472 [0.0596]	4.6112 [0.0033]**	4.4075 [0.0042]**	3.6374 [0.0117]*	3.0485 [0.0261]*
Jarq.Bera: $\chi^2(2)=$	0.3071 [0.8576]	4.4363 [0.1088]	2.2178 [0.3299]	0.22901 [0.8918]	2.7964 [0.2470]
Skewness	-0.179	-0.2548	0.2929	-0.0712	0.0344
Excess Kurtosis	2.5379	3.7501	2.3489	2.4249	3.8658

Apart from autocorrelation problems for some of the series, all the tests above for misspecification suggest no problems.

The correlation of the structural form residuals show significant simultaneous current short-run effects between Δp_t and Δe_t, as well as ΔRs_t and Δm_t and moderate between ΔRs_t and Δe_t, ΔRs_t and Δp_t.[19] I will not consider the moderate ones. The significant ones are interpretable. We need some assumptions about causality such that the simultaneous effects enter into the model. Assuming causality runs from inflation to depreciation rate, we expect the exchange rate to depreciate whenever we have inflationary shocks in the economy. Also by assuming the causality runs from the interest rates to the money, one can also say that,

[19] As a rule of thumb, a residual correlation can be considered as significant, if it exceeds a value of $2.5/\sqrt{T}=0.305$. Hence, we have two significant coefficients at the correlation matrix. One of them is the coefficient between the residuals of inflation and the depreciation rate, 0.35388, and the other is between the interest rate spread and money, -0.57977.

whenever the treasury bill rate increases, people hold more government bonds, which in case might lead to a decrease in the money holdings.

To estimate the model, I regress the depreciation rate on inflation.[20] Table 9 illustrates including the current effect of inflation into the equation for depreciation rate. It reduces the correlation of their structural residuals remarkably, from 0.354 to 0.257. Note that we still have a significant correlation coefficient between the money and the interest rate spread.

The corresponding LR test is $\chi^2(35)=47.013$ with a p-value of 0.084. The estimated coefficient suggests an almost one-to-one relationship between the inflation and depreciation rates.

By examining the parsimonious model, it can be argued that none of variables are weakly exogenous, since all of them are reacting to at least one of the cointegrating relations.

Money and inflation series are fed-back by their own lagged values. An increase in the inflation rate for the last period would also lead to an increase in inflation of this period, by almost 2%, similarly for money balances.

The model also suggests that the changes in the growth rate of output, and changes in the depreciation rate do not affect any of the variables in the model, which is not plausible, because what we expect is a reaction of the nominal variables even in the short-run to fiscal shocks. Moreover, the open economy IS-LM framework suggests a decrease in real output as a response to a depreciation of the currency.

[20] Note that I also try to estimate the SR structure by taking into account the simultaneous effect between the interest rate spread and money. However, the final structure is rejected by $\chi^2(35)=68.357[0.0006]$. Besides the estimated coefficient of the interest rate spread was insignificant.

Table 9: The Short-Run Structure with Current Effect (t-values in brackets)

	Δm_t	Δe_t	Δp_t	Δy^r_t	ΔRs_t
Δm_t	1	0	0	0	0
Δe_t	0	1	0	0	0
Δp_t	0	1.42 [4.46]	1	0	0
Δy^r_t	0	0	0	1	0
ΔRs_t	0	0	0	0	1
Δm_{t-1}	0.353 [3.80]	0	0	0	0
Δe_{t-1}	0	0	0	0	0
Δp_{t-1}	0	0	0.187 [2.41]	0	0.239 [2.56]
Δy^r_{t-1}	0	0	0	0	0
ΔRs_{t-1}	0.565 [5.05]	0	0	0	0
$ecm1_{t-1}$	-0.521 [-3.76]	0	0.303 [5.77]	-0.392 [-4.09]	0
$ecm2_{t-1}$	-0.366 [-5.28]	0	0	0	-0.174 [-5.87]
$ecm3_{t-1}$	0	0	0	0.309 [4.21]	-0.496 [-9.02]
D_p01_t	0	0.184 [2.81]	0.105 [3.91]	0	0.064 [2.40]
ΔD_s94_t	0	0.205 [2.14]	0.217 [8.14]	-0.133 [-3.66]	0.297 [11.7]
ΔD_s00_t	0	0	0	0	-0.157 [-6.58]
constant	5.13 [4.90]	-0.071 [-1.81]	-1.34 [-5.38]	1.600 [4.12]	1.372 [5.77]

Ω correlation of structural residuals (standard deviation on diagonal)

Δm_t	0.049				
Δe_t	-0.147	0.060			
Δp_t	-0.101	-0.257	0.026		
Δy^r_t	0.114	-0.069	-0.121	0.035	
ΔRs_t	-0.580	0.117	0.255	0.070	0.029

$$ecm1_t = y_t - \underset{(-25.9072)}{0.0102}\, trend + \underset{(3.0697)}{0.4928}\, R_{S_t}$$

$$ecm2_t = (m-p-y)_t + \underset{(12.4868)}{0.1423}\, e_t + \underset{(3.3561)}{1.1183}\, R_{S_t} - \underset{(-2.8047)}{0.1644}\, D_s94_t$$

$$ecm3_t = R_{S_t} - \underset{(-2.2311)}{0.0288}\, D_s94_t - \underset{(-5.1329)}{0.1095}\, D_s00_t$$

From the interest rate spread equation we can also say that the increase in the inflation rate will lead to a 2% increase rate in the interest rate spread. Also note that the interest rate spread reacts to the last two cointegration relations, which is plausible. The second relation can be interpreted as a central bank policy rule, in a sense that the distortion of the money market equilibrium might lead the central bank to intervene through interest rate hike or cut.

From the money equation we can see that the increase in the interest rate spread will cause the money stock to increase by 5.6%, which is a puzzling result, because the expected sign is negative. We can also say that the money stock is equilibrium correcting to output gap and long run money demand equations with negative speed of adjustment coefficients, as expected. Essentially this implies that when the equilibrium in the money market disturbed because of an exogenous shock, then 36% of the shock is adjusted in one period.

7. The I(2) Scenario

In this section, I will treat price, money and exchange rate as $I(2)$.

7.1. The Economic Model

For the high inflation periods, aggregate money demand is more appropriately described by including inflation as an opportunity cost of money. Again the portfolio approach is extended by also using the expected exchange rate measure to capture the opportunity cost of holding domestic money. Hence the model in log linear form is as follows,

$$m^r_t = \beta_0 + \beta_1 y^r_t + \beta_2 R_{S_t} + \beta_3 \Delta p_t + \beta_4 \Delta e_t + \varepsilon_t \tag{18}$$

where, m^r is the natural logarithm of real money balances, Δp_t is the inflation level, y^r is the logarithm of real income, R_S is the interest rate spread, as defined at $I(1)$ scenario, Δe is the logarithm of the depreciation rate. Here note that, based on the theory, I need to use the expected depreciation and inflation rates. However, since there is no such data available, one solution is to use ex-post rates to proxy the expected ones.[21] The other solution is using different proxies for the expected rates. Cuddington (1983) and Chaisrisawatsuk et al. (2004) use the ratio of the difference between forward and spot exchange rate to spot rate as a proxy for expected depreciation of the exchange rate. Akcay et al (1997) used estimated exchange rate volatility based on the EGARCH-M model.

The expected signs of the coefficients are $\beta_1 > 0, \beta_2 < 0, \beta_3 < 0, \beta_4 < 0$. That is, whenever income increases, we expect the demand for real balances also increases. On the other hand, it is supposed to be inversely related to the inflation rate and the interest rate spread since they proxy the opportunity costs of holding money. In this model, β_4 measures the effect of currency substitution, hence as argued above, is expected to be negative.

