Modeling the Demand for Currency Issued in Turkey

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Abstract

The purpose of this study is to investigate the empirical relationship between real money balances, real income, and the opportunity cost variables in Turkey using quarterly data between the periods 1987Q1-2003Q3. The estimation results reveal that long run demand for real cash balances depends on real income, interest rate on government securities and the exchange rate. The long run elasticity of income is close to one with the opportunity cost variables carrying the expected signs. Based on the cointegration and the weak exogeneity test results, single equation error correction model is specified and estimated. The estimated models disclose the fact that the income and the interest rate effects is much smaller in the short run than the long run, whereas exchange rate influence is more pronounced in the short run.

JEL Classification: E41, C32, C51, C52
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1. Introduction

Turkish economy is mainly characterized by liberalization and deregulation of financial markets during 1987-2003. Following the comprehensive stabilization and structural adjustment program of 1980s, the stabilization programs were mainly designed for the purpose of reducing inflation and were implemented in various forms of nominal anchoring and monetary tightening. Unfortunately, not all stabilization efforts ended up with the desired outcomes and Turkish economy experienced two major financial crises during the period under study; specifically in April 1994 and February 2001. Following the collapse of the monetary program based on the exchange rate as nominal anchor in February 2001, floating exchange rate regime and the so-called implicit inflation targeting monetary policy is launched.

In the new program, the Central Bank of the Republic of Turkey (CBRT) has been pursuing an implicit inflation targeting monetary policy strategy and it has been using base money as a supplementary anchor. Under this strategy, besides year-end inflation targets, performance criteria for base money are determined so as to be consistent with the inflation target and the growth rate forecast. Since the demand for 'currency issued by the CBRT' is the main determinant of the level of the base money, modeling demand for currency issued is crucially important especially in the implementation of current monetary policy.

The purpose of this study is therefore to model the empirical relationship between currency issued, real income and the opportunity cost variables in Turkey using quarterly data between the periods 1987Q1-2003Q3.

In the study, stationarity properties of the series are investigated based on the unit root theory developed by (Dickey-Fuller 1979). The multivariate cointegration technique to test for the existence of long run relationship, introduced by (Johansen 1988) and (Johansen and Juselius 1990), is used.

Accordingly, the rest of the study is as follows. In section 2, the economic theory of money demand is analyzed and the demand for real currency issued is modeled. Section 3 explains the data and presents the empirical results including unit root tests, cointegration tests and weak exogeneity tests. In section 4, error correction model that captures the short run dynamic adjustment of the cointegrated variables is estimated. Finally, section 5 presents the conclusion and the economic implications of the findings.

2. The Model

Money is demanded for at least two reasons: as inventory to smooth differences between income and expenditure streams, and as an asset among several assets in the portfolio (see, (Baumol 1952), (Tobin 1956), (Friedman 1956)). The first motive to hold money is called the transactions motive, implying that the nominal money demand depends on the price level and some measure of the volume of real transactions. The portfolio motive for holding money as an asset are determined by the return on money as well as returns on alternative assets and by total assets (often proxied by income). Although in theoretical studies emphasis has been given to the different determinants of the money demand depending on the focus, there is general consensus on the long run specification of the money demand function. The typical money demand specification includes a measure of real transactions and the returns of one or more alternative assets to measure the opportunity cost of holding money.

$$M / P = f\ (Y/P,R)$$

where M represents the monetary aggregate modeled, Y is the scale variable capturing real economic activity, P is the price level, and R is a vector of rates of return on competing assets. This specification explicitly imposes price homogeneity into the model. The function f(.) is assumed increasing in Y and those elements of R representing a return on components of M, and decreasing in those elements of R representing a return on competing assets.

The choice of the variables to be included in the model may vary among countries. Moreover, the choice of the monetary variable primarily depends on the purpose of the study. Since the currency issued by the CBRT is crucial in modeling and estimating base money, which is the supplementary anchor used in the implementation of the current monetary program, our main motivation is to analyze the determinants of the demand for real currency issued in Turkey. Therefore, the monetary aggregate used in this study is the real cash balances held by the public.

To proxy the transactions, a great number of studies use Gross National Product (GNP) since this variable satisfies directly or indirectly both the income and wealth criteria that the scale variable should embody. In some studies, using high frequency data, the industrial production index is used since data are usually available on monthly basis. In our study, we will use final private consumption expenditure since we believe that expenditure based proxies for the real economic transactions, especially private spending, is more relevant measure in the determination of the demand for real cash balances. Since the holdings of money are proportional to volume of transactions, the expected sign of this variable in the equation is positive.

The opportunity cost of holding money has two components: (1) the own rate of money; (2) the rate of return on assets alternative to money. In this study, since there is no return of holding cash, the own return is treated as zero.

Our model for the demand for real currency issued takes the effect of inflation expectations into account via its influence on interest rates. There is a line of argument stating that the nominal interest rates alone are sufficient in the money demand models. The justification is that when there is moderate inflation in the economy, variations in the nominal interest rate can capture the variations in the expected rate of inflation. Therefore, expected rate of inflation should not have any additional impact on demand for money other than its implicit influence through the interest rates (see (Heller and Khan 1979) and (Jusoh 1987)). However, in many studies, inflation in addition to nominal interest rates is included in the money demand equation because inflation may also have an impact on the demand for money through channels other than nominal interest rates. Firstly, the shift to lower (higher) inflation may have affected the demand for money by reducing (increasing) the opportunity costs of holding money relative to real goods if money and physical goods (or assets) are substitutes. Secondly, if the nominal interest rates do not fully incorporate expected inflation, it may be better to include both inflation and interest rates in money demand equations. Therefore, following this argument, we included the inflation expectations proxied by the annualized quarterly rate of inflation into our model (not reported here). When the interest rate and inflation are both included in the model, we ended up with the money demand model with counter-intuitive signs; the coefficient of the inflation variable turns out to be positive and insignificant. Moreover, the income variable also becomes insignificant. Therefore, only the interest rate is included in the model assuming that changes in the inflationary expectations are captured by the variations in the nominal interest rate.

