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MONETARY APPROACH TO EXCHANGE RATE DETERMINATION: SINGLE EQUATION VERSUS MULTICOINTEGRATING VAR SYSTEM ESTIMATION FOR EXCHANGE RATES IN TURKEY

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I. Introduction

Exchange rates policies are an important part of the development and stabilization efforts. Since 1980, Turkey implemented a stabilization program which emphasized the liberalization of foreign trade and payments. An important component of these liberalization efforts was the change in the exchange rate regime and greater emphasis of exchange rate flexibility. Turkey, like many developing countries had been following a fixed exchange regime and parallel to the liberalization efforts of the economy the rules of exchange rate regimes were gradually changed towards a market determined, flexible exchange rates.

Prior to 1980, Turkey followed an inward looking, import-substitution development strategy where highly restrictive trade regimes were used to promote industrialization. During this period the economy was frequently disturbed by large trade deficits and foreign exchange shortages. With the exception of periods of unusual foreign exchange abundance, such as in early 1970's when the workers' remittances increased, and in mid 1970's when the conditions of external borrowing was relatively easy due to recycled petro dollars, balance of payment problems became the common element in the economy. Prior to the major change in the development strategy in 1980, there were few short-lived attempts toward trade liberalizations and export promotion. Although the purpose of these policies were to solve the balance of payment

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problems the only sustained change created by these stabilization policies were major devaluations of the Turkish Lira (TL), the domestic currency in accordance with the IMF relief programs.

At the end of 1979, Turkey went through a severe balance of payments and foreign debt crisis with acute foreign exchange shortage. There were two debt rescheduling; one in 1979 and another in 1980 and a series of important changes were introduced as part of the stabilization and liberalization programs. An important difference between this and the previous stabilization programs was that for the first time an outward looking and market oriented approach was taken in economic policy making. The policies were aimed at liberalization of the foreign trade regimes; promoting exports and lifting import restrictions, stabilization of balance of payments, encouragement of foreign direct investment; lifting the restrictions of capital flows, liberalizing the financial markets and the most important of all was the rationalization of the foreign exchange system. Therefore the main objective of the program was directed towards creating a larger inflow of foreign exchange into the domestic economy and to solve the exchange shortages.

The object of the paper is to empirically test the theory of monetary approach to exchange rate determination and to determine the applicability of the theory to exchange rates in Turkey. The empirical investigation of the theory is conducted using two alternative methods. First one is the estimation of single reduced form equation of exchange rate. The variables are defined in their first differences to achieve stationarity and bivariate error correction model is estimated. In the second method, the theory is tested in the framework of multivariate error correction model. This formulation considers the interaction between the exchange rate and other variables in a simultaneous model, where variables are defined in levels and the long-run relationships are highlighted. The hypothetical parameter restrictions implied by the monetary model is not imposed, instead tested for by the information data reveals and hence the single equation bias is avoided. With its recent liberalization efforts and short experience of floating exchange rate regime, Turkey presents an interesting case for the reevaluation of the monetary theory of exchange rate determination. The study examines the applicability of the monetary theory to a rapidly depreciating currency in a high inflation economic environment.

The plan of the paper is as follows: the second section presents a brief historical review of the exchange rate determination rules in the Turkish economy. The third section presents a brief review of the theory of monetary approach to exchange rates. The fourth section presents the empirical analysis. In this section stationarity of the time series variables are investigated. The estimation results for the reduced form equation of the monetary approach to exchange rate determination and the tests of the bivariate cointegating relationship between exchange rates and relative money supplies are reported. The tests of the monetary model using a multivariate cointegrating approach using Johansen procedure is presented in this section and the results are compared to the single equation estimations. Section five is the summary and conclusion.

II. Historical review of Turkish exchange rate regimes and rules of the present exchange rate determination

Prior to the liberalization of the foreign exchange markets in 1980's, Turkey followed an adjustable pegged exchange rate system. The government had strong control over the foreign exchange policy. There were no legal foreign exchange market, the national money, Turkish Lira (TL) was not convertible. The official parity between US dollar (US$) and TL was determined by The Ministry of Finance, instead of the Central Bank. After the breakdown of the Bretton Woods system, between the years 1974 and 1981, Turkey kept the dependency of the TL on the US$. However, the parity was adjusted more frequently, every three or four months.