7.2. The Statistical Model

The representation of the vector process becomes:[22]

$$\begin{pmatrix} m_t \\ e_t \\ p_t \\ y^r{}_t \\ R_{S_t} \end{pmatrix} = \begin{pmatrix} c_{11} \\ c_{21} \\ c_{31} \\ 0 \\ 0 \end{pmatrix} \left(\sum_{s=1}^{t} \sum_{i=1}^{s} u_{1i} \right) + \begin{pmatrix} d_{11} & d_{12} \\ d_{21} & d_{22} \\ d_{31} & d_{32} \\ d_{41} & d_{42} \\ d_{51} & d_{52} \end{pmatrix} \begin{pmatrix} \sum u_{1i} \\ \sum u_{2i} \end{pmatrix} + \begin{pmatrix} g_1 \\ g_2 \\ g_3 \\ g_4 \\ 0 \end{pmatrix} t + stat.comp. \quad (19)$$

[21] See for instance Ericsson et al. (2003), and Akinci (2004).
[22] See Juselius(2004) for details

where, $\sum_{s=1}^{t}\sum_{i=1}^{s} u_{1t}$ denotes the twice accumulated nominal shocks, $\sum u_{1t}$ once cumulated nominal shocks, and finally $\sum u_{2t}$ denotes once cumulated real shocks. The trend component, t, is needed to capture the linear trend presents the levels of all series except the interest rate spread.

Hence, money, exchange rate, and prices can be rewritten as,

$$\begin{aligned} m_t &= c_{11}\sum\sum u_{1t} + d_{11}\sum u_{1t} + d_{12}\sum u_{2t} + g_1 t + stat.comp. \\ e_t &= c_{21}\sum\sum u_{1t} + d_{21}\sum u_{1t} + d_{22}\sum u_{2t} + g_2 t + stat.comp. \\ p_t &= c_{31}\sum\sum u_{1t} + d_{31}\sum u_{1t} + d_{32}\sum u_{2t} + g_3 t + stat.comp. \end{aligned}$$

If, $(c_{11}, c_{21}, c_{31}) \neq 0$, then $\{m_t, e_t, p_t\} \sim I(2)$. The *I*(2)'ness of the model is checked first by the maximum likelihood (ML) procedure by using the nontransformed series, namely *m, e, p,* y^r, R_s. Table 10 below represents the results. Given the rank test statistics, one can conclude that there is at least one series which has an *I*(2) trend and the cointegration rank is two.

Table 10: The *I*(2) analysis- ML procedure

		p-r-s					
p-r	*r*						
5	0	469.7884	397.3422	341.2134	297.7895	260.3229	234.8664
		[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
4	1		254.9679	183.2065	141.5891	107.1734	81.5726
			[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
3	2			120.1298	80.7697	**48.5455**	40.2465
				[0.0000]	[0.0035]	**[0.1457]**	[0.0894]
2	3				46.5250	14.5282	12.9346
					[0.0791]	[0.9641]	[0.7445]
1	4					4.3689	3.2003
						[0.9898]	[0.8428]

The first candidate is the exchange rate. First I transform the exchange rate into the depreciation rate. However the ML test results again indicates an I(2) trend with a p- value of 0.3883. Hence, I need the long run price homogeneity to get rid of the *I*(2) problem. The condition for long-run price homogeneity is $\{c_{11} = c_{31}\}$, i.e. the nominal shocks u_{1t} affect nominal money and prices in the same way. Note that the long-run price homogeneity implies a stationary spread between price inflation and money growth. That is, $(m_t - p_t) \sim I(1)$ implies $(\Delta m_t - \Delta p_t) \sim I(0)$. Imposing long-run price homogenity is tested by the *LR* test, and cannot be rejected by $\chi^2(4)$=6.5541 with a p-value of 0.1614.

By imposing long-run price homogeneity between money and the price level, and including the depreciation rate instead of the exchange rate, the nominal system (19) can be transformed to the following system:

$$\begin{pmatrix} m_t - p_t \\ \Delta e_t \\ \Delta p_t \\ y^r{}_t \\ R_{S_t} \end{pmatrix} = + \begin{pmatrix} d_{11} & d_{12} - d_{32} \\ c_{21} & 0 \\ c_{31} & 0 \\ d_{41} & d_{42} \\ d_{51} & d_{52} \end{pmatrix} \begin{pmatrix} \sum u_{1t} \\ \sum u_{2t} \end{pmatrix} + \begin{pmatrix} g_1 - g_3 \\ 0 \\ 0 \\ g_4 \\ 0 \end{pmatrix} t + stat.comp. \qquad (20)$$

All variables are at most $I(1)$ at (20). The nominal growth rates $\{\Delta e_t, \Delta p_t\}$ are only affected by the once cumulated nominal trend, but the others can be affected by both of the stochastic trends.

7.3. Expected Long-Run Relations, Some Theoretical Background

Besides the long-run analysis, the short run dynamics of the cointegrated VAR model are subject to interest. In the following, I describe potential long-run economic relationships in the cointegrated VAR model.

The first potential long-run relation is the money demand equation as given by (18). As argued Section 6.3, locating an endogenous money demand function in the system is possible.

With the transformed variables, we have long-run price homogeneity, $(\Delta m_t - \Delta p_t) \sim I(0)$, that is, money growth and inflation are cointegrated.

We can test whether velocity might be stationary by itself. However it is inconsistent with the monetarist assumption and usually does not find empirical support (see Juselius (2003)). However, it might well be the case that the opportunity costs of money in terms of inflation, the interest rate spread and the exchange rate depreciation can form a cointegrating relationship with the inverse velocity of money. That is;

$$(m - p - y)_t + a_1 R_{S_t} + a_2 \Delta e_t + a_3 \Delta p_t \sim I(0) \qquad (21)$$

For equation (21) to express a money demand equation, the expected signs for a_1, a_2, and a_3 are positive, since one expects the real domestic holdings to decrease whenever the opportunity cost of money decreases. For the unexpected signs, it can be interpreted as a policy reaction function.

We might anticipate the existence of some kind of interest rate policy rule with respect to inflation and possibly output. That is,

$$\begin{aligned} &R_{S_t} + b_1 y^r{}_t + b_2 \Delta p_t + b_3 t \sim I(0) \text{ or,} \\ &R_{S_t} + b_1 (y^r{}_t - t) + b_2 \Delta p_t \sim I(0) \end{aligned} \qquad (22)$$

where the coefficient b_1 can be interpreted as the deviation from the output gap in the second equation. Again to interpret as an interest rate policy rule, one expects both b_1 and b_2 as negative. That is, whenever the actual output is above the expected one (ie. positive output gap), the interest rates will increase. Similarly, higher levels of inflation would lead to higher levels of the interest rate spread.

7.4. Length Determination and the Construction of the Model

Like $I(1)$ analysis, LR test and model selection criteria are used in order to check the validity of the lag length. The LR test generates the evidence of the optimal lag length as two.

Table 11: LR Test for Lag Determination

Lag Deletions	F-Statistics (p-Value)
k=4→k=3	F(35,94)=0.97962[0.5121]
k=4→k=2	F(70,108)=0.83878[0.7843]
k=4→k=1	F(105,112)=1.1963[0.1753]
k=3→k=2	F(35,124)=0.70150[0.8869]
k=3→k=1	F(70,142)=1.3130[0.0873]
k=2→k=1	F(35,153)=2.0600[0.0015]**

Table 12: Information Criteria for Lag Determination

	SBC	*HQ*	*AIC*
k=4	-11.966	-15.717	-18.142
k=3	-13.000	-16.021	-17.974
k=2	-14.572	**-16.864**	**-18.346**
k=1	**-15.285**	-16.848	-17.858

While the Schwarz criterion chooses one, both Akaike and Hannan Quinn information criteria choose the optimal lag length as two. I will continue on the $VAR(2)$ model. Hence equation (2) becomes,

$$\Delta x_t = \Gamma \Delta x_{t-1} + \Pi x_{t-1} + \phi D_t + \mu_0 + \varepsilon_t \qquad (23)$$

At the $I(2)$ scenario, the $VAR(2)$ model in the *ECM* form with the transformed variables are given as follows;

$$\begin{pmatrix} \Delta m^r_t \\ \Delta y^r_t \\ \Delta^2 e_t \\ \Delta^2 p_t \\ \Delta R_{S_t} \end{pmatrix} = \Gamma \begin{pmatrix} \Delta m_{t-1} \\ \Delta y^r_{t-1} \\ \Delta^2 e_{t-1} \\ \Delta^2 p_{t-1} \\ \Delta R_{S_{t-1}} \end{pmatrix} + \Pi \begin{pmatrix} m^r_{t-1} \\ y^r_{t-1} \\ \Delta e_{t-1} \\ \Delta p_{t-1} \\ R_{S_{t-1}} \\ D_S 94_{t-1} \\ D_S 00_{t-1} \\ trend \end{pmatrix} + \phi D_t + \mu + \varepsilon_t, \qquad t = 1,\ldots,T, \;\; \varepsilon_t \sim N(0,\Omega) \qquad (24)$$

where, $m^r_t = (m-p)_t$.

