# Determinants of reserve money demand: a multivariate co-integrating approach

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2008

# Determinants of reserve money demand: a multivariate co-integrating approach

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**Abstract**
In this paper, a reserve money demand model is constructed for the Turkish economy. Base on the contemporaneous multivariate co-integration estimation methodology, our findings indicate that the main alternative costs to hold reserve money balances in hand are the expected exchange rate depreciation representing ongoing currency substitution phenomenon in the economy and the equity prices. The semi-elasticity of domestic inflation reveals high degree of substitutability between real monetary balances and durable commodities. Furthermore, there exists evidence in favor of the effects of financial development on the money demand function in the sense that diversification of financial tools held in hand against demand for money balances is a necessary condition for the determination of long-run course of the monetary policy.

**Key words**: Reserve Money Demand; Co-integration; Turkish economy;

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**Özet**
Rezerv Para Talebinin Belirleyicileri: Çokdeğişkenli Bir Eş-Bütünleşim Çözümlemesi
Bu çalışmada, bir rezerv para talebi modeli Türkiye ekonomisi için kurulmuştur. Çağdaş çokdeğişkenli eş-bütünleşim tahmin yöntemi kullanılarak elde ettiğimiz bulgular, rezerv para büyüklüklerinin elde tutumu için başlıca almaşık maliyet öğelerinin ekonomide süregelen para ikame olgusunu temsil eden beklenen döviz kuru değer kayıpları ve hisse fiyatları

olduğunu göstermektedir. Enflasyon yarı-esnekliği reel parasal büyüklükler ve dayanıklı mallar arasındaki yüksek ikame derecesini ortaya koymaktadır. Ayrıca, para talebi işlevsel ilişkisi üzerinde finansal gelişmenin etkilerini gösterecek şekilde bulgular elde edilmekte, parasal büyüklük talebi karşısında elde tutulan finansal araçların çeşitlendirilmesinin para politikasının uzun dönemli gelişim yolunun belirlenmesi açısından gerekli bir koşul olduğu sonucuna ulaşılmaktadır.

**Anahtar kelimeler**: Rezerv Para Talebi; Eş-bütünleşim; Türkiye Ekonomisi;

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## 1. INTRODUCTION

The phenomenon money demand examines what motives determine the economic agents' holding of monetary balances. Considering properties derived from a money demand equation, monetary authorities can test appropriateness of the monetary policies to the current economic conditions and appreciate the success of monetary policy implementations given the *ex-ante* designed policy purposes. For instance, in a situation where the demand for real money balances which should be under the control of monetary authority is perceived with an endogeneous characteristic for the other economic aggregates, the monetary authorities, to the great extent, cannot follow an independent monetary policy in order to attain the own policy purposes. Furthermore, the choice of the most significant alternative costs that economic agents take into consideration has been of special importance for policy makers in applying to monetary-based stabilization policies. If policy makers lack of extracting the true knowledge of monetary balances, monetary velocity shocks which lead to deviations of growth rates of monetary aggregates from estimated values will dominate monetary markets in the economy. Therefore, estimation of money demand equations will provide crucial knowledge of how economic agents determine their behaviors of monetary holdings as well as the course of their transactions necessities.

In the paper, these issues of interest have been examined by constructing an empirical reserve money demand model for the Turkish economy. Within the last two decades, the Turkish economy witnessed many unstable economic events, such as two major economic crises and different monetary policies as to the sub-periods for both the 1990s and 2000s as well as a financial deregulation of the economy led mainly by rapid dollarization process, and had also been dominated by an interest burden under a high public sector borrowing requirement in a two–digits chronic inflationary framework. A detailed investigation of this process can be found in the papers such as Ertuğrul and Selçuk (2002) and Baydur and Süslü (2002). The rest of the paper is organized as follows. The preliminary data specification issues and time series characteristics of the variables used in the paper are described in the next section. Section 3 presents unit root test results. Methodological issues for estimation purposes are discussed in Section 4. Section 5 is devoted to the estimation of a reserve money demand model for the Turkish economy. The last section summarizes results to conclude the paper.