In the open economies, the inclusion of the exchange rates in explaining money demand is suggested. Exchange rate represents the opportunity cost of holding domestic currency as opposed to foreign currency. (Choudry 1995) concludes that the existence of a stationary long-run money demand function in three high inflation countries (Argentina, Israel, Mexico) are only ensured if the annualized rate of change of the exchange rate is included in the relationship. According to (Ramirez Rojas 1985), in order to estimate a money demand function in high inflation countries, it may be necessary to include a measure of currency substitution in the money demand function. Although the inflation rate in Turkey is not as high as Argentina, Israel, or Mexico, (Selçuk 1994) concludes the existence of a high currency substitution in Turkey. The direct currency substitution literature argues that if portfolio shifts between the domestic and the foreign money has been realized in an economy, then the rate of change in the exchange rate can be treated as the opportunity cost of holding money.

Following these arguments, the exchange rate is used as the second opportunity cost variable in the real currency issued demand model. The formulation including exchange rate provides us with the additional information regarding the size and the direct effect of the changes in the exchange rate on demand for real currency issued.

The exchange rate influence is represented in a number of different ways in the empirical modeling. (Sriram 1999) used period average of the bilateral nominal exchange in the open-economy formulation of the demand for the real M2 in Malaysia. (Egoume-Bossogo 2000) firstly used annualized quarterly changes in the nominal exchange rate to capture the currency substitution in the demand for real M2 model in Guyana. However, he could not find any cointegrating vector consistent with the money demand (the stationarity of the inflation and the exchange rate depreciation is proposed as one of the reasons explaining that result). Therefore, in the money demand formulation, he used the nominal exchange rate. Several other studies used various proxies for the expected depreciation of domestic currency such as the weighted sum of current and past exchange rate; real exchange rate, nominal effective exchange rate, real effective exchange rate.

In our model, the nominal exchange rate, which turns out to be best among the several alternatives, is used. Exchange rate level also captures the confidence shocks and crises. Currency demand is sensitive to financial disruptions, especially in the short run; hence the inclusion of exchange rate level in the long run currency demand equation help the model to capture these influences.

As to functional form, money demand function is generally specified in real terms on the assumption that price elasticity of nominal money balances is unity. This implies that public is free of money illusion in its demand for real money balances. Sticking with this assumption, we will deflate currency issued by consumer price index (CPI) to obtain real variable. Interest rate variables will enter the model in nominal terms. Following the empirical literature, real monetary aggregate, real income and the nominal exchange rate will be expressed in logarithms and interest rates in level.

Following the discussions above, final form of the long run model for the demand for real currency issued in Turkey can be expressed as follows:

$$Log\ (M\ /\ P)_t = \beta_0 + \beta_1\ Log(PCONr)_t + \beta_2\ R_{TB} + \beta_3\ Log\ (NER)_t + \varepsilon_t$$

where M is the currency issued , P is the price level, PCONr is the real private consumption expenditure, RTB is the interest rate on government securities, and NER is the nominal exchange rate.

3. The Data, Integration and Cointegration

The Data

The data used in the estimation of the money demand model are as follows. M is the currency issued by the CBRT (Turkish lira billion). P is the consumer price index (CPI, 1987=100). PCONr is the private consumption expenditure (Turkish lira billion, at 1987 factor costs). R_{TB} is the compound three-month Treasury bill rate. NER is the nominal bilateral exchange rate calculated as the Turkish lira per unit of US dollar (TL/$). All the series are quarterly and seasonally unadjusted end of period figures and estimation sample extends from 1987:1 to 2003:3. The data are collected from the CBRT and Treasury. The data set and the graphical representation of the series used in the cointegration analysis are presented in the Table 1 and Figure 1 in the Appendix.

Integration and Cointegration

A. Integration

Since cointegration requires a certain stochastic structure of the time series involved, before starting the empirical analysis, the degree of integratedness of the data series are checked. Among the alternative tests Augmented Dickey-Fuller (ADF) test is preferred to determine the order of the integration of the series. The possibility that the data-generation process contains a constant or a deterministic time trend is also considered.

Assuming that y_t follows an AR (p) process, the simplest form of the ADF test comes to estimating:

$$y_t = \theta_1 y_{t-1} + \theta_2 y_{t-2} + \ldots + \theta_p y_{t-p} + u_t$$

or

$$\Delta y_t = \theta' y_{t-1} + \sum_{i=1}^{p-1} \theta_i' \Delta y_{t-i} + u_t \text{ where } \theta' = (\theta_1 + \theta_2 + \ldots + \theta_p) - 1$$

$$\text{and } u_t \sim IID(0, \sigma^2)$$

If the null hypothesis of $H_0 : \theta' = 0$ is rejected against the alternative of $H_0 : \theta' < 0$ then y_t is said to be stationary. Since under the null hypothesis, the computed test statistics ($\hat{\theta}' / se(\hat{\theta}')$) does not follow a standard t-distribution, (MacKinnon[1] 1991) critical values for rejection of hypothesis of a unit root is used depending on the form of the regression and the sample size. The regression can also be rearranged by considering the presence of the deterministic elements constant and linear trend.