Similar to the $I(1)$ scenario, restricted trend and the two weakly exogenous variables in the analysis, namely D_s94 and D_s00, will be allowed to be in the cointegration space. Because of the instability of the economy, there were a considerable number of outliers. Their effects are almost eliminated by the shift dummies, except the period 2001Q2 for the exchange rate depreciation and inflation. Hence, D_t contains the blip dummy.[23]

The unrestricted model estimates are given in Appendix B, in Table B3 and B4. The shift dummies and trend were all significant, at least for one of the variables, based on the unrestricted VAR estimates. By looking at the Π matrix one can also concludes that all of the variables seem equilibrium correcting. Estimated short-run parameters are also given in Table B4 in Appendix B. Results depict that seasonal dummies are highly significant for real output. Besides, the blip dummy is highly significant for the exchange rate depreciation, the inflation level and the interest rate spread with t-values of 5.4274, 4.3943 and 2.8507 respectively. Finally examining the results shows that D_s94_t is significant for all of the variables at time t, whereas significant for inflation and the exchange rate for time t-1. D_s00_t on the other hand, is significant for inflation and the interest rate spread for time t, whereas significant for depreciation rate only at time t-1.

[23] See section 6.3 for the construction of the dummies.

7.5. Misspecification Tests

Table 13 presents the specification tests, namely tests for autocorrelation, normality and ARCH effects for the unrestricted VAR model with dummies.

Table 13: Specification tests for the unrestricted VAR(2) model with dummies

Multivariate Tests:						
Residual Autocorrelations:						
		LM_1:	$\chi^2(25)=$	34.7238	p.val.	0.093
		LM_4:	$\chi^2(25)=$	32.6542	p.val.	0.140
Normality:						
		LM:	$\chi^2(10)=$	10.7157	p.val.	0.380
Univariate Tests						
		$m\text{-}p$	Δe	Δp	y	R_s
ARCH 1-4:	$F(4,35)=$	0.54746 [0.7021]	1.3737 [0.2636]	0.18721 [0.9434]	0.97154 [0.4358]	0.24063 [0.9133]
AR 1-4:	$F(4,38)=$	0.73418 [0.5744]	1.3601 [0.2659]	1.9054 [0.1295]	2.4833 [0.0599]	1.6229 [0.1885]
Jarq.Bera:	$\chi^2(2)=$	0.1792 [0.9143]	6.7100 [0.0349]*	0.2229 [0.8945]	0.1182 [0.9426]	5.3565 [0.0687]
Skewness		0.1168	0.0840	0.1311	0.0576	0.5371
Kurtosis		2.7481	4.1259	2.6897	2.8167	4.0796
Std. Deviation		0.0462	0.0443	0.0177	0.0293	0.0242

Both univariate and vector tests of autocorrelation indicate that autocorrelation does not appear at none of the series. Also, there is no sign for ARCH effects. All of the variables, except the exchange rate depreciation are normal at 5% significance level. Also note that the normality of the interest rate spread is borderline accepted. This is mainly because of the kurtosis than skewness. However, the vector normality test cannot be rejected by a p-value of 0.380.

7.6. Rank Determination

From a theoretical point of view we would expect to have at least two cointegration relations in our model. First cointegration relation could take into account the money demand. Based on the portfolio balance approach outlined in Section 7.3, one expects to reach a relation which explains the real money balances as a function of output and opportunity costs for holding money. Those costs could be expressed both in terms of the inflation rate, the interest rate spread, as well as depreciation rate.

The second long-run relation might be about the output gap and the interest rate differential, or putting differently an interest rate policy based on the output gap. Another relation can be capturing the dynamics of inflation.

The trace tests, the eigenvalues and the selected roots of the companion matrix for the model are reported in Table 14.

Table 14: The trace test, the eigenvalue roots and the 5 largest modulus of the model

p-r	r	λ_r	$\tau(p\text{-}r)$	$\tau^*(p\text{-}r)$ (Brt. Cor.)	$C^{sim}_{.95}$	r=5	R=4	r=3	r=2	r=1
5	0	0.6280	174.7753	160.4843	110.0590	0.7167	1.0000	1.0000	1.0000	1.0000
4	1	0.5559	111.4888	104.8805	81.6344	0.4494	0.4625	1.0000	1.0000	1.0000
3	2	0.3855	59.5389	57.1609	56.8961	0.4494	0.4625	0.4753	1.0000	1.0000
2	3	0.2952	28.3767	27.7076	35.9443	0.0368	0.0347	0.4753	0.0572	1.0000
1	4	0.0894	5.9914	5.9672	18.1119	0.0368	0.0347	0.0372	0.0572	0.2677

Again because of the shift dummies, simulated values have been employed, $C^{sim}_{.95}$. One can note that the null hypotheses r=1 (i. e. the p-r=4 smallest eigenvalues are zero) are highly rejected, whereas I can borderline accept the null of r=3, by using both the small sample corrected Bartlett test and the usual trace test. As argued in Section 6.6, one might need to use additional information with the trace test in order to find a reasonable rank choice. Examining the roots of the companion matrix gives an evidence of rank 3 as well. Hence a correct choice of the cointegrating rank would correspond to the largest unrestricted root not being very close to the unit circle. Our preferred choice of r=3, and the largest unrestricted root is 0.4753 which is significantly away from the unit circle.

The unrestricted VAR results for all five α and β vectors are given in Appendix B. Note that the alphas corresponding to the first four beta vectors contain at least one variable that is highly significant with a t-value above 3.5. When we look at the significance of the adjustment coefficients for the third relation, we can see that the adjustment coefficients α_{31}, α_{32} are quite significant, indicating the equilibrium correcting behavior of real money and depreciation rate. Besides, α_{44}, α_{43} are also significant for output and the interest rate spread indicating the rank as four. Thus, a choice of rank three or four would be consistent with the short-run dynamic properties of the system.

Finally the recursively estimated trace test results is given at Figure 8.

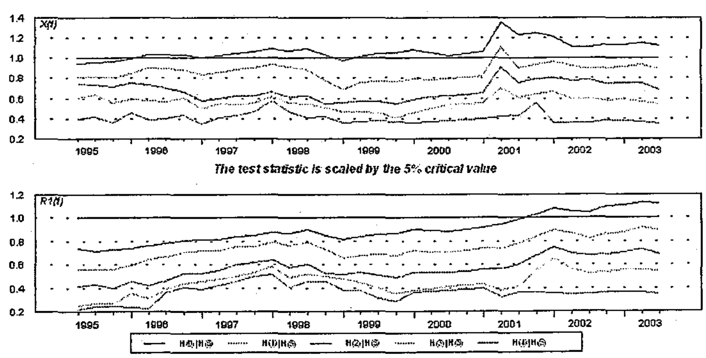


Figure 8: Recursively Estimated Trace Test

Concentrating on the 'R-form'we can conclude that the three cointegration relations are clearly constant, indicated by three linearly growing trace statistics.

To sum-up, based on the formal test results and the economic interpretation the relations, the rank of the system is chosen as three.

7.7. Recursive Tests of Constancy

In this section I give an overview of the several tests of parameter constancy in the reduced rank model with r=3. The base sample in all tests is from 1987:04 to 1996:02. The sample for test of beta is the full sample. All tests are performed for both the full model and the concentrated model, 'R-form' (i.e., the model in which the short run dynamics and the deterministic components are concentrated out).

Figure 9 shows the recursively estimated log-likelihood function. Apart from some evidence for parameter instability in the concentrated model for the period 1996:02-1996:04, the results indicate stable parameter estimates.