## 2. DATA

The data used in the paper indicate seasonally unadjusted values and cover the period from 1987Q1 to 2007Q2 using quartely observations. The monetary variable (*m*) represents the reserve money aggregate, which is the sum of currency issued, deposits of banking sector consisted of required reserves and free deposits, extrabudgetary funds and deposits of non-bank sector, under the liability of the monetary authorities. Such a monetary variable choice can easily reflect a policy aggregate. The gross domestic product (GDP)-deflator is used to deflate the reserve money supply. The scale-income variable (*y*) for the maximum amount of money balances to be held in hand is the real GDP at constant 1987 prices. The alternative cost variables to hold reserve money balances are determined as the maximum rate of interest on the Treasury bills ($r_b$) gathered from the electronic data delivery system of the Central Bank of the Republic of Turkey (CBRT), whose maturity are at most twelve months representing returns on financial assets, the three-month time deposit rate (*td*), the quarterly domestic inflation (*p*) based on the GDP-deflator for the expected return on real assets under the assumption of substitution between commodities and domestic monetary aggregates, and the Istanbul Stock Exchange (ISE) National-100 index (*q*) to represent the effect of equity prices on money demand. Bahmani-Oskooee and Karacal (2006) emphasize that stability of demand for money will be affected by the (non-)inclusion of exchange rate variable representing currency substitution phenomenon into the functional relationship. Following papers by Goldfajn and Valdes (1999) and Civcir (2003), expected exchange rate depreciation (*e*) is included into the model to represent currency substitution phenomenon. For this purpose, at first a regression of trade weighted real exchange rate series based on producer price indices published by the CBRT, for which an increase means appreciation of the domestic currency, is estimated onto a constant and trend and then the deviation of the actual series from the predicted series is calculated for real exchange rate misalignment which is assumed to represent expected depreciation of exchange rate. Besides, own rate of return for reserve money demand is assumed to be zero for economic agents. All the data used are obtained from the electronic data delivery system of the CBRT and used in their seasonally unadjusted natural logarithms except the interest rate and inflation data which are considered in their linear-forms.

## 3. UNIT ROOT TESTS

Granger and Newbold (1974) bring out that non-stationary time series steadily diverging from long-run mean will yield biased standard errors with an unbounded variance process. Such a case means that variables of the model must be differenced (*d*) times to obtain a covariance-stationary process. Dickey and Fuller (1979) suggest the use of one of the commonly applied test methods known as augmented Dickey-Fuller (ADF) test to detect whether the time series is of stationary form. However, Dickey-Fuller type tests may have low estimation power against plausible stationary alternative hypothesis and the null hypothesis of a unit root may tend to be accepted unless there is strong evidence against it. Considering these facts, Kwiatkowski et al. (1992) develop an alternative approach known as the KPSS tests which are designed to test the null hypothesis of stationarity against the unit root alternative. The KPSS test statistic is computed based on the residuals of the regression of any $Y_t$ series onto the exogenous variable $\zeta_t$ which follows a random walk process (Mahadeva and Robinson, 2004):[1]

$$Y_t = \zeta_t + \varepsilon_t \quad (1)$$

$$\zeta_t = \zeta_{t-1} + \upsilon_t \quad (2)$$

[1] Any deterministic linear trend component can be included into Eq. (1) to test trend-stationarity.

where $\varepsilon_t$ represents a stationary process and $\upsilon_t$ has been subject to an expected value with a normally distributed zero-mean and constant variance process. $H_0$ and $H_1$ hypothesis for the KPSS test can be shown as follows:

$$H_0 : \sigma_\upsilon^2 \text{ and } H_1 : \sigma_\upsilon^2 > 0 \tag{3}$$

Kwiatkowski et al. (1992) propose the following test statistic for the unit root test:

$$KPSS = T^{-2} \sum_{t=1}^{T} S_t^2 / \sigma^2 \tag{4}$$

where:

$$S_t = \sum_{i=1}^{t} \hat{u}_t \text{ , } \hat{u}_t = \mathrm{Y_t} - \mathrm{\hat{Y}_t} \text{ and } \sigma^2 = \lim_{t \to \infty} T^{-1} Var \sum_{t=1}^{T} \varepsilon_t \tag{5}$$