In choosing the lag length (p) in the test equations, essentially three kinds of information; namely, Akaike Information Criterion (AIC), the Schwartz Information Criterion (SIC) and the sequential testing of the coefficient of the last lag are used. If two of these comply with each other, the corresponding lag length is chosen, if there is no compliance among them, the choice is made according to the one that gives the highest lag length. The distribution of the Dickey Fuller tests

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[1] Dickey and Fuller (1979) simulated the critical values for selected sample sizes. More recently, MacKinnon (1991) has implemented a much larger set of simulations than those tabulated by Dickey and Fuller. In addition, MacKinnon estimates the response surface using the simulation results, permitting the calculation of Dickey-Fuller critical values for any sample size and for any number of right-hand variables.

assumes that the errors are statistically independent and have a constant variance. Thus if there is autocorrelation in the residuals despite agreement among all the other criteria, we increase the lag length until we get rid of autocorrelation. While choosing the lag length, the sample size is kept fixed. Ljung-Box Q statistic and the LM test (not reported here) are used in testing for autocorrelation. Furthermore, a special care is given to avoid heteroscedasticity.

B. Integration Results

The results from the different ADF tests with both including and excluding trend concerning the Log (M/P), Log(PCONr), R_{TB}, Log(NER), the annualized quarterly inflation rate (π) and the annualized quarterly rate of change of exchange rate (ER) series are presented in Table 2.

The results of the unit root tests states that both the annualized quarterly rate of change of exchange rate and the annualized quarterly inflation rate are I(0), but the real currency issued, real private consumption expenditure, nominal interest rate[2] and nominal exchange rate are I(1) at 5% level of significance.

[2] The nominal interets rates is found to I(1) at 1% when *only intercept* is included in the ADF test.

Table 2
Augmented Dickey-Fuller Unit Root Test Results[1]

	Levels					
	Intercept			Trend and Intercept		
Variables	t-Test statistic	Lag Length	LB[2] statistic	t-Test	Lag Length	LB[2] statistic
Log (M/P)	-2.80	2	18.389 (0.784)	-2.44	2	18.358 (0.785)
Log (PCONr)[3]	-1.37	5	36.113 (0.054)	-2.41	4	28.295 (0.221)
R_{TB}	-3.19*	0	21.710 (0.597)	-3.08	0	21.762 (0.593)
Log(NER)	-0.83	1	7.846 (0.999)	-1.47	1	7.8022 (0.999)
Π	-3.94**	1	8.136 (0.999)	-6.83**	0	15.520 (0.905)
ER	-5.13**	0	10.673 (0.991)	-5.10**	0	10.731 (0.991)

	First differences[4]		
	Intercept		
Variables	t-Test statistic	Lag Length	LB[2] Statistic
Δlog (M/P)	-8.17**	2	19.884 (0.703)
Δlog(PCONr)[3]	-3.80**	5	36.198 (0.053)
ΔR_{TB}	-7.94**	1	25.338 (0.388)
Δlog(NER)	-5.99**	0	7.5457 (0.999)

[1] The critical values for the ADF test is based on MacKinnon's (1991)

With constant		With constant and trend	
1% Critical Value	-3.537	1% Critical Value	-4.106
5% Critical Value	-2.908	5% Critical Value	-3.480
10% Critical Value	-2.591	10% Critical Value	-3.168

[2] LB represents Ljung-Box statistics for k (number of autocorrelations) =24. The figure in parenthesis is its p-value.
[3] Due to high seasonality in the PCONr series, the unit root test for this series is conducted by including three centered seasonal dummies. The same critical values for the ADF test with constant and with constant and trend cases are used.
[4] Since differencing eliminates trend, unit root tests for the first differences of the series are carried out and reported with only constant.
** and * denote rejection of null hypothesis of a unit root at 1% and 5% significance levels respectively.

C. Cointegration

The finding that many macro time series may contain a unit root has prompted to the development of the theory of non-stationary time series analysis. If stationary linear combination exists among two or more non-stationary series, it is called as the cointegration equation and may be interpreted as a long-run equilibrium relationship, where the variables linked by some theoretical economic relationship should not deviate from each other. Even though in the existence of some deviations as a result of the exogenous shocks, they ought to have a tendency to revert to their equilibrium relationship. Thus, the concept of cointegration may be viewed as the statistical expression of the nature of such equilibrium relationships (see Harris for the details, 1995).

In this paper, VAR-based cointegration test using the methodology developed in (Johansen 1995) is used to determine the rank *r* and to identify a long-run money demand function due to its advantage of producing asymptotically optimal estimates.

We consider a VAR of order p as:

$$\Delta Z_t = \Pi Z_{t-1} + \sum_{1=1}^{p-1} \Gamma_i \Delta Z_{t-i} + \Psi X_t + \varepsilon_t$$

where Z is a k-vector of non-stationary variables and ε_t is an independently and identically distributed vector of innovations. X is the deterministic variables such as seasonal dummies, constant term, which are often included to take account of short-run shocks to the system. Finally, the long run or cointegrating matrix is given by Π which is a $k \times k$ matrix.