The new economic policies of 24 of January 1980, brought a more liberal international trade regime which required more freedom on the foreign exchange policy. Starting May 1, 1981, Central Bank determined the exchange rates of the US$ and the other currencies on a daily basis with the objective that "TL should bear its real value against foreign currencies".[1] As part of the softening of the foreign exchange controls, residents of Turkey were allowed to trade and have foreign exchange deposit accounts. Initially, the commercial banks used the exchange rates set by the Central Bank, then they were able to set the foreign exchange values within a specified margin of the Central Bank rate. Eventually they were free to determine their

[1] see Central Bank of Turkey Annual Report, various years.

own rates for the foreign exchange transactions. In addition, in January 1987 private financial institutions other than the banks were also allowed to trade in foreign currencies and these were called 'foreign exchange buffets'.

In August 1988, the major reform in exchange rate determination rules occured and with this change, demand and supply forces became the determining factor of exchange rates in Turkey. The Central Bank of Turkey opened, within the institution, an interbank foreign exchange markets. Foreign exchange fixing sessions were first used on August 8, 1988. From this date on, the official foreign exchange rates are determined in a daily fixing sessions in these markets. In these sessions participants quote buying and selling prices for the US$ and the equilibrium rate for TL price of one US$ is determined. The other currency values in terms of the TL are calculated according to the cross rates that prevail in the world markets. The commercial banks, private financial institutions and the branch of the Central Bank in charge of its foreign exchange position are the participants. In this method of exchange rate determination, demand and supply of foreign exchange are the main factors determining the exchange rates. Among the various exchange rate determination rules in Turkey, this is the closest to a regime of floating exchange rates.

III. Theory of Monetary Approach to Exchange Rate Determination

The asset market approach to exchange rates determination views the exchange rate as the price of international assets that adjusts, to clear the relative demand and supply of domestic and foreign assets. These theories emphasize the role of the asset markets and asset market equilibria compared to the traditional view which accepts the flow of foreign exchange resulting from the flow of goods and services as the main determinant of exchange rates. Even though it presents a partial theory of exchange rate determination, it is useful in bringing empirical explanations to the sources of exchange rate changes.

The main assumption of the asset market approach is the perfect capital mobility. That is, there are no impediments to capital flows, no transaction cost or no capital controls. If it is further assumed that domestic and foreign bonds are perfect substitutes, then the portfolios will adjust instantaneously and the nominal domestic interest rate will be equal to the foreign interest rate plus the expected rate of depreciation of the domestic currency. The international capital markets converge into one market with the instantaneous adjustment of portfolios. This leaves the money markets as the main determinants of exchange rates. This branch of asset market approach views the exchange rates as equilibrating domestic and foreign money markets and is referred to as the monetary approach to exchange rates.[2]

The monetary approach to exchange rates states that the exchange rates is the price of foreign currency, and as any other relative price the exchange rate is determined by relative demand and supply of two monies. A static semi linear money demand equation is assumed for each country. Here, money demand is a function of exogenous real income and nominal interest rates and money supply is exogenous. For the domestic economy, the equilibrium in the domestic money market is given as

$$m - p = ky + hi \qquad (1)$$

where m is the nominal money supply, p is the price level and y is the real income defined in natural logarithms and i is the nominal interest rate. A similar money market equilibrium is assumed for the foreign economy,

$$m^* - p^* = ky^* + hi^* \qquad (2)$$

where (*) denotes the foreign variables.

Taking the difference in two money market equilibrium gives the relative money demand functions:

$$(m - m^*) - (p - p^*) = k(y - y^*) + h(i - i^*) \qquad (3)$$

where the money demand parameters are assumed to be the same for both countries.

[2] For a detailed view of the asset market approach see Frankel (1983).

The linkages between the domestic price levels and foreign price levels are used to close the model. Different assumptions about the speed of adjustment in the goods market results in different versions of the monetary approach. These are flexible-price (Frenkel-Bilson) monetary model with purchasing parity assumption, sticky-price (Dornbusch-Frankel) monetary model with slow price adjustment assumption and sticky-price (Hooper-Morton) monetary model with cumulative trade balances included as a determining factor for exchange rates. These versions can be summarized in the following general specification as:

$$e = (m - m^*) - h(y - y^*) + k(i - i^*)$$

$$-1/\theta[i - E(\Delta p) - i^* - E(\Delta p^*)] - \psi(TB - TB^*) \qquad (4)$$

where $E(\Delta p)$ is the expected rate of inflation and TB is the cumulated trade balance.