Following these theoretical issues, unit root test results are reported below:[2]

**Tablo 1. Unit Root Tests**

| Variable | *c* (levels) | *c&t* (levels) | *c* (first differences) | *c&t* (first differences) |
|---|---|---|---|---|
| *m* | 0.54 | 0.29 | 0.45 | 0.13 |
| *y* | 1.23 | 0.22 | 0.11 | 0.09 |
| $r_b$ | 0.52 | 0.29 | 0.25 | 0.08 |
| *td* | 0.53 | 0.30 | 0.31 | 0.11 |
| *p* | 0.94 | 0.33 | 0.22 | 0.15 |
| *q* | 1.10 | 0.24 | 0.17 | 0.03 |
| *e* | 0.51 | 0.21 | 0.15 | 0.06 |

Notes: c and c&t represent a constant and constant&trend terms in the testing equation, respectively. 5% critical values are 0.46 forf the former and 0.15 for the latter case.

[2] Yavuz (2004) examines the KPSS test and the KPSS statistic derived from the Lagrange multiplier statistic in a much more elaborately way.

Results obtained from the unit root tests indicate that for all the variables non-stationary characteristic in the level form cannot be rejected but differencing provides stationarity. Therefore, from now on all the time series are assumed integrated of order one, which enable to test for co-integrating relationships within the long-run variable space.

## 4. ESTIMATION METHODOLOGY

In order to test for a stationary relationship among the variables, the multivariate co-integration methodologies proposed by Johansen (1988) are used. Let us assume a $z_t$ vector of the same order integrated non-stationary $n$ endogenous variables and model this vector as an unrestricted vector autoregression (UVAR) involving up to $k$-lags:

$$z_t = \Pi_1 z_{t-1} + \Pi_2 z_{t-2} + \ldots + \Pi_k z_{t-k} + \varepsilon_t \quad (6)$$

where $\varepsilon_t$ follows an i.i.d. process with a zero mean and normally distributed N(0,$\sigma^2$) error structure and $z_t$ is ($n$x1) and the $\Pi_i$ an ($n$x$n$) matrix of parameters. Eq. 6 can be rewritten in a vector error correction (VEC) model as follows:

$$\Delta z_t = \Gamma_1 \Delta z_{t-1} + \Gamma_2 \Delta z_{t-2} + \ldots + \Gamma_{k-1} \Delta z_{t-k+1} + \Pi z_{t-k} + \varepsilon_t \quad (7)$$

where:

$$\Gamma_i = -I + \Pi_1 + \ldots \Pi_i \ (i = 1,2, \ldots, k\text{-}1) \text{ and } \Pi = \mathrm{I} - \Pi_1 - \ldots - \Pi_k \quad (8)$$

Eq. 7 can be arrived by substracting $z_{t-1}$ from both sides of Eq. 6 and collecting terms on $z_{t-1}$ and then adding $-(\Pi_1\text{-}1)X_{t-1} + (\Pi_1\text{-}1)X_{t-1}$. Repeating this process and collecting of terms will yield Eq. 7 (Hafer and Kutan, 1994). This specification of the system of variables brings out the knowledge of both the short- and the long-run adjustment to changes in $z_t$, via the estimates of $\Gamma_i$ and $\Pi$. Following Harris (1995), $\Pi = \alpha\beta'$ where $\alpha$ measures the speed of adjustment coefficient of particular variables to a disturbance in the long-run equilibrium relationship as a matrix of error correction terms, while $\beta$ is a matrix of long-run coefficients which ensure that $z_t$ converge to their long-run steady-state solutions. All terms in Eq. 7 which involve $\Delta z_{t-i}$ are I(0) while $\Pi z_{t-k}$ must also be stationary for $\varepsilon_t \sim$ I(0) to be white noise of an N(0, $\sigma_\varepsilon^2$) process.