Granger's representation theorem states that if the coefficient matrix Π has reduced rank $r < k$, then there exist $k \times r$ matrices α and β each with rank *r* such that $\Pi = \alpha\beta'$ and $\beta' Z_t$ is I(0). Each column of β form the *r* cointegrating vectors. The matrix α is called the adjustments or the coefficients matrix, and measures the speed of adjustment of particular variables with respect to a disturbance in the equilibrium relation. Johansen's method is to estimate the Π matrix from an unrestricted VAR and to test whether we can reject the restrictions implied by the reduced rank of Π. (Johansen and Juselius 1990) offer two likelihood test statistics known as trace and maximum eigenvalue to find the number of cointegration relationships.

The sequential modified likelihood ratio (LR) test and various information criteria (FPE, AIC, SBC and HQ) are employed to decide the number of lags used in the VAR, however, in the case of serial correlation sufficient number of lags are introduced to eliminate the serial correlation of the residuals.

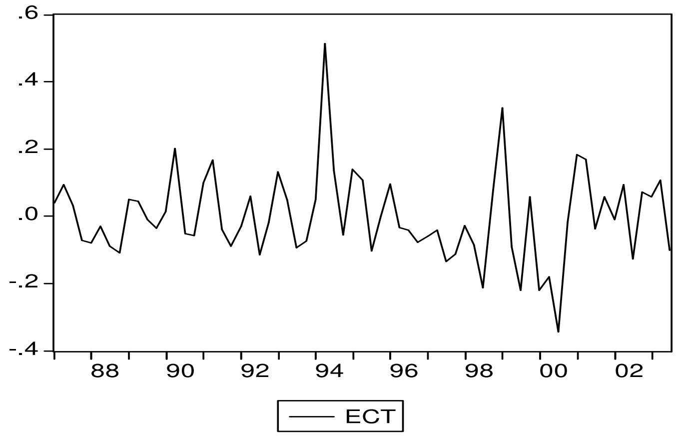
D. Cointegration Results

As the unit root tests show, the variables are I(1); hence the cointegration technique is appropriate to estimate long run real currency issued demand. The variables Log(M/P), Log(PCONr), R_{TB}, Log(NER) are included in the model in that order. The cointegration tests amongst Log(M/P), Log(PCONr), R_{TB}, Log(NER) include five lags in the VAR depending on the sequential LR test and the information criteria. As private consumption expenditure series is affected by seasonality, we introduced a set of quarterly centered seasonal dummy variables (see (Johansen 1995)), a constant term, and two impulse dummy variables; namely, D94 and D01 which are included to capture the currency crises in April 1994 and February 2001 respectively. In general, the diagnostic tests such as error autocorrelation and autoregressive conditional heteroscedasticity (ARCH) are carried out by lag length 4. The normality test is also conducted. Diagnostic test results are quite satisfactory.

The Johansen cointegration test results are presented in Table 3. The maximum eigenvalue and trace score together with both 1% and 5% critical values are reported in the table to decide on the number of cointegrating vectors. They indicate that the maximum eigenvalue test results are not consistent with the trace test results; while the formal suggest that there is only one cointegrating vector, the latter points out the existence of two cointegrating vector at 5 % level of significance. As the maximum eigenvalue and the trace test statistics do not unequivocally confirm the existence of more than one cointegrating vector, we focus on one cointegrating vector consistent with the money demand theory.

Among the alternative formulations, the one including Log(M/P), Log(PCONr), R_{TB} and Log(NER) yields one cointegrating vector that can be interpreted as a long run money demand relationship for the real currency issued. Figure 2 confirms that this cointegrating vector is stationary.

Fig. 2. Error Correction Term



The cointegrating vector can be written in an equation form as follows:

$$Log\,(M/P)_t = 0.847\,Log\,(PCONr)_t - 0.284\,R_{TB\,t} - 0.051\,Log\,(NER)_t + 4.309$$

Table 3
Cointegration and Weak Exogeneity Test Results

Johansen Test Results for Real Currency Issued for the Number of Cointegrating Vectors [1]				
Null Hypothesis	r = 0	r =1	r = 2	r = 3
Eigen value	0.3593	0.2347	0.1373	0.0941
λ trace	***58.5184*****	***31.3598****	***15.0393***	***6.0283***
5 % critical value	47.21	29.68	15.41	3.76
1 % critical value	54.46	35.65	20.04	6.65
λ max	***27.1585****	***16.3205***	***9.0110***	***6.0283***
5 % critical value	27.07	20.97	14.07	3.76
1 % critical value	32.24	25.52	18.63	6.65

Standardized β'Eigenvectors				
Variable	*Log(M/P)*	*Log(PCONr)*	R_{TB}	*Log(NER)*
Row 1	1.000	-0.847	0.284	0.051
Row 2	0.801	1.000	0.072	-0.064
Row 3	-7.566	1.811	1.000	-0.484
Row 4	5.696	-18.695	-3.847	1.000

Adjustment Coefficients				
Column	1	2	3	4
Log(M/P)	-0.0194	-0.0243	-0.0109	0.0013
Log(PCONr)	0.0123	-0.0025	-0.0074	-0.0012
R_{TB}	-0.0373	0.0430	-0.0013	-0.0308
Log(NER)	-0.0089	0.0223	-0.0080	0.0031

Weak Exogeneity Test Results [2]				
Variable	*Log(M/P)*	*Log(PCONr)*	R_{TB}	*Log(NER)*
χ 2 (1)	2.613	7.692	2.348	0.814
p-value	0.056*	0.006**	0.125	0.367

Statistic for Testing the Significance of the Given Variable [2]				
Variable	*Log(M/P)*	*Log(PCONr)*	R_{TB}	*Log(NER)*
χ 2 (1)	6.208	4.255	9.990	3.739
p-value	0.013*	0.039*	0.002**	0.053*