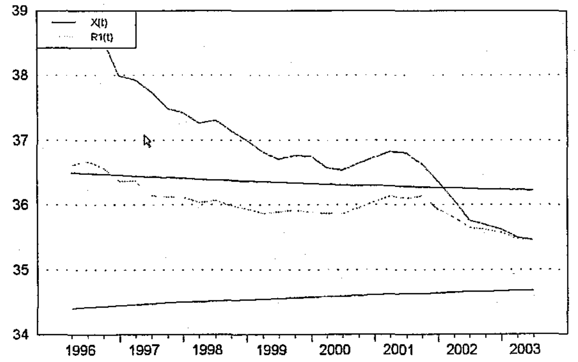
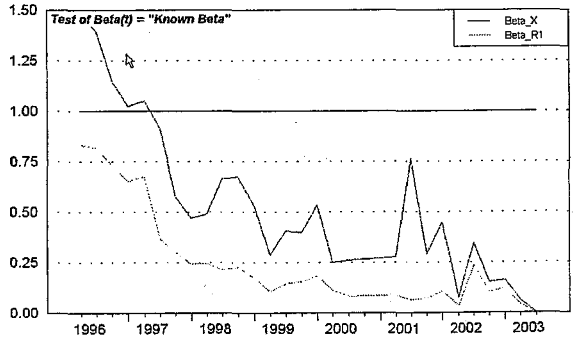


Figure 9: Recursively Calculated Log-Likelihood

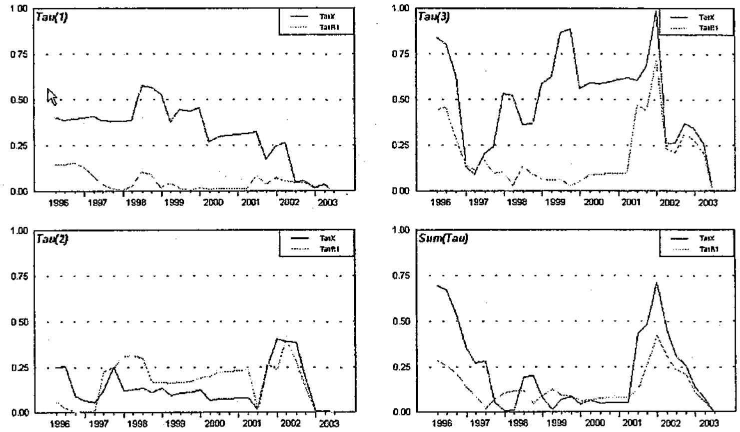


The test statistic is scaled by the 5% critical value

Figure 10: Test of beta

Figure 10 presents the test of beta. Note that a value higher than 1.0 indicates instability. Based on the concentrated model we have hardly any evidence of instability of βs.

Figure 11 plots the so called the fluctuation test, which is a formal test on the stability of the eigenvalues, $\lambda_{i.}$ Again the test statistics are scaled by the 5% critical values. Recall from section 6.7 that, testing the stability of λ_i is implicitly testing the stability of α_i and $\beta_{i.}$. Figure 11 generates the evidence that not only the relations separately, but also the model as a whole is stable.



The test statistic is scaled by the 5% critical value

Figure 11: Fluctuation Test of Eigenvalues

To sum up, the graphical analysis cannot reject the null hypothesis of parameter constancy for our sample period.

7.8. Testing Simple Hypotheses on α and β

The next step is to test simple hypotheses on α and β. Table 15 shows the test results for long run variable exclusion, stationarity and weak exogenity for the chosen rank, 3.

Table 15: Testing Simple Hypotheses on α and β

	Test for long-run exclusion	Test for stationarity	Test for weak exogenity
$m-p$	$\chi^2(3)=20.0116$	$\chi^2(5)=23.7243$	$\chi^2(3)=11.4428$
Δe	$\chi^2(3)=29.9328$	$\chi^2(5)=28.5375$	$\chi^2(3)=20.8196$
Δp	$\chi^2(3)=25.0392$	$\chi^2(5)=25.1961$	$\chi^2(3)=27.7696$
Y	$\chi^2(3)=8.0402$	$\chi^2(5)=26.2442$	$\chi^2(3)=8.4987$
R_S	$\chi^2(3)=9.8684$	$\chi^2(5)=20.7302$	$\chi^2(3)=8.2963$
D_s94	$\chi^2(3)=11.0221$		
D_s00	$\chi^2(3)=1.7521$		
trend	$\chi^2(3)=10.6944$		

The test for long-run exclusion supports the evidence of the exclusion of one of the shift dummies namely, D_s00. However, as the unrestricted VAR estimates given at Appendix B suggest that the D_s00 is significant not only in the long-run but also the long-run especially for the depreciation rate and the exchange rate. Juselius(2003) notes that some caution is needed here because the potential collinearity between the variables are biasing the results. Hence I will continue with the included shift dummy.

Second, test for stationarity is computed without the restricted trend and shift dummies.[24] This result is particularly interesting with regard to the first differences of consumer prices (i.e. the inflation rate) and the depreciation rate. Results mimic the evidence for $I(2)$ behavior in the consumer price level and exchange rate.

Finally test for the weak exogenity, that is hypothesizing a variable has influenced the long-run stochastic path of the other variables while has no influence on them, is reported. For the chosen rank, test indicates that none of the variables are weakly exogenous, hence they are equilibrium correcting. So I can reach the long run equations which theory predicts.

[24] The stationarity with the restricted trend and shifts dummies is also highly rejected for all the variables with the corresponding p-values; 0.0001, 0.0223, 0.0053, 0.0022, 0.0006.

7. 9. Long-Run Identification

The appropriate rank is chosen as three and the purpose is to impose restrictions on the coefficients in order to reach economically meaningful relations as introduced in Section 7.3. The β vector for three long-run relations can be written as follows;

$$\beta' = \begin{pmatrix} 1 & \beta_{12} & \beta_{13} & -1 & \beta_{15} & 0 & 0 & \beta_{18} \\ 0 & \beta_{22} & 1 & 0 & 0 & \beta_{26} & 0 & \beta_{28} \\ 0 & 0 & \beta_{33} & \beta_{34} & 1 & 0 & \beta_{37} & \beta_{38} \end{pmatrix}$$

note that the $x_t = \{(m-p)_t, \Delta e_t, \Delta p_t, y_t, R_{S_t}\}$.

Table 16 reports identified long-run structure.

Table 16: Identified Long-Run Structure (*t*-values in brackets)

	m-p	Δe	Δp	*y*	R_S	D_s94	D_s00	*trend*
β'_1	1.0000 [0.0000]	0.7980 [3.9052]	3.2947 [5.0169]	-1.0000 [0.0000]	0.7030 [2.4794]	0.0000 [0.0000]	0.0000 [0.0000]	0.0144 [17.8095]
β'_2	0.0000 [0.0000]	-0.4203 [-10.4287]	1.0000 [0.0000]	0.0000 [0.0000]	0.0000 [0.0000]	-0.0390 [-4.0701]	0.0000 [0.0000]	0.0011 [4.1269]
β'_3	0.0000 [0.0000]	0.0000 [0.0000]	-3.3458 [-8.4911]	1.0760 [5.9132]	1.0000 [0.0000]	0.0000 [0.0000]	-0.0705 [-1.9528]	-0.0113 [-5.9797]

Loadings: α_i (*t*-values in brackets)

	α_1	α_2	α_3
$\Delta(m\text{-}p)$	-0.4439 [-4.8418]	-0.6154 [-1.5901]	-0.6291 [-4.2590]
$\Delta^2 e$	0.0482 [0.5836]	1.9606 [5.6287]	0.4479 [3.3694]
$\Delta^2 p$	0.0738 [2.1716]	-0.2831 [-1.9731]	0.2819 [5.1477]
Δy	-0.0458 [-0.7653]	0.1051 [0.4162]	-0.2278 [-2.3631]
ΔR_s	-0.0805 [-1.6483]	0.3499 [1.6974]	-0.0488 [-0.6201]

The corresponding *LR* statistic for the over identification restriction is $\chi^2(4)$=4.0164 has a *p*-value of 0.4038.