The lag length of the UVAR model is determined by using the sequential modified LR statistic. For the maximum lag of 5, reduction of system from 5 to 4 lags is accepted by an LR statistic 42.55 but is first rejected when the reduction from 4 to 3 lags is tested by an LR statistic 79.66. Following Johansen (1995), a set of centered seasonal summies which sum to zero value over a year is included into the model as exogeneous variable.

## 5. RESULTS

The co-integration rank tests using critical values taken from Osterwald-Lenum (1992) and the unrestricted co-integrating coefficients are indicated below:

**Tablo 2. Co-Integration Rank Tests**

| H0: | r=0 | r=1 | r=2 | r=3 | r=4 | r=5 | r=6 |
|---|---|---|---|---|---|---|---|
| Eigen value | 0.46 | 0.39 | 0.31 | 0.26 | 0.10 | 0.06 | 0.02 |
| λ trace | 149.2* | 101.7* | 64.44 | 36.70 | 13.94 | 6.19 | 1.57 |
| 5% cv | 125.6 | 95.75 | 69.82 | 47.86 | 29.80 | 15.49 | 3.84 |
| λ max | 47.49* | 37.28 | 27.73 | 22.76 | 7.75 | 4.62 | 1.57 |
| 5% cv | 46.23 | 40.08 | 33.88 | 27.58 | 21.13 | 14.26 | 3.84 |

Notes: * denotes rejection of the hypothesis at the 0.05 level.

**Tablo 3. Unrestricted Co-Integrating Coefficients**

| $m$ | $y$ | $r_b$ | $td$ | $p$ | $p$ | $e$ |
|---|---|---|---|---|---|---|
| 11.31 | -46.31 | 4.72 | 0.03 | 28.63 | 3.29 | 20.80 |
| 8.48 | -7.92 | 3.07 | 0.12 | -53.27 | -0.34 | -11.20 |
| -0.36 | -1.46 | 0.44 | 0.05 | -59.26 | -0.06 | -7.29 |
| -0.96 | 7.45 | -10.03 | 0.06 | 24.62 | -0.56 | -15.37 |
| -1.98 | -15.52 | 3.81 | -0.14 | -9.73 | 0.81 | -8.55 |
| -7.13 | -0.45 | -3.15 | 0.01 | 1.31 | -0.01 | 23.95 |
| 10.16 | -7.04 | 4.57 | 0.03 | -23.21 | 0.16 | 4.67 |

Trace test considering 5% critical values indicates 2 and maximum eigenvalue test 1 potential co-integrating vectors lying in the long-run variable space. When the unrestricted co-integrating coefficients are examined in Tab. 3, the first vector with the largest eigenvalue seems to be a theoretically plausible money demand vector. Rewriting the normalized money demand equation under the assumption of $r$ = 1 yield in Eq. 10 below (standard errors are given in parentheses):

$$\beta' z_t = m - \underset{(0.54)}{4.10}y - \underset{(0.16)}{0.42}r_b + \underset{(0.01)}{0.01}td + \underset{(1.29)}{2.54}p + \underset{(0.04)}{0.29}q + \underset{(0.48)}{1.84}e + 30.51 \tag{10}$$

Eq. 10 indicates that all the normalized coefficients upon real money balances have expected signs. The real income elasticity is found above unit value indicating an increasing ongoing monetization process in the economy. Furthermore, the unit income elasticity homogeneity restriction which requires a proportional relationship between real money balances and real income through a quantity theoretical perspective is rejected by using $\chi^2(1)$=6.30. Among the alternative costs, the most significant variables are estimated as the expected exchange rate depreciation and equity prices. The predominant role of exchange rate depreciation rate as an alternative cost to hold reserve money balances brings out the importance of currency substitution phenomenon in the economy when the economic agents make their decisions for their monetary holdings. Choudhry (1995) states that significance of this variable provides evidence of currency substitution phenomenon in a high inflationary country, which reduces domestic monetary control by also reducing the financing of deficit by means of seigniorage and the base of the inflation tax. The semi-elasticity of domestic inflation indicates the high degree of substitutability between real monetary balances and commodities by changing relative returns on the real assets. The significance of the Treasury bill interest rates and the equity prices is an indicator of financial development which diversifies the financial tools in the economy against holding money for the economic agents. Such a conclusion means that modeling demand for monetary balances without including these variables can lead policy makers and researchers to wrong policy conclusions. The only insignificant alternative cost variable is found as the interest rate on 3-month time-deposits, however this variable has an expected true sign. The adjustment coefficients of this vector are given in Tab. 4 below:

**Tablo 4. Adjustment Coefficients for the Co-Integrating Vector**

| D($m$) | D($y$) | D($r_b$) | D($td$) | D($p$) | D($q$) | D($e$) |
|---|---|---|---|---|---|---|
| -0.12 | 0.01 | -0.12 | -0.45 | -0.04 | -0.41 | -0.12 |
| (-2.13) | (0.17) | (-0.47) | (-0.66) | (-0.46) | (-1.99) | (-1.52) |

Our findings indicate that about 12% of the adjustment in money demand disequilibrium conditions to long run equilibrium is realized within one period. The weak exogeneity condition for the variables can only be rejected for the real money balances and equity prices and thus no information will be lost in a single equation dynamic vector error correction model constructed on weakly exogenous variables which cannot be Granger-caused by real base money balances. In these results, the weak exogeneity of inflation coefficient in the money demand variable space has been of special importance for policy makers and researchers since this requires that no feedback effect of disturbances form the long-run money demand functional relationship can be modeled as a dynamic vector error correction model upon domestic inflation. Such a case means explicitly that the main factors leading to the changes in the domestic inflation are determined out of the money demand variable space. Therefore, reserve money aggregate under the control of monetary authorities should not be considered a main forcing factor for the long-run evolution of domestic inflation. Whereas, in line with a quantity theoretical perspective, excess money balances derived from a money demand equation should have a positive significant effect on the inflation (Civcir, 2003).

Finally, the vector error correction model diagnostic test results and the multivariate statistics used for testing stationarity derived from the Johansen methodology are indicated below:

**Tablo 5. VEC Residual Serial Correlation LM Statistics**

H0: no serial correlation at lag order h

| Lags | LM-Stat. | Prob. |
|---|---|---|
| 1 | 57.56 | 0.19 |
| 2 | 54.15 | 0.28 |
| 3 | 47.09 | 0.55 |
| 4 | 41.11 | 0.78 |

**Tablo 6. VEC Normality Tests**

Ho: system residuals have normal distribution

| | | |
|---|---|---|
| Skewness $\chi^2(7)$ | 3.37 | Prob. 0.85 |
| Kurtosis $\chi^2(7)$ | 83.03 | Prob. 0.00 |
| Jarque-Bera $\chi^2(14)$ | 86.41 | Prob. 0.00 |

Notes: Normality tests assume Cholesky orthogonalization of Lütkepohl (1991).

**Tablo 7. Multivariate Statistics for Testing Stationarity**

| | $m$ | $y$ | $r_b$ | $td$ | $p$ | $q$ | $e$ |
|---|---|---|---|---|---|---|---|
| $\chi^2(6)$ | 37.31 | 28.00 | 34.91 | 37.47 | 28.98 | 27.06 | 42.81 |

No serial correlation problem at any order can be observed in Tab. 5 above. There has been found no skewness problem, but the vector normality assumption of the system residuals has been rejected through excess kurtosis. However, Gonzalo (1994) indicates that Johansen multivariate co-integration methodology performs better than other estimation methods even when the errors are non-normal distributed. Besides, multivariate statistics used for testing stationarity are estimated in line with univariate unit root test results obtained above and we conclude that no variable alone can represent a stationary relationship in the co-integrating vector.