The empirical tests of the monetary model are conducted by estimating the following equation:

$$et = ao + a_1(m - m^*)_t + a_2(y - y^*)_t + a_3(i - i^*)_t$$

$$+ a_4(ir - ir^*)_t + a_5(TB - TB^*)_t + \varepsilon_t$$

where a_2, a_3, a_4 and a_5 corresponds to k, h, $1/\theta$ and ψ of the original model and ir is the real interest rate. Different formulation of the monetary model of exchange rate determination and expected coefficients are as follows:

Model 1: Flexible-Price Model: $a_1>0$, $a_2<0$, $a_3>0$, $a_4=a_5=0$.

Model 2: Sticky Price Model: $a_1>0$, $a_2<0$, $a_3>0$, $a_4<0$, $a_5=0$.

Model 3: Model with Cumulated Trade Balance: $a_1>0$, $a_2<0$, $a_3>0$, $a_4<0$, $a_5<0$.

IV. Empirical Analysis

In this section empirical evidence of the monetary approach for Turkish Lira is considered. The period under study is 1988:8 - 1993:4 during which the exchange rates in Turkey are determined in the interbank foreign exchange market. The empirical tests of the monetary model for Turkish exchange rates proceeds with establishing the time series properties of the series used as dependent and explanatory variables in the estimation of the monetary models. Augmented Dickey Fuller tests are conducted. The proportionality between the exchange rates and relative money supplies are investigated and the monetary model is estimated using an Error Correction Model (ECM) in a single reduced form equation of space exchange rates, to incorporate the bivariate cointegrating relation that may exist between the exchange rates and the relative money supplies. An alternative formulation for empirical tests of the monetary model is in a multivariate cointegrating framework where a VAR model in levels is set with the variables of the model. Here the interaction between the exchange rates, relative money supplies, relative income levels, interest rate differentials and trade balance variables are considered in a simultaneous model without imposing any parameter restrictions of the model. Instead the existence of multivariate cointegrating relationship and the restrictions are tested for by the data within the cointegrating space using the Johansen's multivariate cointegrating technique. The monetary approach is tested for Turkish Lira(TL)/US dollar($) exchange rates. The data is seasonally adjusted monthly data, with Turkey as the domestic country (see Appendix for the description of the data and its sources).

IV.1. Time Series Properties:

A critical issue in time series models is testing for the presence of unit roots. Most macroeconomic series tend to behave as random walks and the use of these variables in regressions will lead to spurious results. Variables that follow a random walk do not have a finite variance and Gauss-Markov theorem does not hold and OLS does not give consistent parameter estimates.[3]This section tests the presence of unit roots in Turkish exchange rate series and the other explanatory variables in the monetary models of exchange rate models.

Time series zt can be described by the following equation:

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[3]Pindycke and Rubenfield(1991), pp.440-465.

$$zt = \alpha + T + pz_{t-1} + \omega_t \quad (1)$$

where T, and ω_t are time trend and the Gaussian disturbance term, respectively. Testing for unit roots is testing whether $p = 1$, against the alternative hypothesis of $p < 1$ which implies a stationary series.

Dickey-Fuller test for unit roots are based upon the following Augmented Dickey-Fuller (ADF) regression:

$$\Delta zt = \alpha + \beta T + (p-1)z_{t-1} + \sum \lambda_i \Delta z_{t-i} + \omega_t \quad (2)$$

The test of unit roots can be performed by running the above unrestricted equation for time series data, where Δz_{t-i} is the change in z_t, lagged i th period. The ADF test statistics is calculated by dividing the estimate of $(p-1)$ by its standard error and the cumulative distribution of the ADF statistics is provided by Fuller (1986). The null hypothesis is that the series is integrated of order 1 i.e. I(1). If the test statistic is less than the critical value, then the null hypothesis can be rejected and the series zt is stationary and integrated of order zero, i.e. I(0). All variables with the exception of interest rates are defined as natural logarithms. For variables that are I(1), the stationarity tests are also conducted for the first difference of the series to ensure that first differencing establishes stationarity. The results are reported in Table 1.

Table 1: ADF Test applied to all variables and their first differences

Augmented Dickey-Fuller Test Statistics		
Variables	Zt Lag	ΔZt Lag
eTL/US dollar	-0.259 (9)	-3.085 (5)
$e_{TL/DM}$	0.424(10)	-3.591(6)
$m_T - m_{US}$	-0.898 (9)	-2.887 (6)
$m_T - m_G$	-0.453(11)	-3.224(4)
$y_T - y_{US}$	-0.910 (7)	-3.802 (6)
$y_T - y_G$	-1.712(7)	-3.419(6)
$i_T - i_{US}$	-1.753 (11)	-3.649 (7)
i_T-i_G	-2.312(13)	-3589(8)
$TB_T - TB_{US}$	-2.351 (12)	-3.512 (9)
TB_T-TB_G	-1.041(11)	-3.016(7)

The appoximate critical values of ADF statistics are -2.93 for 5% level of significance and -2.60 for 10% significance. The numbers in paranthesis are the number of lagged terms in the ADF regression which are determined according to Akaike Information Criterion (AIC) or by the level of significance of the coefficients on the lagged variable using standard t-test.