The first cointegration relation can be interpreted as to the ratio of real money to expenditure, (*m-p-y*), negatively related to the opportunity costs of holding money; inflation, interest rates, and the exchange rate depreciation corresponding to an excess demand for transactions. The second cointegration relation shows exchange rate pass through. Finally the third one defines us an interest rate policy rule. That is, the interest rate spread is positively related to the inflation rate and negatively related to the output gap.

$$(m-p-y)_t = \underset{(-5.0169)}{-3.2947}\Delta p_t \underset{(-3.9052)}{-0.7980}\Delta e_t \underset{(-2.4794)}{-0.7030}R_{S_t} \underset{(-17.8095)}{-0.0144}trend \qquad (25)$$

The coefficient on the expected depreciation variable has correct sign and highly statistically significant, this might indicate an existence of currency substitution. That is, whenever Turkish residents expect TL to lose value, they might hold more foreign currency as asset or for transaction purposes. Hence demand for real balances decreases. Also we can see that the interest rate spread on Turkish Lira deposits and the inflation rate have significant effects on demand for money. Compared to Circiv (2003), one can argue that the extent of the estimated coefficient of the depreciation rate is decreased when the period is extended and the narrow definition of money is used instead a broad one. Ericsson et al. (2003) analyze the currency substitution in Argentina and the estimated coefficient of the depreciation rate predicts a higher extend of currency substitution in Argentina than Turkey.

The second cointegration relation can be written as;

$$\Delta p_t = \underset{(10.4287)}{0.4203}\Delta e_t \underset{(-4.1269)}{-0.0011}trend + \underset{(4.0701)}{0.0390}D_s94_t \qquad (26)$$

Equation (26) can be interpreted as kind of exchange rate pass through from prices. Formally, one needs to explain "pass-through" using the level of exchange rate, not the depreciation rate. Equation shows that the 1% increase in the depreciation rate would lead to 42% increase in the inflation rate.

Finally the third relation is as follows;

$$R_{S_t} = \underset{(8.4911)}{3.3458}\Delta p_t - \underset{(-5.9132)}{1.0760}\, y^r{}_t + \underset{(5.9797)}{0.0113}\, trend + \underset{(1.9528)}{0.0705}\, D_s 0_t \quad (27)$$

By rearranging the terms in the third relation to get the output gap, we have,

$$R_{S_t} = 3.3458\Delta p_t - 1.0760(y^r{}_t - 0.0105 trend) + 0.0705 D_s 00_t \quad (28)$$

The coefficient of trend at equation (28) measures the growth rate of the Turkish GDP from the estimated model during the sample period. If the output gap increases, then central bank might intervene and reduce the interest rates to boom the economy. Similarly it can be argued that the increase in the inflation rate would lead the policy makers to increase the interest rates.

Looking at the adjustment coefficients α_i, we observe that the lagged excess money induces smaller holdings of current money. Also growth rates of real money, inflation and the depreciation rates have short run responses to the disequilibrium in the interest rate policy rules. Unexpectedly, the short-run response of the lagged interest rate spread to any of the relations is borderline.

7.10. Short-Run Identification

The short-run identification issues has been discussed at $I(1)$ scenario.

The simultaneous equation framework based on the long-run model is again used. Table 17 reports the results of the parsimonious VAR. The null hypothesis of all the chosen parameters are restricted to zero is tested by LR-test of overdentifiying restrictions. The corresponding test statistics is $\chi^2(29)$=34.436 and the null is accepted by a p-value of 0.2236.

Table 17: Parsimonious VAR

	Δm^r_t	$\Delta^2 e_t$	$\Delta^2 p_t$	Δy^r_t	ΔRs_t
Δm^r_{t-1}	0.322 [3.06]	0	0	0	0
$\Delta^2 e_{t-1}$	0	0	-0.075 [-2.92]	0	0
$\Delta^2 p_{t-1}$	0	0	0	-0.343 [-3.02]	0.426 [4.53]
Δy^r_{t-1}	0	0	0	0	0
ΔRs_{t-1}	0.499 [3.01]	0	0	0	-0.214 [-2.07]
$ecm1_{t-1}$	-0.327 [-4.70]	-0.187 [-10.0]	0	0	-0.208 [-4.75]
$ecm2_{t-1}$	-0.762 [-3.20]	1.43 [5.32]	-0.250 [-2.06]	0	0
$ecm3_{t-1}$	-0.563 [-5.14]	0.317 [9.12]	0.216 [8.35]	-0.146 [-3.12]	-0.193 [-3.00]
D_p01_t	-0.135 [-1.99]	0.341 [5.29]	0.111 [4.28]	0	0
ΔD_s94_t	-0.131 [-2.03]	0.394 [5.92]	0.207 [7.94]	-0.119 [-2.94]	0.274 [7.43]
ΔD_s00_t	0	0	0	0	0.135 [3.37]
constant	4.81 [5.19]	0	-0.849 [-7.88]	0.594 [3.17]	2.349 [4.21]

Ω correlation of structural residuals (standard deviation on diagonal)

Δm^r_t	0.060				
$\Delta^2 e_t$	**-0.426**	0.063			
$\Delta^2 p_t$	**-0.601**	**0.474**	0.025		
Δy^r_t	0.318	-0.320	-0.205	0.039	
ΔRs_t	**-0.640**	0.415	**0.387**	-0.133	0.035

$$ecm1_t = m^r_t - y^r_t + 0.798\Delta e_t + 3.295\Delta p_t + 0.703 R_{S_t} + 0.014 trend$$

$$ecm2_t = \Delta p_t - 0.420\Delta e_t - 0.039 D_s94_t + 0.001 trend$$

$$ecm3_t = R_{S_t} - 3.346\Delta p_t + 1.076 y^r_t - 0.070 D_s00 - 0.011 trend$$

Table 18 shows the misspecification tests for the parsimonious model above.

Table 18: Specification tests for the parsimonious model

Multivariate Tests:					
Residual Autocorrelations:					
	$F(100,155)=$	1.6817	p.val.	0.0018	
Normality:					
	$\chi^2(10)=$	10.610	p.val.	0.3887	
Univariate Tests					
	Δm^r	$\Delta^2 e$	$\Delta^2 p$	Δy^r	ΔR_S
ARCH 1-4:	0.90442	1.0440	0.77644	0.71232	0.61481
$F(4,47)=$	[0.4691]	[0.3947]	[0.5461]	[0.5877]	[0.6541]
AR 1-4:	2.0145	3.9791	3.7551	5.2659	3.3834
$F(4,45)=$	[0.1085]	[0.0076]**	[0.0102]*	[0.0014]**	[0.0167]*
Jarq.Bera:	0.26854	6.0045	0.94836	1.7036	5.6711
$\chi^2(2)=$	[0.8744]	[0.0497]*	[0.6224]	[0.4267]	[0.0587]
Skewness	0.11541	-1.2270	-0.54667	-0.12692	2.2513
Excess Kurtosis	2.5119	3.1557	2.4293	2.2306	4.3711

Again we can see the problem of autocorrelation at the univariate tests. Besides, the normality of the exchange rate series is rejected but it is mainly because of the excess kurtosis. Other misspecification tests are satisfactory.

As argued in Section 6.10, the correlations of the residuals play an important role. Unfortunately, from the correlation matrix, based on the rule of thumb, we can see that all of the correlations accept the correlation between the interest rate spread and output are significant. The largest one is between $\Delta R_{S_{t-1}}$ and $\Delta m'_t$. The indicated sign is plausible for the money demand equation, that is, the increase in the interest rate spread would lead to an increase in the opportunity cost of holding money hence would cause a decrease in the money holdings even in the short-run. The second correlation is between $\Delta^2 p_{t-1}$ and Δm^r_t with a value of -0.601. Because of the indicated sign, we can think the causality runs from inflation to money, that is, whenever the (acceleration in) inflation increases in the last period, then central bank might intervene and reduce money supply to control inflation.

I will estimate the model by taking into account both relations. Table 19 represents the identified SR structure with current effects. The restrictions are accepted by $\chi^2(28)=35.341$ with a p-value of 0.1602.