Multivariate Statistic for Testing Stationary				
Variable	Log(M/P)	Log(PCONr)	R_{TB}	Log(NER)
χ 2(3)	15.330	19.267	16.406	18.427
p-value	0.002**	0.000**	0.001**	0.000**

[1] The statistics λ_{max} and λ_{trace} are the Johansen's maximum eigenvalue and trace test statistics for testing for the cointegration. The null hypothesis is in relation to the cointegration rank r. rejection of r=0 is evidence in favor of at least one cointegrating vector.
[2] The weak exogeneity and the significance tests are evaluated under the assumption that the cointegration rank is r=1 and so asymptotically distributed as $\chi 2(1)$ if weak exogeneity of the specified variable(s) for the cointegrating vector is valid.
** and * indicate that the null hypothesis are rejected at 1 % and 5% significance levels respectively.

Interpretation of the Coefficients of Currency Demand Equation

All the variables in the model have the expected sign. The demand for real currency issued is positively affected by the real income; while the interest rate and the exchange rate affect the money demand negatively.

The elasticity of income is 0.85, close to 1 as suggested by the quantity theory of money demand. The interest rate and the exchange rate variables also behave in the manner suggested by the theory. In the long run, while the exchange rate has a low impact on the demand for real currency issued as suggested by small exchange rate elasticity of 0.05, the effect of interest rate is stronger as the semi-elasticity of interest rate is 0.28.

Interpretation of the Adjustment coefficients

The α matrix contains weight with which cointegrating vectors enter the equation in the system. Each nonzero column of the matrix also measures the speed of short run response to disequilibrium in endogenous variables of the system. For example, the coefficient in the first column of α in Table 3 measure the feedback effect of the lagged disequilibrium in the cointegrating vector onto the variables in the VAR. Specifically, the first term in α represent the speed at which Log(M/P), the dependent variable in the first equation of the VAR moves toward restoring the long-run equilibrium; and the second term shows how fast Log(PCONr) responds to the short run disequilibrium in the cointegrating vector.

We focus on the real demand for currency issued as only one cointegrating vector was identified. The first term in α shows that money has a feedback coefficient of -0.0194, which implies that the 2 percent of the adjustment is achieved in the first quarter. The negative coefficient implies that the lagged excess money induces smaller holdings of current money. As it is presented in the table, adjustment from nominal exchange rate is small. The weak exogeneity test results indicate that adjustments are primarily carried out via Log(M/P) and Log(PCONr). Significant adjustments do not occur in the R_{TB} and Log (NER) equations.

E. Weak Exogeneity and Other Relevant Test

The classic reference for the exogeneity concepts is the article by (Engle, Hendry, and Richard 1983). They introduced three types of exogeneity, specifically, weak, strong and super exogeneity for the following purposes: to make inferences about parameters of interest, to forecast conditional on the exogenous variables, and to make policy analysis. Since our aim is to make inference about the parameters of money demand function, we will consider whether our parameters are weak exogenous.

As we know, a joint probability density function can be written as a product of a marginal distribution of one or more variables and a conditional distribution of a scalar variable *y* on those variables. If the conditioning variables are weakly exogenous, then inferences about the parameter of interest from the conditional distribution will be equivalent to inferences from the joint distribution. For this reason weak exogeneity guarantees that there is no loss of information about the parameter of interest from analyzing only the conditional distribution, thus the marginal distribution of the conditioning variables may be ignored. In other words; the weak exogeneity property allows us to model a single equation that captures the short run dynamics of money demand without loss of information.

As it is stated before, $k \times r$ adjustment matrix α measures the speed of adjustment of particular variables with respect to a disturbance in the equilibrium relation. The existence of weak exogeneity is examined by imposing some linear restrictions on the adjustment coefficients α (in general terms, weak exogeneity involves testing whether or not the corresponding row of α is zero (Johansen 1992). If the null hypothesis is not rejected, then the i-th endogenous variable is said to be weakly exogenous with respect to the β parameters. In other words, disequilibrium in the cointegrating relationship does not feed onto that variable; but any disequilibrium of a given variable will have an impact on the cointegrating relation.

Since one cointegrating relationship has been identified, the weak exogeneity test is conducted under the assumption of rank of 1. The test statistics will be asymptotically distributed as χ^2 (1) under the null hypothesis of the existence of weak exogeneity. Test results presented in Table 3 reveals that weak exogeneity cannot be rejected for interest rates and the exchange rate. However, real currency issued and the real private consumption are not weakly exogenous at 5% level of significance; suggesting that each of these variables has a long run relationship, in other words a cointegrating vector. But as it is stated before, the estimation results point out to one cointegrating vector consistent with money demand theory; therefore we proceed with the error correction model of money demand.

Table 3 also represents the results for testing the significance of each individual variable in the model. The coefficients of all variables are significantly different from zero at 5% level of significance.

The final row of Table 3 reports values of a multivariate statistic for testing the stationarity of a given variable. Specifically, this statistic tests the restriction that the cointegrating vector contains all zeros except for a unity corresponding to the designated variable, where the test is conditional on there being one cointegrating vector. For instance, the null hypothesis of a stationary real currency issued implies that the cointegrating vector is (1,0,0,0)'. As presented in Table 3, the multivariate stationarity is rejected in all cases.

4. Error Correction Model

Based on the cointegration analysis and the weak exogeneity test results, the next step is to model the short run demand for real currency issued in a single equation context using error correction model (ECM). The short-run model reveals how the adjustment mechanism works to revert to the equilibrium condition when it is disturbed by exogenous shocks and thus deviations from the long-run level occur.