According to these results the hypothesis of unit root in the level data is not rejected at the 5 percent critical level across every series. The result using first difference data reject the hypothesis of unit root for all the variables at 5 percent critical level.

IV.2. Bivariate cointegration and Error Correction Model formulation of the monetary approach:

Engel and Granger(1987) discussed the concept of a long-run relationship using the notion of cointegration. If there exists a cointegrating relationship between exchange rates and relative money supplies, which indicates a long-run proportionality between exchange rates and relative money supplies, then the monetary model should be formulated as an Error Correction Model. According to Granger, error correction models should provide the short-run dynamics necessary to obtain long-run equilibrium. Boothe and Glassman (1987) suggested the use of error correction models in the empirical test of the monetary approach. Hence, the empirical tests of the monetary models begin with the tests of bivariate cointegrating relationship between exchange rates and relative money supplies.

Two time series variables, zt and xt integrated of order d, are said to be cointegrated if there exist a constant δ that yields a linear combination, $y_t = z_t - \delta x_t$ where yt is integrated of order d-b and b>0.[4] The test of cointegration between the exchange rates and relative money supplies can be conducted by estimating the following cointegration equation:

$$et = \alpha + \beta(m - m^*)_t + \mu t$$

The test of stationarity of the residuals from the above regression is the test of cointegration. If μt is integrated of order 0 then the exchange rates and relative money supplies are cointegrated. The cointegrating regression and ADF statistics on the residuals are reported in Table 2.

Table 2: Cointegration tests between exchange rates and relative money supply variables

Cointegration Equation

Exchange rate	Constant	m- m*	R2	CRWDa	SEE	ADF for residuals[b,c]
eus dollar	5.056 (33.31)	0.904 (20.31)	0.888	0.109	0.172	-0.874(7)
eDM	1.158 (14.32)	1.158 (22.13)	0.904	0.185	0.177	-1.724(8)

[a] The critical value of the CRWD statistics is approximately 0.78 at the 5% level and 0.69 at the 10% level of significance for 50 observation. (Engle and Yoo(1987)).

[b] The critical value for the ADF statistics is -2.93 at the 5% level and -2.60 at the 10% level of significance for 50 observation. (Fuller(1986))

[c] The number inside the brackets if the number of lagged terms in the ADF regression which is determined according to the AIC criteria.

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[4]Engle and Granger (1987)

For the TL/US dollar exchange rate cointegration equation, the ADF statistics reported on the residuals are greater than the critical value. The Cointegration Regressions Durbin-Watson (CRDW) is also less than the critical value. Both of these tests indicate that exchange rates and relative money supplies series are integrated of order one, the linear combination of these time series are also integrated of order one. That is, the two series are not cointegrated.

According to the results, in formulating the monetary approach to exchange rate determination, an Error Correction Model is not necessary and first differencing of the time series variables is sufficient to obtain stationarity and consistent estimates of the parameters. Hence, the empirical tests of the monetary approach to exchange rate determination is conducted in the following relationship.

$$\Delta e_t = a_0 + a_1(\Delta m - \Delta m^*)_t + a_2(\Delta y - \Delta y^*)_t + a_3(\Delta i - \Delta i^*)_t$$

$$+ a_4(\Delta ir - \Delta ir^*)_t + a_5(\Delta TB - \Delta TB^*)_t + a_6\mu_{t-1} + \varepsilon_t$$

The formulation is a general form which incorporates different versions of the monetary approach. Significance of the individual or combination of coefficients ai's will either support or refute the models. An error correction term μ_{t-1} is included to the empirical tests even though the above test indicates that it was not necessary. The significance of a_6 will further test whether the error correction models have any relevance for the monetary models. If a_6 is significant then a certain fraction of the disequilibrium in the exchange rate is corrected in the following period in the adjustment to the long-run equilibrium.