Table 19: The Short-Run Structure with Current Effect

	Δm^r_t	$\Delta^2 e_t$	$\Delta^2 p_t$	Δy^r_t	ΔRs_t
Δm^r_t	1	0	0	0	0
$\Delta^2 e_t$	0	1	0	0	0
$\Delta^2 p_t$	-2.082 [-4.02]	0	1	0	0
Δy^r_t	0	0	0	1	0
ΔRs_t	0.0445 [0.144]	0	0	0	1
Δm^r_{t-1}	0.358 [3.32]	0	0	0	0
$\Delta^2 e_{t-1}$	0	0	-0.075 [-2.84]	0	0
$\Delta^2 p_{t-1}$	0	0	0	-0.307 [-2.68]	0.317 [3.20]
Δy^r_{t-1}	0	0	0	0	0
ΔRs_{t-1}	0.337 [2.07]	0	0	0	-0.166 [-1.63]
$ecm1_{t-1}$	-0.274 [-3.16]	-0.188 [-10.0]	0	0	-0.217 [-5.02]
$ecm2_{t-1}$	-0.939 [-3.58]	1.438 [5.31]	-0.242 [-2.00]	0	0
$ecm3_{t-1}$	0	0.318 [9.14]	0.219 [8.50]	-0.136 [-2.91]	-0.228 [-3.68]
D_p01_t	0.123 [1.18]	0.343 [5.28]	0.112 [4.30]	0	0
ΔD_s94_t	0.288 [1.57]	0.395 [5.92]	0.207 [7.95]	-0.119 [-2.96]	0.274 [7.46]
ΔD_s00_t	0	0	0	0	-0.156 [-4.85]
constant	2.154 [3.26]	0	-0.860 [-8.04]	0.555 [2.96]	2.56 [4.71]

Ω correlation of structural residuals (standard deviation on diagonal)

Δm^r_t	0.051				
$\Delta^2 e_t$	-0.033	0.063			
$\Delta^2 p_t$	**0.273**	0.475	0.024		
Δy^r_t	0.138	-0.310	-0.201	0.039	
ΔRs_t	**-0.415**	0.399	0.396	-0.131	0.035

By considering the current effect between the inflation rate and money, I can get a significant coefficient. It suggests that the increase in the inflation will lead to a 2% decrease for the money supply. The correlation of the structural residuals between the series becomes insignificant. However, there are still significant simultaneous current effects between the other series.

Although the sign is again correct, the estimated coefficient for the interest rate spread is not significant at 5% level.

The first thing is to note about the parsimonious model is that, all of the repressors are reacting to at least one of the cointegrating relations, which indicates that none of them are weakly exogenous variable. Besides, all of the variables react the disequilibrium at the third relation, namely the interest rate policy function.

The parsimonious model suggest that the changes in the growth rate of output does not affect any of the variables in the model, which is not plausible, because what we expect is a reaction of the nominal variables even in the short-run to fiscal shocks.

Moreover, the (acceleration in) depreciation rate does not react to the other variables in the model in the short-run. This may be the case because of the managed floating of the exchange rate.

Money stock and the interest rate spread react to the movements in the acceleration in inflation. Higher inflation rates for the previous period will leads to a 3% decrease in the real output, and almost 4% increase in the interest rate spread.

Real money reacts to all of the cointegration relations, which may be argued as plausible, because the first cointegration relation relates to the money equation itself, the second one can be interpreted as the excess of inflation and the third one as the interest rate policy function. The signs are also correct, because whenever we have excess money or unanticipated increase in inflation we expect central bank to intervene and reduce the money stock. Besides, the excess of the interest rate spread over the inflation and output may also lead the central bank to intervene.

Inflation equation also reacts to the second and the third *ecm* relations. Arguing the excess interest rate spread cause inflation to increase is again plausible.

8. Conclusion

This thesis models the $M1$ money balances using real output, price level, exchange rate and the interest rate spread for Turkey for the period 1987Q1-2003Q3. The period was characterized by high inflation, financial liberalization, capital account liberalization, and financial innovations driven mainly by an increasing public debt and two effective currency crises. This conjecture is modeled using Johansen Multivariate Cointegration Analysis Approach, and extended portfolio balance type of money demand function. In order to find an empirically well-behaved specification as the starting point for cointegration analysis, two different scenarios have been considered; treating nominal variables[25] as integrated of order one and two. For both of the scenarios, two shift dummies- to capture the currency crises- and a trend are included in the cointegration space. Cointegration analysis reveals that there are three stationary long-run relationships between those variables for both scenarios.

The first long-run relation for the $I(1)$ scenario discloses that the increase in the interest rate spread would lead to output gap to decrease in the long-run. The second cointegration relation tells us that there is a long-run relationship between the velocity of money, the interest rate spread and exchange rate. The interest rate spread has a negative sign, reflecting the opportunity cost of holding money. Significance of the exchange rate variable in the money

[25] Except the interest rate spread

demand function indicates the opportunity cost of holding domestic balances in terms of foreign ones. The third relation predicts that by taking into account the trend and the structural changes occurred because of the crises, the interest rate spread can be stationary even in the long-run.

In the other scenario, since prices are treated as $I(2)$, the original $I(2)$ series is transformed to $I(1)$, based on long-run price homogeneity assumption. The test for the long run homogeneity is also highly accepted. The first cointegration relation gives us the demand for real balances. It concludes that the velocity of money is inversely related to the opportunity cost of holding money; inflation and the interest rate spread. Again the negative estimated coefficient of the depreciation rate is a signal for the currency substitution in Turkey for the given period. The second cointegration relation asserts that the increase in the depreciation rate will lead to an increase in the inflation rate even in the long-run. Finally I can reach an interest rate policy rule as a third relation. This claims that the increase in the output gap will lead the policymakers to decrase the interest rates to boom the economy.

The results of this study in comparison with the previous results in the literature indicate that the opportunity cost of holding M1 is higher than the opportunity cost of holding currency, in line with expectations. In addition, the extent of currency substitution in Turkey is estimated to be smaller than Argentina and Thailand, and also smaller over time.

As noted earlier, the degree of currency substitution plays an important role in determining a stabilization policy and conducting monetary policy in a high-inflation economy. Compared with the previous studies, one can argue that the extent of the substitution of the domestic balances to foreign ones in Turkey has decreased when the dynamics after 2001 is taken into account. This might be because of the reduced volatility of the interest rate and inflation after 2001. Moreover, as noted in Section 3, reverse currency substitution took place for 2003 and 2004. In addition to the macroeconomic environment (decreasing inflation and interest rates, good signs in macroeconomic indicators) and agents' expectations of future political stability play a crucial role in the process of reverse currency substitution. Particularly, the demand for domestic money becomes more stable and this makes it easy to conduct a disinflationary monetary policy to fight inflation. In turn, the monetary policies become more efficient because of the increased credibility of the Central Bank.

The short run analysis for both of the variables is also developed for both of the scenarios. However, the short-run estimates are not that satisfactory as the long-run results, in the sense that some of the results are conflicting with the theory. For instance; for both of the scenarios the changes in the growth rate of output does not affect any of the variables in the model. On the other hand, the results also indicate significant simultaneous effects between the inflation rate and the depreciation rate, as well as the interest rate spread and the money growth rate, which are all plausible.

For both of the scenarios, real output and interest rates are the main determinants of the real money balances, which is consistent with the conventional money demand relationships. Besides, again for both scenarios, the significant and negative coefficient of the exchange/depreciation rate is consistent with the existence of currency substitution in Turkey.

It is also important that such an analysis as conducted in this thesis might not yield robust results, for example, when the time period is extended. Moreover, in an inflationary environment, economic agents update their decisions frequently. But due to the lack of higher frequency data, quarterly data is used in this study. Furthermore, I use the link between the exchange rate and currency substitution in order to find empirical evidence. However, different determinants of currency substitution could also be used.[26] Although the impulse response analysis is not covered in this thesis, it might be interesting in order to identify the shocks to the system variables.