The short run model is a fourth order Autoregressive Distributed Lag (ARDL) model in Log(M/P), Log(PCONr), R_{TB} and Log (NER) given that 5 lags retained for the vector autoregression. The dummies added in the VAR are also included here to capture the events that may affect money demand. Moreover, the additional dummy variable, which is believed to capture the impact of the general elections held in 1999 on Turkish economy, is introduced. Seasonal dummies are also added, as the series are seasonally unadjusted. ARDL contains error correction representation, which captures long run relations. In the case of money demand, the error correction term (ECT) represent the disequilibrium from the long run solution, with money adjusting in the subsequent periods if $\gamma_5<0$. The error term coefficient should have a negative sign not larger than one.

$$\Delta Log(M/P)_t = \sum_{i=1}^{p-1} \gamma_{1i}\, \Delta Log(M/P)_{t-i} + \sum_{i=0}^{p-1} \gamma_{2i}\, \Delta Log(PCONr)_{t-i} + \sum_{i=0}^{p-1} \gamma_{3i}\, \Delta R_{TB\,t-i} + \sum_{i=0}^{p-1} \gamma_{4i}\, \Delta Log(NER)_{t-i} + \gamma_5\, ECT_{t-1} + C + \sum_{i=1}^{3} \gamma_{6i} SD_i + \gamma_7\, D94 + \gamma_8\, D99 + \gamma_9 D01 + u_t$$

According to the results of the extensive literature on money demand estimations, the signs of the coefficients are expected to be:

$$\sum_{i=1}^{p-1} \gamma_{1i} < 0$$

$$\sum_{i=0}^{p-1} \gamma_{2i} > 0$$

$$\sum_{i=0}^{p-1} \gamma_{3i}, \sum_{i=0}^{p-1} \gamma_{4i}, \gamma_5 < 0$$

The model is fitted to the quarterly data over the period 1987Q1-2003Q3. Then the reduction based on (Hendry's 1989) general to specific simplification methodology is made by eliminating step by step the statistically as well as economically most insignificant regressors. As a result, the model is reduced to the parsimonious model for short run real money demand. The last remaining equation with all variables being significant is as follows:

$$\Delta Log(M/P)_t = -0.399\,\Delta Log(M/P)_{t-1} - 0.401\Delta Log(M/P)_{t-2}$$

$$+0.380\Delta Log\,(PCONr)_t - 0.131\Delta R_{TB_t} - 0.302\Delta Log\,(NER)_t$$

$$-0.292 ECT_{t-1} + 0.017 + 0.125 D94 + 0.286 D99 + 0.258 D01$$

Interpretation of the Coefficients of the ECM

The negative coefficient of the ECT is significant, validating that the cointegrating relationship between the variables is valid. Essentially, it implies that when an exogenous shock disturbs the equilibrium condition, 29 percent of its effect is adjusted in one period. Looking at the other coefficients, as opposed to long run relationships, the income coefficient falls to 0.38, the interest rates coefficient also decreases to 0.13, whereas the impact of exchange rate increases in the short run. This shows that the currency held by public is sensitive to the movements in the exchange rate in the short run. Short run demand for real currency issued is also affected by its first and second lag.

Interpretation of the Diagnostic tests of the ECM

The diagnostic test statistics for the short run money demand model presented in Table 4 reveal that the model is econometrically well specified. The model has 77% explanatory power with σ= 6.0%.

Table 4
Estimates and the Diagnostic Test Results for the Error Correction Model

Error Correction Model					
Dependent Variable:					
ΔLog(M/P)			Sample(adjusted):		1987:4 2003:3
Method: Least Squares					observations: 64
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**	**HCSE[1]**
$\Delta log(M/P)_{t-1}$	-0.399	0.0747	-5.3425	0.0000	0.0870
$\Delta log(M/P)_{t-2}$	-0.401	0.0746	-5.3744	0.0000	0.0739
$\Delta log(PCONr)_t$	0.380	0.0575	6.6124	0.0000	0.0612
ΔR_{TBt}	-0.131	0.0388	-3.3846	0.0013	0.0341
$\Delta log(NER)_t$	-0.302	0.1039	-2.9055	0.0053	0.0947
ECT_{t-1}	-0.292	0.0794	-3.6807	0.0005	0.0985
C	0.017	0.0137	1.2689	0.2099	0.0139
D94	0.125	0.0589	2.1150	0.0391	0.0471
D99	0.286	0.0618	4.6242	0.0000	0.0135
D01	0.258	0.0705	3.6573	0.0006	0.0278
R-squared	0.7686	Durbin-Watson stat			1.7517
Adjusted R-squared	*0.7300*	F-statistic			19.925
S.E. of regression	0.0595	Prob(F-statistic)			0.000

[1]HSCE is White's Heteroscedasticity Consistent Standard Errors

Diagnostic Tests of Short Run Model			
Test on residuals			
Breusch-Godfrey Serial Correlation LM Test			
Lag Length=1			
F-statistic	1.3782	Prob.	0.2457
Obs*R-squared	1.6220	Prob.	0.2028
Lag Length=4			
F-statistic	1.0708	Prob.	0.3808
Obs*R-squared	5.0501	Prob.	0.2822
ARCH Test			
Lag Length=1			
F-statistic	0.3142	Prob.	0.5772
Obs*R-squared	0.3228	Prob.	0.5699
Lag Length=4			
F-statistic	0.4685	Prob.	0.7586
Obs*R-squared	1.9770	Prob.	0.7400
White Heteroskedasticity Test			
F-statistic	0.4046	Prob.	0.9709
Obs*R-squared	7.1839	Prob.	0.9523
Normality Test			
Jarque-Bera Statistics	3.3256	Prob.	0.1896
Stability tests			
Chow Breakpoint Test: 2001:2			
F-statistic	0.2829	Prob.	0.9578
Chow Forecast Test: Forecast from 2001:2 to 2003:3			
F-statistic	0.3960	Prob.	0.9419