In Table 3 the results of the estimation of the monetary model for TL/US dollar exchange rates are presented. The estimation results obtained from the application of the monetary model to exchange rates in Turkey are not very encouraging. The coefficients of the relative money supply (a_1) and real income (a_2) variables are not significant and are with signs that is contrary to what the monetary policy predicts. In some of the models the coefficients of the nominal interest rate (a_3), real interest rate (a4) and cumulated trade balance (a_5) variables are significant at approximately 10% significance levels and have the expected signs. Among different versions of the monetary approach, the sticky-price version and sticky price with cumulated trade balance variable are models supported by the data. Since the estimated model flexible-price model have the poorest results, it is possible to conclude that the necessary assumption of Purchasing Power Parity does not hold and is only a long-run condition for Turkey. Consistent with the results of the bivariate cointegration test, the coefficient of the error correction term is not significant in any of the equations.

Overall these results provide the conclusion that for the short period of floating exchange rate experience, the theory of monetary approach to exchange rate determination does not present a sufficient explanation for the exchange rates in Turkey, when estimated in a reduced form exchange rates equation with variables defined in their first differences. But there is some evidence that traditional flow approach provides a more appropriate explanation for the exchange rates during this period. The significant coefficient of the cumulated trade balance in the TL/US$ exchange rates is one indication. Another evidence is the signs of the coefficients of income and interest rate variables. These signs are contrary to the predictions of the monetary model but they support the traditional flow approach to exchange rate. Positive coefficient on income can be interpreted as faster increase in income worsens the trade balance and depreciates the currency. The negative sign on the coefficient of interest rate shows that an increase in interest rate results in faster capital inflow and an improvement of the balance of payments and appreciation of the domestic currency. These findings demonstrate that, during the period under study, the short-run dynamics Turkish exchange rates are governed by the flow of foreign exchange resulting from the balance of payments transactions. The long-run properties of asset market equilibriums are less obvious.

Table 3: Estimation Results of the TL/US Dollar Exchange Rates (all variables are in First Difference Form)

Model Exp. Var.	Model 1	Model 2	Model 3	Model 1 w/EC	Model 2 w/EC	Model 3 w/EC
Constant	0.036 (8.26)	0.036 (8.14)	0.035 (8.13)	0.036 (8.30)	0.036 (8.13)	0.036 (8.18)
m-m*	-0.041 (-0.57)	-0.037 (-0.51)	-0.030 (-0.41)	-0.052 (-0.71)	-0.047 (-0.63)	-0.042 (-0.57)
y-y*	0.018 (0.42)	0.021 (0.47)	0.038 (0.84)	0.020 (0.45)	0.021 (0.49)	0.041 (0.90)
i-i*	0.000 (0.27)	0.002 (1.75)	0.001 (1.61)	0.000 (0.40)	0.001 (1.73)	0.001 (1.58)
ir-ir*		-0.001 (-1.77)	-0.001 (-1.71)		-0.001 (1.70)	-0.001 (-1.63)
TB-TB*			-0.002 (-1.36)			-0.002 (-1.50)
ECterm				0.020 (0.96)	0.016 (0.74)	0.021 (0.98)
Statistics						
R^2	0.0195	0.0777	0.1128	0.0375	0.0883	0.1308
R^2	-0.0393	0.0009	0.0184	-0.0411	-0.0086	0.0175
F	0.332	1.012	1.195	0.477	0.911	1.155
DW	1.546	1.763	1.747	1.620	1.817	1.820
Godfrey	1.281 F(12,50)	1.012 F(12,48)	1.013 F(12,47)	1.227 F(12,49)	0.993 F(12,47)	0.969 F(12,46)
White	5.949 $\chi^2(3)$	6.193 $\chi^2(4)$	6.428 $\chi^2(5)$	8.316 $\chi^2(4)$	8.869 $\chi^2(5)$	8.391 $\chi^2(6)$

Numbers in parathesis below coefficient estimates are t-values.
Godfrey's LM test (twelveth order serial correlation), and White test (heteroskedasticity) are reported. The degrees of freedom of the F-test and χ^2 are provided.

IV.3. Multivariate cointegrating relationships among the variables of the monetary theory of exchange rate determination:

Single equation estimations give poor results for the monetary models. The estimates of similar models for different currencies

(Gandolfo et al. (1990), Ballie and Selover (1987)) give analogous results. When economic variables are non-stationary in their levels, models are estimated in their first difference forms. This satisfies the requirements of stationarity, but removes much of the long-run characteristics of the model and leads to misspecification if there are long-run cointegrating relationships between the variables. When testing for cointegrating relationship in a single equation framework, Engle and Granger type of cointegration analysis assumes only one cointegrating relationship and construct tests according to this apriori assumption. In their tests of cointegration, the parameters of the cointegrating vector are estimated with OLS. These OLS estimates will differ with the selection of independent variables and the implicit normalization that this selection creates. Different arbitrary normalizations can alter the Engle and Granger test results.