## 6. CONCLUDING REMARKS

In this paper, determinants of reserve money demand are tried to be examined for the Turkish economy. Based on the contemporaneous multivariate co-integration methodology, results obtained indicate that the main alternative costs to hold reserve money balances are the expected exchange rate depreciation and the equity prices. The role of exchange rate depreciation in the money demand relationship is attributed to the existence of an ongoing currency substitution phenomenon in the economy when the economic agents make their decisions for their monetary holdings. Moreover, there exists evidence in favor of the effects of financial development on the money demand function in the sense that diversification of financial tools held in hand against demand for money balances is a necessary condition for the determination of long-run course of the monetary policy.

## REFERENCES


Bahmani-Oskooee, M. & Karacal, M. (2006). "The Demand for Money in Turkey and Currency Substitution", **Applied Economics Letters**, 13, pp: 635-42.

Baydur, C.M. and Süslü, B. (2002). "1990'lı Yıllarda Türkiye'de Para Politikası Uygulamasında Çapalar", **IMKB Dergisi**, 6/21, pp: 37-85.

Choudhry, T. (1995). "High Inflation Rates and the Long-Run Money Demand Function: Evidence from Cointegration Tests", **Journal of Macroeconomics**, 17/1, pp. 77-91.

Civcir, I. (2003). "Broad Money Demand, Financial Liberalization and Currency Substitution in Turkey", **Journal of Economic Studies**, 30/5, pp: 514-34.

Dickey, D.A. and Fuller, W.A. (1979). "Distribution of the Estimators for Autoregressive Time Series with a Unit Root", **Journal of the American Statistical Association**, 74, pp: 427-31.

Ertuğrul, A. and Selçuk, F. (2002). “Turkish Economy: 1980-2001”, **Inflation and Disinflation in Turkey**, (Eds. A. Kibritçioğlu, F. Selçuk and L. Rittenberg), Ashgate Pub. Ltd., pp: 13-40.

Goldfajn, I. and Valdes, R.O. (1999). “The Aftermath of Appreciations”, **Quarterly Journal of Economics**, 114/1, pp: 229-62.

Gonzalo, J. (1994). “Five Alternative Methods of Estimating Long-Run Equilibrium Relationships”, **Journal of Econometrics**, 60, pp: 203-33.

Granger, C.W.J. and Newbold, P. (1974). “Spurious Regressions in Economics”, **Journal of Econometrics**, 2/2, pp: 111-20.

Hafer, R.W. and Kutan, A.M. (1994). “Economic Reforms and Long-Run Money Demand in China: Implications for Monetary Policy”, **Southern Economic Journal**, 60/4, pp: 936-45.

Harris, R.I.D. (1995). **Using Cointegration Analysis in Econometric Modelling**, 1. Ed., Prentice Hall.

Johansen, S. (1988). “Statistical Analysis of Cointegration Vectors”, **Journal of Economic Dynamics and Control**, 12, pp: 231-54.

Johansen, S. (1995). **Likelihood-based Inference in Cointegrated Vector Autoregressive Models**, Oxford University Press.

Kwiatkowski, D., Phillips, P.C.B., Schmidt, P. and Shin, Y. (1992). “Testing the Null Hypothesis of Stationary against the Alternative of a Unit Root”, **Journal of Econometrics**, 54, pp: 159-78.

Lütkepohl, H. (1991), **Introduction to Multiple Time Series Analysis**, Springer-Verlag, New York.

Mahadeva, L. and Robinson, P. (2004). “Unit Root Testing to Help Model Building”, **Handbooks in Central Banking**, (Ed. A. Blake ve G. Hammond), Centre for Central Banking Studies, Bank of England, No. 22, July.

Osterwald-Lenum, M. (1992). “A Note with Quantiles of the Asymptotic Distribution of the Maximum Likelihood Cointegration Rank Test Statistics”, **Oxford Bulletin of Economics and Statistics**, 54, pp: 461-72.

Yavuz, N.Ç. (2004). “Durağanlığın Belirlenmesinde KPSS ve ADF Testleri: İMKB Ulusal Endeksi ile Bir Uygulama”, **İstanbul Üniversitesi İktisat Fakültesi Mecmuası**, 54/1, pp: 239-47.