Parameter Constancy Test of the ECM

Parameter constancy is one of the key feature of the money demand specification has to exhibit. Several tests on parameter stability are conducted. The chow test results presented in Table 3 imply that when 2001 February financial crisis is considered as the breakpoint, our short run model do not reveal any sign of instability and there is no structural shift in the currency issued demand relationship.

Parameter constancy tests are also implemented by the recursive estimation of the coefficients and the residuals of the model. The results are presented in the Figure 4 and Figure 5 respectively.[3]

The model exhibits stable coefficients with the standard error intervals narrowing quickly. For the interest rate and the exchange rate series, two shift point - one in 1994 and the other in 2001 - are observed. These shifts may result from the exclusion of the dummy variables from the model. If we take this fact into account, it is possible to say that coefficients in the short run money demand model are virtually constant, indicating that there is no evidence of a major instability over the sample period.

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[3] When the coefficient of the variables and the residuals are estimated recursively, the dummy variables are excluded from the model due to the fact that dummy variables are only present in the specific period of time and hence the inclusion of the dummies hinders the estimation to be carried out starting from 1990s.

Fig. 4. ECM _ Recursive Estimates of the Coefficients for Testing the Parameter Constancy

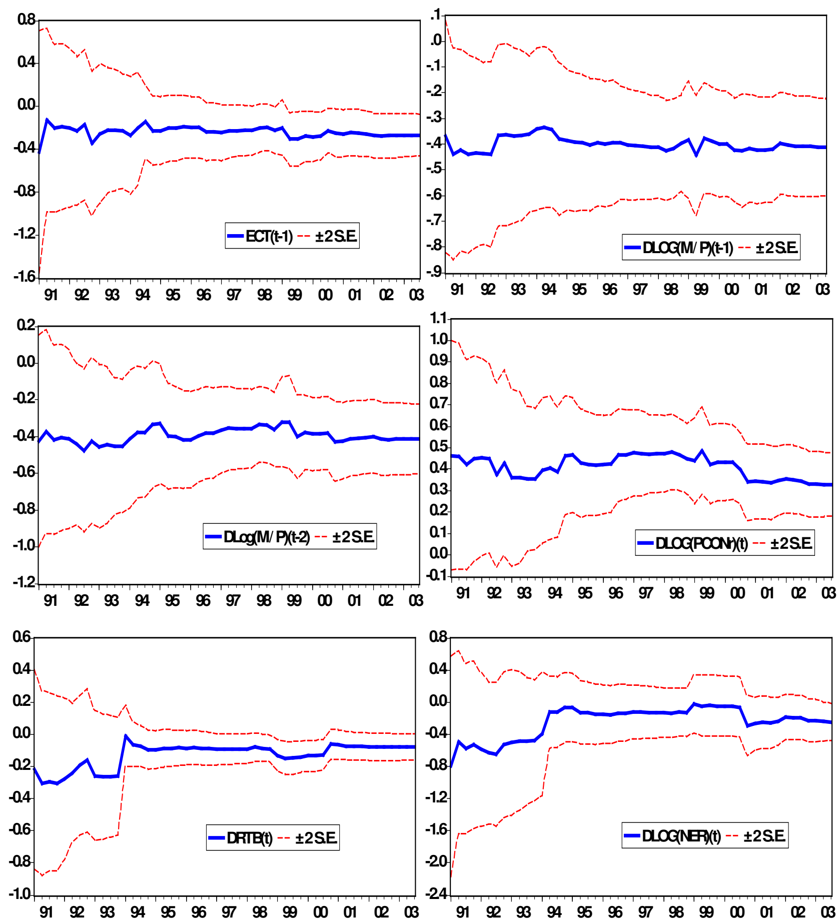
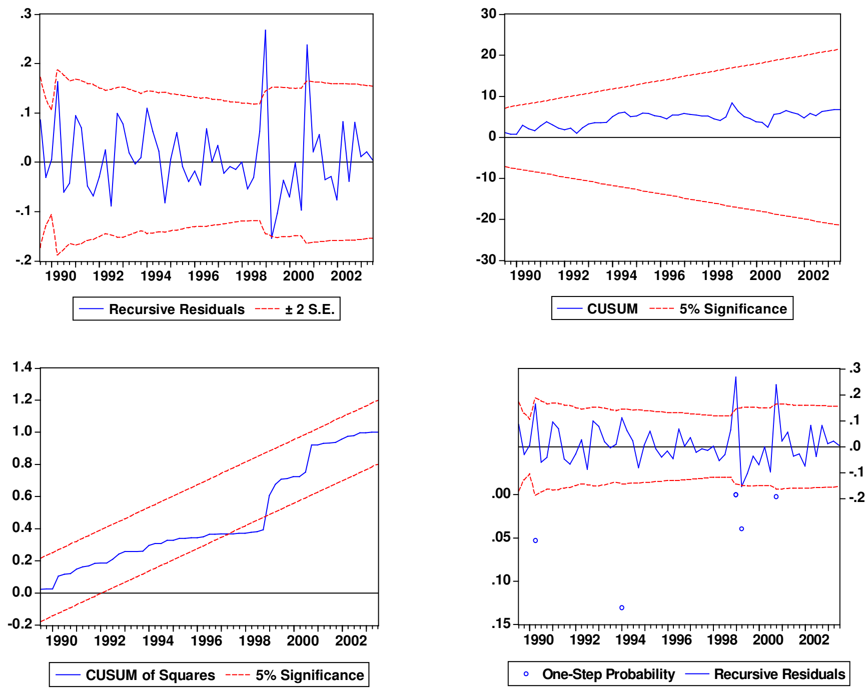