Johansen (1988) and Johansen and Juselius (1990) suggested an alternative procedure to examine the cointegrating relationships in the data. Their method gives MLE estimators of the cointegrating vectors and does not put any prior restriction on the cointegrating relationships and explicitly tests the number of cointegrating vectors. Since it does not work with the first differenced series it does not restrict the attention to growth rates but focuses on the trends in the level series. This distinguishes the short-run and long-run effects. The interaction between the variables are considered in a simultaneous model. In this paper, the monetary approach to TL/US dollar exchange rates is reexamined using the Johansen multicointegration procedure. A VAR system in levels is set for the variables of the monetary model which includes a constant and a trend and allows six order of lags of each variable.[5] The variables of a monetary approach to exchange rates et, (m-m*)t, (y-y*)t, (i-i*)t and (TB-TB*) are collected in a vector Zt.[6]

[5]The number of significant lags in the ADF test were between 7 and 13. The VAR system is estimated with 6 lags which is the maximum that the sample size allows. Tests with shorter lags do not alter the conclusions.

[6]The multicointegration analysis was performed using D.Hendry's PC-FIML and Jurgen Doornik's test copy of PC-FIML. Since the number of variables that can be included is limited, only the nominal interest rate differential is included among the two interest rate variables in the general formulation of the monetary model

$$Zt' = [z_{1t}, z_{2t}, z_{3t}, z_{4t}, z_{5t}]$$

The elements of Zt' are integrated of order one and the changes in these variables are stochastic with constant mean. In this setting, to find out whether the variables are driven by common trends, the existence of linear independent cointegrating relationships between z_{jt} such as

$$z_{jt} = \sum ß_{ji}\, z_{it} \qquad i= 1,..,r.$$

is investigated. Even though z_{jt} are I(1), the ε_{it} are I(0) series. The long-run behavior of z_{jt} is determined by 5-r common trends.

To test the number of cointegrating relationships by the method proposed by Johansen(1988) and Johansen and Juselius(1990) the time series variables, in levels, are represented by vectorauto-regressive representation.

$$Z_t = \eta + \Sigma\pi_\tau Z_{t-\tau} + n_t$$

where n_t is $N(0, \sigma^2 V)$ distributed. In the first difference from

$$\Sigma Z\tau = \eta + \Sigma\Gamma_\tau \Delta Zt-\tau + \Sigma\Gamma k Z_{t-k} + nt$$

where $\Gamma_\tau = -I + \pi 1 + \ldots\ldots.. \pi\tau$.

Cointegration can be detected by examining the Γ_k matrix. If pxp matrix Γ_k has rank 0 then all elements of Z_t has unit roots and first differencing is necessary. If Γk is of full rank p, then all elements of Z_t are stationary in levels. If Γ_k has a rank 0< rank $(\Gamma_k)=r<p$, then there are p-r cointegrating relations among the elements of Z_t. Therefore the rank of Γ_k is the number of cointegrating vectors and this matrix conveys information about the long-run relationship between the z_t variables.

Matrix Γ_k can be written as:

$$-\Gamma_k = \alpha\beta'$$

where β is the pxr matrix of cointegrating vectors and α is called the loading matrix which gives the weight attached to each cointegrating vector in every equation.

Johansen and Juselius(1990) demonstrated that β, the cointegrating vector can be estimated as the eigenvector associated with the r largest, statistically significant eigenvalues found by solving:

$$| S_{kk} - S_{ko} S_{oo}^{-1} - S_{ok} | = 0$$

where S_{oo} is the residual moment matrix from the least squares regression of ΔZ_t on $\Delta Z_{t-1}....\Delta Z_{t-k+1}$ and S_{kk} is the residual moment matrix from a least square regression of Z_{t-k} on Z_{t-k+1}. S_{ok} is the cross product moment matrix.

Using these eigenvalues one can test the hypothesis that there are at most r cointegrating vectors by using the eigenvalues and calculating the likelihood test statistics:

$$(-2)\ln(Q) = -T \sum \ln (1-\lambda_i)$$

where λ_{r+1} .....λp are the p-r smallest eigenvalues, and this is called the Trace test. There is also a likelihood ratio test called the maximal eigenvalue test which the null hypothesis of r cointegrating vectors is tested againts the alternative of r+1 cointegrating vectors.