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[26] see for instance Ericsson and Kamin (2003) , Cuddington (1983)

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10. Appendix A: Data Issues

Table A1: Data Definitions and Sources of the transformed Series Used in Cointegration Space

variable	definition	source
m_t	natural logarithm of nominal M1, currency in circulation and demand deposits	CBRT
p_t	natural logarithm of consumer price index, (2000=100)	IFS
y_t	natural logarithm of Real Gross Domestic Product, GDP, (2000=100)	IFS
e_t	natural logarithm of nominal market exchange rate, average, TL/$	IFS
R_{b_t}	end-of period compound 3-month Treasury bill interest rate, divided by 400	CBRT[27]
R_{m_t}	weighted averages of 3-month deposit interest rate, divided by 400	CBRT
R_{S_t}	$R_{b_t} - R_{m_t}$	
m^r_t	$m_t - p_t$	

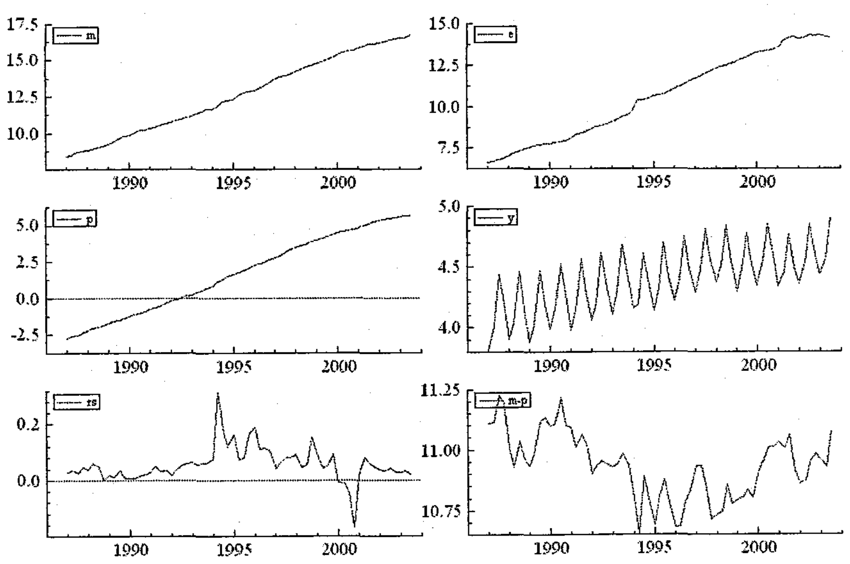

Figure A1: Series in Levels

[27] I wolud like to thank Ozge Akıncı from CBRT for supplying the data.

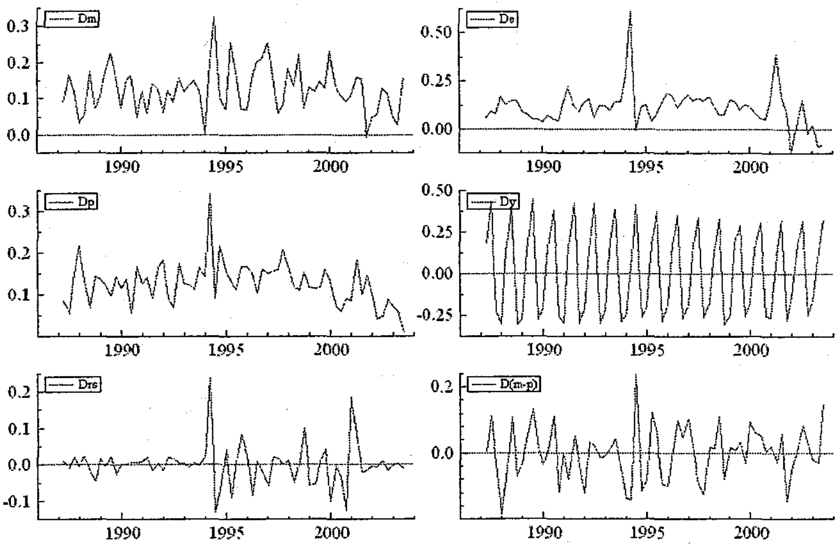

Figure A2: Series in First Differences

11. Appendix B

1. *I*(1) Scenario

Table B1: The Unrestricted VAR(2) Model Results, Estimated eigenvectors, and loadings

Non-Normalized Eigenvectors: β'_i								
	m	e	p	y	R_S	D_s94	D_s00	$trend$
β'_1	10.3723	5.4624	-14.8579	-1.9239	42.3462	-3.583	-4.025	0.0526
β'_2	-7.5409	-5.1385	14.3054	4.2718	-5.4745	1.7406	1.2536	-0.404
β'_3	-9.2490	-4.8552	18.4565	-24.636	-6.0854	-1.418	1.8933	-0.434
β'_4	-0.8636	10.9887	-22.807	-9.4045	-20.135	4.4942	-7.897	1.8915
β'_5	6.3512	-7.8584	1.8196	-14.792	-4.2443	2.6685	0.3467	-0.041

Loadings: α_i					
	α_1	α_2	α_3	α_4	α_5
Δm	-0.0016	0.0202	0.0176	0.0081	-0.008
	[-0.3204]	[3.9559]	[3.4358]	[1.5789]	[-1.6027]
Δe	0.0101	0.0230	-0.0076	-0.0167	0.0034
	[1.9230]	[4.4032]	[-1.4574]S	[-3.1834]	[0.6572]
Δp	0.0094	0.0083	-0.0097	0.0037	0.0014
	[0.6572]	[3.6106]	[-4.2159]	[1.6004]	[0.6299]
Δy	0.0061	-0.0013	0.0174	0.0054	0.0067
	[1.6001]	[-0.3402]	[4.5195]	[1.4060]	[1.7461]
ΔR_S	-0.0165	0.0017	-0.0069	-0.0000	0.0058
	[-5.7145]	[0.5794]	[-2.3992]	[-0.0109]	[2.0129]

The Combined Effects: $\hat{\Pi}$								
	m	e	p	y	R_S	D_s94	D_s00	$trend$
Δm	-0.3912	-0.0451	0.4391	-0.2981	-0.4150	0.0306	-0.001	-0.003
	[-4.4824]	[-0.5442]	[2.3904]	[-1.9046]	[-1.6976]	[0.8894]	[-0.0297]	[-0.0266]
Δe	0.0374	-0.2364	0.4254	0.3726	0.6670	-0.0508	0.1067	-0.037
	[0.4188]	[-2.7903]	[2.2645]	[2.3281]	[2.6682]	[-1.4445]	[2.2267]	[-3.5761]
Δp	0.1306	0.0848	-0.2810	0.1996	0.3321	0.0148	-0.0743	0.0082
	[3.3380]	[2.2825]	[-3.4110]	[2.8443]	[3.0294]	[0.9571]	[-3.5377]	[1.8095]
Δy	-0.0490	-0.0374	0.0994	-0.5950	0.0246	-0.0068	-0.0338	0.0033
	[-0.7481]	[-0.6005]	[0.7208]	[-5.0636]	[0.1339]	[-0.2615]	[-0.9620]	[0.4282]
ΔR_S	-0.0830	-0.1114	0.1529	0.1242	-0.6915	0.0874	0.0578	0.0012
	[-1.6798]	[-2.3760]	[1.4711]	[1.4023]	[-4.9989]	[4.4935]	[2.1808]	[0.2034]

Table B2: The Unrestricted VAR(2) Model Results, SR Parameters

	Γ				
	Δm_{t-1}	Δe_{t-1}	Δp_{t-1}	Δy_{t-1}	$\Delta R_{S_{t-1}}$
Δm_t	0.3032 [2.4968]	0.0834 [0.7749]	-0.2638 [-1.0613]	0.2762 [1.5172]	0.4487 [2.3627]
Δe_t	0.1478 [1.1901]	0.3066 [2.7862]	-0.0721 [-0.2834]	-0.1834 [-0.9852]	-0.1451 [-0.7470]
Δp_t	-0.0310 [-0.5701]	0.0359 [0.7446]	0.2936 [2.6337]	-0.1198 [-1.4671]	-0.1008 [-1.1839]
Δy_t	0.0735 [0.8067]	0.0289 [0.3576]	-0.0901 [-0.4830]	0.2280 [1.6688]	0.0709 [0.4971]
ΔR_{S_t}	0.0137 [0.2000]	-0.0297 [-0.4874]	0.3099 [2.2027]	-0.2306 [-2.2389]	-0.0273 [-0.2543]
	Weakly Exogenous Variables				Dummy Variable
	$\Delta D_s 94_t$	$\Delta D_s 00_t$	$\Delta D_s 94_{t-1}$	$\Delta D_s 00_{t-1}$	$Dp01_t$
Δm_t	0.0773 [1.5791]	0.0313 [0.6425]	0.0596 [0.7531]	0.0187 [0.2611]	0.0118 [0.2037]
Δe_t	0.4791 [9.5707]	0.0595 [1.1920]	-0.2758 [-3.4066]	0.1308 [1.7833]	0.3131 [5.2842]
Δp_t	0.2020 [9.2027]	-0.0542 [-2.4766]	-0.1411 [-3.9742]	0.0725 [2.2528]	0.1432 [5.5112]
Δy_t	-0.1148 [-3.1238]	0.0325 [0.8881]	-0.0058 [-0.0972]	-0.0013 [-0.0243]	-0.0426 [-0.9801]
ΔR_{S_t}	0.2926 [10.5637]	-0.1824 [-6.6065]	-0.0415 [-0.9256]	0.0255 [0.6294]	0.0556 [1.6967]
	Centered Seasonals			*constant*	
	CS_1	CS_2	CS_3	c	
Δm_t	-0.0311 [-0.5030]	-0.0264 [-0.2736]	0.0810 [1.7551]	6.1042 [3.4676]	
Δe_t	0.0130 [0.2060]	-0.0764 [-0.7746]	-0.0698 [-1.4796]	0.9405 [0.5224]	
Δp_t	-0.0056 [-0.2029]	0.0126 [0.2907]	-0.0381 [-1.8398]	-3.1497 [-3.9901]	
Δy_t	0.2075 [4.4744]	-0.2733 [-3.7736]	-0.2272 [-6.5591]	3.3684 [2.5487]	
ΔR_{S_t}	0.0852 [2.4379]	0.1201 [2.2000]	-0.0311 [-1.1927]	1.3284 [1.3336]	