Fig. 5. ECM_ Recursive Estimates of the Residual for Testing the Parameter Constancy



Recursive residuals being outside the standard error bands suggest instability in the parameters of the equation. The one step forecast test also shows the probability values for those sample points where the hypothesis of parameter constancy would be rejected at the 5, 10, or 15 percent levels. The points with p-values less the 0.05 correspond to those points where the recursive residuals fall outside the two standard error bounds. The general elections held in 1999 and 2000 November and the 2001 February financial crisis experienced in Turkey constitute the major causes of the possible instability, which is also supported by the CUSUM of the squares test results. To reduce the influences of these events, impulse dummies are introduced into our error correction model.

Overall, the parameter constancy test results reveal that short term Turkish money demand for real currency issued is fairly stable.

5. Conclusion

The paper models the demand for real cash balances in Turkey for the period of 1987Q1-2003Q3. Empirical analysis is carried out by means of Johansen multivariate cointegration analysis and error correction models. Cointegration analysis reveals that there is long-run relationship between real currency issued, private consumption expenditure, interest rates on government securities, and the exchange rate. In this long run equilibrium, the income elasticity is found to be close to unity, consistent with the economic theory. The interest rate and the exchange rate variables also have the expected signs. Interest rate on government securities has a negative impact, representing an opportunity cost. The test results reveal that economic agents are more sensitive to movements in the interest rate than movements of exchange rate in the long run.

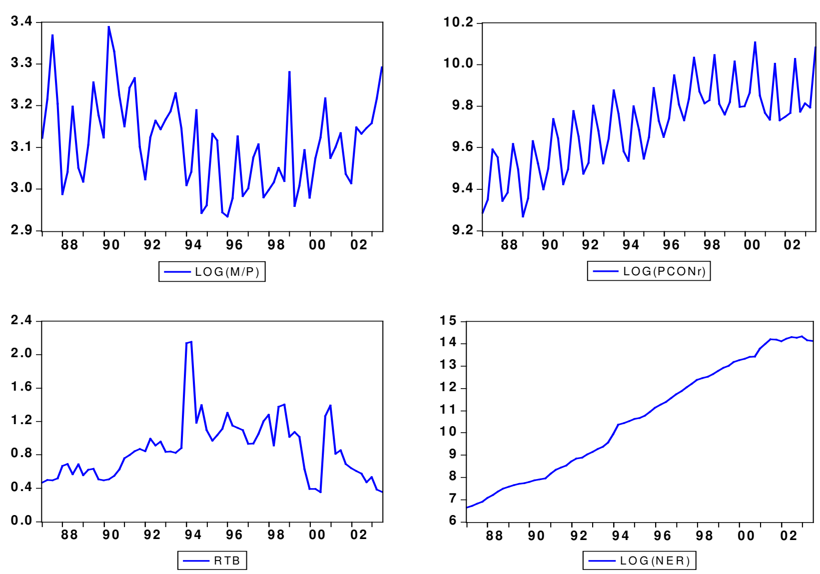
The paper also develops an error correction model based on long run cointegrating vector of demand for real currency issued. The short run elasticities and semi-elasticities are also found to be consistent with the theory. While the income elasticity and the semi elasticity of the interest rate are weaker in magnitude than those related to long run equilibrium; the exchange rate elasticity is more effective in the short run. This indicates that in the dynamics of economic agents' demand for cash, exchange rate may be a powerful indicator in the short run. Moreover, the high and significant exchange rate coefficient is consistent with the existence of the currency substitution in Turkey. In the long run, however, real income and the interest rate variables appear to be the main determinants of the demand for real cash balances, a result consistent with the conventional money demand relationships.

Appendix: Data Issues

Table 1
Data Definitions and Sources of the Series Used in the Cointegration Analysis

	Monetary Variable	**Opportunity Cost Variables**	
Variable	Real Currency Issued	Interest rate	Nominal Exchange Rate
Name	Log(M/P)	R_{TB}	Log(NER)
Definition	Natural logarithm of the quarterly end of period real Currency Issued by the CBRT deflated by the CPI (1987=100)	End-of period compound 3-month Treasury Bill interest rate.	Natural logarithm of the quarterly end of period bilateral nominal exchange rate of Turkish lira vis-â-vis US dollar (an increase indicates the depreciation of Turkish lira)
Sources	CBRT	Treasury	CBRT
	Scale Variables	**Dummy Variables**	
Variable	Real Private Consumption Expenditure	Seasonal Dummies	Impulse Dummies
Name	Log(PCONr)	SD1, SD2, SD3	D94, D01
Definition	Natural logarithm of the quarterly end of period real final private consumption expenditure at 1987 prices.	Quarterly centered seasonal dummies	Financial crisis dummies for the April 1994 and the February 2001 crisis respectively.
Sources	CBRT		

Fig. 1. The Graphical Representation of the Time Series used in the Cointegration



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