The results of the application of the Johansen approach to TL/US dollar exchange rates are reported in Table 4.[7] The maximum eigenvalue test, reported in the first column, evaluates the null hypothesis r=0 againts the alternative $r \leq 1$. The trace test tests the null hypothesis that there are r or fewer cointegrating vectors againts a general alternative. It is possible to make inference on the number of cointegating vectors by using the trace test and maximum eigenvalue tests statistics and comparing the the 95% quantiles of the appropriate limiting distibutions.

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[7]The multicointegration analysis was performed using D.Hendry's PC-FIML and Jurgen Doornik's test copy of PC-FIML.

In the VAR system formulated for the TL/US$ exchange rate, it was found that there are at least 2 but possibly 3 cointegrating vectors present. Both statistics indicate that the hypothesis of two or less cointegrating vectors can be rejected. The estimates of the unconstrained cointegrating vectors are reported. Since there are more than one cointegating vectors the interpretation of the estimated vectors are not straightforward and only an heuristic interpretation can be obtained from these coefficients.

Table 4: Results of Johansen Maximum Likelihood Estimation for TL/US dollar exchange rates

			5% Critical	
	λMax	Trace	λMax	Trace
r≤4	6.269	6.269	8.083	8.083
r≤3	7.856	14.125	14.595	17.844
r≤2	31.635	45.759	21.279	31.256
r≤1	35.940	81.700	27.341	48.419
r≤0	52.405	134.106	33.252	68.977

Eigenvalues

[0.6211 0.4860 0.4434 0.1354 0.1096]

β' EIGENVECTORS [in rows, largest λi first]:

e_t,	$(m-m^*)_t$,	(y-y*)t,	$(i-i^*)_t$	$(TB-TB^*)_t$
40.84856	53.82345	11.64711	3.88138	1.59768
31.74357	29.58636	-12.62842	.14583	.13100
31.79910	24.32950	-17.01987	8.99777	.25448
12.20241	17.77126	26.92976	3.58572	-45506
25.93175	12.72197	42.76461	.70018	-.14835

It is possible to standardize the coefficients of the cointegating vectors by normalizing each cointegrating vector with respect to the coefficient of variable e. This will give the following vectors:

[1, 1.31, 0.28, 0.09, 0.03] (1st)

[1, 0.93, -0.40, 0.0045, 0.0041] (2nd)

[1, 0.77, -0.54, 0.283, 0.007] (3rd)

One of the relationships that can be observed in all the vectors is the cointegrating relationship between the exchange rate and the relative money supply differential. In all the cointegrating vectors an approximate relationship such as (1, 1, 0, 0, 0) is observed. This can be interpreted as the relationship between the exchange rate and relative money supply is $e = -(m - m^*)$. This is contrary to the predictions of the monetary theory which expects a coefficient of 1 rather than -1. But this result is due to the events that took place in the Turkish economy during the period. In the years that study covers, expansionary monetary policies were followed in conjunction with a policy to keep an overvalued domestic curreny. The increase in foreign reserves that was obtained through heavy international borrowing were used to keep the nominal value of the domestic currency stable all through the years of floating regime.

Any linear combination of the stationary vectors is also a stationary vector between the variables involved. One linear combination (1st + 2nd + 3rd equations) gives the vector [3.0 3.01 -0.66 1.185 0.041] or the following relationship for the exchange rate when normalized by the coefficient of the exchange rate:

$$e = -1.01(m-m^*) + 0.22(y-y^*) -0.395(i-i^*)-0.0137(TB-TB^*)$$

The relative money supply enters the exchange rate equation with a -1 coefficient as indicated above. The interest rate differential affect exchange rate negatively and relative income has a positive sign which are contrary to the predictions of the monetary approach. When compared to the single equation estimation of the monetary approach to exchange rate determination of TL/US$ rates such as the results of Model 3, in Table 3, the same signs for the variable are observed. The cumulated trade balance variable has the expected negative sign.

Another concern for the exchange rate movements in Turkey, is the role of the cumulated trade balance differentials and its role in determining exchange rates. The system is reestimated with the following linear restriction on ß. That $ß_{5i} = 0$ (i=1,2, ...r). This amounts to the question whether the cumulated trade balance differential can be excluded from the exchange rate determination equation. The test is:

$$-2\ln(Q) = T\{ \sum \ln[(1-\lambda\forall*)/(1-\lambda)]\} = 54.6$$

where λ^* is the eigenvalues of the restricted system and this statistic has an asymptotic $\chi 2(3)$ distribution. The critical value is 7.81, and hence the hypothesis about the restriction of excluding the trade balance variables is rejected for the TL/US dollar exchange rate.