2. *I*(2) Scenario

Table B3: The Unrestricted VAR(2)Model Results, Estimated eigenvectors, and loadings

Non-Normalized Eigenvectors: β'_i

	m-p	Δe	Δp	*y*	*Rs*	D_s94	D_s 00	*trend*
β'_1	8.7991	17.3991	-18.1269	0.0277	12.2937	0.8733	-0.4222	0.0119
β'_2	0.6292	8.4991	-60.571	13.2050	5.6927	2.1140	-0.784	-0.184
β'_3	-11.92	13.3828	-22.834	-8.3139	-30.707	1.7276	1.3746	-0.001
β'_4	-1.097	1.2315	-27.137	-21.764	22.4066	-1.3091	-3.5190	0.2259
β'_5	-6.3696	2.4726	-0.4564	14.9207	10.4127	-1.4836	2.1441	-0.1175

Loadings: α_i

	α_1	α_2	α_3	α_4	α_5
$\Delta(m\text{-}p)$	-0.0213	-0.0056	0.0212	0.0164	0.0069
	[-3.6838]	[-0.9611]	[3.6658]	[2.8479]	[1.1901]
$\Delta^2 e$	-0.0308	0.0107	-0.0283	-0.0011	0.0015
	[-5.5745]	[1.9424]	[-5.1151]	[-0.1957]	[0.2761]
$\Delta^2 p$	0.0047	0.0164	-0.0041	0.0011	-0.0024
	[2.1210]	[7.4000]	[-1.8411]	[0.4833]	[-1.0682]
Δy	-0.0015	-0.0138	0.0033	0.0112	-0.0062
	[-0.3969]	[-3.7734]	[0.9046]	[3.0642]	[-1.6813]
ΔR_S	-0.0108	0.0017	-0.0009	-0.0094	-0.0054
	[-3.5684]	[0.5702]	[-0.3053]	[-3.1198]	[-1.7943]

The Combined Effects: $\hat{\Pi}$

	m-p	Δe	Δp	*y*	R_S	D_s94	D_s 00	*trend*
$\Delta(m\text{-}p)$	-0.5048	-0.0968	-0.2110	-0.5053	-0.5032	-0.0255	-0.0007	0.0037
	[-5.4041]	[-0.7070]	[-0.5040]	[-2.8541]	[-2.0904]	[-1.2661]	[-0.0276]	[2.0238]
$\Delta^2 e$	0.0640	-0.8214	0.5829	0.4226	0.5425	-0.0539	-0.0272	-0.0028
	[0.7156]	[-6.2656]	[1.4536]	[2.4921]	[2.4921]	[-2.8000]	[-1.1095]	[-1.5906]
$\Delta^2 p$	0.1139	0.1615	-1.0104	0.1914	0.2750	0.0337	-0.0292	-0.0024
	[3.1862]	[3.0849]	[-6.3075]	[2.8258]	[2.9859]	[4.3835]	[-2.9810]	[-3.5085]
Δy	-0.0341	-0.0999	0.4865	-0.5468	-0.0109	-0.0303	-0.0367	0.0058
	[-0.5748]	[-1.1499]	[1.8306]	[-4.8648]	[-0.0716]	[-2.3767]	[-2.2593]	[5.0243]
ΔR_S	-0.0380	-0.2105	0.3708	0.1545	-0.3624	0.0130	0.0235	-0.0019
	[-0.7761]	[-2.9369]	[1.6911]	[1.6668]	[-2.8754]	[1.2368]	[1.7525]	[-2.0383]

Table B4: The Unrestricted VAR(2) Model Results, SR Parameters

	Γ				
	$\Delta(m-p)_{t-1}$	$\Delta^2 e_{t-1}$	$\Delta^2 p_{t-1}$	Δy_{t-1}	$\Delta R_{S_{t-1}}$
$\Delta(m\text{-}p)_t$	0.3671 [2.6884]	0.0654 [0.5807]	0.2524 [0.9106]	0.3542 [1.7716]	0.4505 [2.1837]
$\Delta^2 e_t$	0.1226 [0.9372]	0.1019 [0.9457]	-0.2758 [-1.0391]	-0.2268 [-1.1845]	-0.0124 [-0.0627]
$\Delta^2 p_t$	-0.0472 [-0.9044]	-0.1116 [-2.5914]	0.1045 [0.9851]	-0.1001 [-1.3086]	-0.0604 [-0.7649]
Δy_t	0.0882 [1.0171]	0.1521 [2.1290]	-0.4039 [-2.2957]	0.2119 [1.6694]	0.0394 [0.3009]
ΔR_{S_t}	0.0209 [0.2923]	0.0846 [1.4352]	0.0727 [0.5006]	-0.2753 [-2.6293]	-0.1600 [-1.4807]
	Weakly Exogenous Variables				Dummy Variable
	$\Delta D_s 94_t$	$\Delta D_s 00_t$	$\Delta D_s 94_{t-1}$	$\Delta D_s 00_{t-1}$	$Dp01_t$
$\Delta(m\text{-}p)_t$	-0.1455 [-2.7789]	0.0685 [1.3021]	0.1382 [1.6778]	0.0379 [0.5140]	-0.0829 [-1.2317]
$\Delta^2 e_t$	0.4245 [8.4651]	0.0293 [0.5807]	-0.3651 [-4.6288]	0.2181 [3.0849]	0.3497 [5.4274]
$\Delta^2 p_t$	0.2183 [10.8961]	-0.0461 [-2.2883]	-0.1148 [-3.6437]	0.0319 [1.1296]	0.1131 [4.3943]
Δy_t	-0.1239 [-3.7274]	0.0385 [1.1528]	0.0172 [0.3284]	-0.0071 [-0.1505]	-0.0253 [-0.5924]
ΔR_{S_t}	0.2825 [10.3022]	-0.1816 [-6.5871]	-0.0474 [-1.0992]	0.1007 [2.6040]	0.1004 [2.8507]
	Centered Seasonals			*constant*	
	CS_1	CS_2	CS_3	c	
$\Delta(m\text{-}p)_t$	-0.0033 [-0.0549]	0.1030 [1.0701]	0.0109 [0.1604]	7.6918 [5.8656]	
$\Delta^2 e_t$	-0.1004 [-1.7665]	-0.1045 [-1.1327]	-0.0274 [-0.4210]	-2.4490 [-1.9500]	
$\Delta^2 p_t$	0.0122 [0.5385]	-0.0221 [-0.5986]	0.0152 [0.5866]	-1.9262 [-3.8394]	
Δy_t	-0.4819 [-12.7908]	-0.4260 [-6.9700]	-0.2136 [-4.9560]	2.5635 [3.0796]	
ΔR_{S_t}	0.0295 [0.9499]	-0.1533 [-3.0404]	-0.1012 [-2.8467]	-0.2152 [-0.3134]	