The overall results of the multicointegration test indicate that there are cointegrating relationships between the variables of the monetary model to exchange rate determination. This conclusion is similar to the results of MacDonald and Taylor(1991) study which analyzed the multivariate cointegrating relationships of the monetary approach for DM, Yen, and the UK pound exchange rates in US. This demonstrate that monetary model might have some long-run validity. These findings contradict the results of single equation estimation of the model that denies the validity of the model because of the lack of support in these estimated equations. Single equation formulation, in addition to imposing certain restrictions because of the formulation of the relationship, also looses the long-run dynamics when variables are defined in their first differences to establish stationarity. Hence the conclusions of single estimated equations only point to the short-run dynamics, the multicointegrating relationships in a system defined in levels reveal some of the long-run dynamics.

However the interpretation of the cointegrating equations as a proof of the monetary model and the long-run relationships needs some amount of caution. Not only the presence of one or more cointegrating vectors but the vectors themselves and the relationships among the variables indicated by these vectors should be carefully analyzed. Especially, when a specific structural model such as the monetary model is tested for, the signs and the restrictions should be investigated as proof of the expected long-run relationships.

The closer analysis of the results of the multicointegrating technique reveals that even though there are some long-run relationships between the variables of the monetary approach to Turkish economy, they are not exactly what the theory predicts. The theory predicts proportionality between the nominal exchange rates and the relative money supplies whereas the data shows a negative relationsip. The trade balance effect is negative and proved to be crucial for both exchange rates. It is expected that a persistent trade deficit will depreciate the long-run exchange rates. The theoretical rational for the presence of the balance of payments variables in the exchange rate equations are the following. According to the traditional flow approach to exchange rate determination, the balance of payment equilibriums such as trade balances or capital account balances indicate the demand and supply conditions for the foreign currency in a country and these flows of foreign exchange are the determining factors of the value of the foreign currency in an economy.[8] It was not possible to find a relationship between exchange rates and relative income and exchange rates and interest rate differential similar to the one that the monetary theory predicts for the long run for the TL/US$ exchange rates.

V. Summary and Conclusions

In this study the recent experience of floating exchange rate regime in Turkey is considered to evaluate the relevance of the monetary approach to exchange rate determination. Single equation estimations of the monetary model when variables are defined in their first differences do not give results that strongly support the monetary model. Even though the data does not indicate a bivariate cointegrating relationship between exchange rates and relative money supplies, the cointegrating vectors found by Johansen multicointegration procedure indicate some long-run relationship between the variables of the monetary approach.

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[8] An alternative explanation is within the framework of asset market approach to exchange rate determination. If foreign and domestic bonds are not perfect substitutes the supplies of these assets become an important factor in exchange rate determination. Since stocks of assets can not be measured easily, the risk premium important in holding foreign or domestic asset is expressed with cumulated current account or capital account balances.(Hooper and Morton(1982))

The presence of multivariate cointegrating relationships between the variables in the monetary model show that this formulation provides a suitable framework to capture the underlying relationships present in the long-run behavior of the exchange rates. The evaluation of the monetary model with multicointegation framework, indicate that there are long-run relationships between the variables but this relationship is not in the direction that the monetary theory predicts. If a formulation of a structural model is the goal, these should provide some guideliness for structural models and helps us select the relevant mechanisms in the exchange rate determination. For the case of recent Turkish experience of floating exchange rate, relationships such as the effect of the trade balances are highlighted. The effects of the long-run asset market equilibriums are less obvious and are not very conclusive in the short period of market determined exchange rates in Turkey.

Appendix: Description of the Data and Sources:

e_1: Exchange rate, TL/US$, monthly averages, average of buying and selling price, Central Bank of Turkey Quarterly Bulletin.

y: Monthly Industrial Production Index, seasonally adjusted, Central Bank of Turkey Quarterly Bulletin.

y_{us}: US Industrial Production Index, period average, seasonally adjusted. Series 66c, IFS.

m: adjusted Turkish M1, billions of TL, end of period, seasonally adjusted. Series 34b IFS.

m_{us}: adjusted US M1, billions of dollars, end of period, seasonally adjusted. Series 34b IFS.

p: Wholesale Price Index, period averages, State Institute of Statistics

pus: US Wholesale Price index, period averages, Series 63 IFS

r: Interest rate on overnight interbank money market transactions (monthly averages),(annual), Central Bank Quarterly Bulletin

r_{us}: Federal Funds rate, period averages, Series 60b IFS

TB: Exports-Imports, billions of US dollars, Series 70d,71d IFS

TBus: Exports-Imports, billions of US dollars, Series 70,71 IFS

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