COINTEGRATION TEST FOR MONEY DEMAND
THE CASE FOR TURKEY AND ISRAEL

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INTRODUCTION

Empirical money demand estimations are used by monetary authorities as a major tool in designing policies to influence real and monetary balances. Starting from the 1980's, search for the economic variables such as income, interest rates, foreign exchange rates and inflation gained importance in the literature. According to Friedman (1956), money demand function assumes that there are a stationary long-run equilibrium relationship between real money balances, real income, and the opportunity cost of holding real balances.

In this paper, the hypothesis of existence of stationary long-run money demand function is tested by using cointegration method for Turkey and Israel that in both countries the high inflation was the main economic problem. If money demand function shows a stationary long-run relationship among real income and opportunity cost of holding money, then it means that the stochastic trend in real money balances is related to the stochastic trend in real income and opportunity cost of holding money. Thus, by cointegrated variables, it will be constrained to equilibrium relationship in the long-run.

Generally, " time series variables are not stationary individually, one or more linear combinations of the variables are stationary eventhough individually they are not" (Dickey et.al. 1991) Therefore, variables in an econometric model should carry out the property of stationarity. Unit root test are performed on univariate time series in order to test order of integration. If individual time series are found to be integrated of the same order after the unit root tests, then these variables may be cointegrated. Cointegration deals with the relationships among a group of variables, where unconditionally each

has a unit root. "When this occurs, the time paths of the individual variables are ultimately constrained to an equilibrium relationship and are said to be cointegrated. While deviations from equilibrium are possible, they are eventually self revising" (McNown, Wallace 1992). Therefore, we can interpret the long-run paths of these variables are interdependent. Application of cointegration test in the estimation of the money demand function are analyzed by Johansen and Juselius (1990), Dickey, Jansen and Thornton (1991), Mehra (1989),etc.

The paper proceeds as follows. In the next section the model is presented, after general outlook of Turkish and Israel economy, description of the data and procedure are given. The discussion of the empirical results conclude the paper.

THE MODEL

In this study the long-run real money demand relationship is investigated by the following model;

$$m = f(y,P,R)$$

where

m... the real money demand found by dividing nominal money balances to price index

y... the real income

P... the inflation rate

R... the rate of change of exchange rate in terms of US dollar as an opportunity cost of holding money.

For the economies suffering from high inflation, it is better to include rate of inflation and the rate of exchange rate. According to Abel (1979), it is necessary because goods and foreign assets can

be substituted for domestic currency. Also, the rate of change of exchange rate act as a proxy for the domestic rate of inflation in the money demand function in high inflation countries. Moreover, it may measure the expected rate of depreciation, and thus of the opportunity cost of holding domestic currency as opposed to foreign currency. Also, Frenkel (1977,1980) pointed out that if commodities and domestic money are substituted, then opportunity cost of holding money is the expected inflation. Similarly, if foreign money and domestic money are substituted, then the opportunity cost of holding money is the rate of change in the exchange rate.

DEVELOPMENTS IN TURKISH ECONOMY

Due to the developments in the world economy and internal economic environment, Turkish economy has been subject to the inflation and low level of growth in GNP until 1980. In this period Turkish economy can be summarized as, a restrictive monetary policy, negative real interest rates, contraction on real monetary aggregates, overvalued and severe shortage in foreign exchange and high inflation rate. Therefore, economic stabilization program was taken into account in January 1980. Between the period of 1980-1982 growth rate of GNP declined and economy entered the recession with high inflation rate. Both high real interest rates and high rates of depreciation of Turkish Lira resulted in a sizeable increase in the demand for money. Success in the control of money, together with the rise in money demand, contributed to the deceleration of inflation. In 1981, savings time deposits increased due to the shifts from sight to time deposits. Therefore, the rate of acceleration in M2 realized above the rate of M1. Between 1980-1982, high real positive interest rates coupled with high rates of depreciation of Turkish Lira resulted in a sizeable increase in the

demand for money. The success in the control of money, together with the rise in money demand, contributed to the deceleration of inflation.

In 1983, real interest rates became negative, time and saving deposits declined in real terms and growth rate of money supplies M1 and M2 decreased.

The Turkish economy had experienced relatively higher and stable growth rates between 1984 and 1987. During 1984, inflation continued to increase and nominal interest rates on time deposits were raised significantly. Monetary aggregates expanded quite strongly. Several measures were taken from mid-1984 onwards to curb the growth of the money supply. Positive real interest rates remained at low levels and Turkish lira appreciated. These developments bring about a decline in the demand for money. Inflationary pressures continued. Growth rate of M1 remained lower then the growth rate of M2. By setting higher interest rates on shorter maturity deposits, time deposits became to concentrate in the shorter maturities. High real growth rates were recorded in time and saving deposits in 1985. Broad money M2 strongly expanded and also, foreign exchange deposits became important. However, in response to strongly positive real interest rates and real depreciation of Turkish Lira, demand for money increased significantly throughout the year. In 1986, the rate of inflation decelerated significantly. The growth rate of money supplies slowed down, but they expanded in real terms. The excess liquidity generated and money supply M1 increased in the second half of 1986. Also, growth rate of M2X rose significantly due to increase in foreign exchange deposits. In 1987, eventhough deposit interest rates were behind the inflation rate, deposits went up, and liquidity expanded very rapidly.

During 1988 and 1989 the rate of growth of real GNP fell down sharply. Due to instability in financial markets some measures were taken in order to increase attractiveness of Turkish Lira. Term structure of deposit interest rates changed in favor of longer maturities. In 1988, the growth rates of all monetary aggregates, except reserve money, were below the inflation rate. The relatively slow growth of sight deposits, caused M1 to increase less than M2. Real interest rates were generally negative and this caused a decline in real money demand. The amount of currency issued, inflation and inflationary expectations increased. Interest rates of deposits were freed on July 1988. Also, the structural changes made in financial markets by passing to the market determined exchange rates and by beginning Foreign Exchange Market operations. Despite the declining trend in deposit interest rates, the return from bank deposits increased in 1989. M2X realized above the rate of M2 in 1988 but below in 1989

The rate of growth of real GNP increased by 9.9 percent which was the highest rate in the last two decades. In 1990, deposit interest rates continued to slow down, but in real terms surpassed the rates of 1989 on average. Real appreciation of Turkish Lira continued. Following Gulf Crises, the sensitivity of depositors to deposit rates was reduced. In February 25, 1990 restrictions on foreign exchange were removed to a great extend. This development was considered as a step toward the convertibility of Turkish currency. Central Bank announced the monetary program in January 1990. All targets of the Central Bank monetary program were items from its balance sheet. Implementation and success of the monetary program were realized in a great extent. Also, broader monetary aggregates slowed down.

DEVELOPMENTS IN ISRAEL ECONOMY

Before 1977, budget deficit reached almost 18 percent of GDP on the average under pegged exchange rate policy in Israel. Therefore, government tried to take some measures such as devaluation of the currency about 40 percent then inflation began to decline.

In 1977, Foreign Exchange Regulation was abolished, at this time, inflation was about 30 percent and budget deficit was 15 percent of GDP. Toward the end of 1977, the controlled prices were risen by the government 70 percent and exchange rate was devaluated. With those developments inflation accelerated and reached 50 percent annually.

In 1978, new type of deposits emerged and foreign exchange linked deposits gained importance. Currency substitution began with rising inflation and inflationary expectation. Budget deficit reached 20 percent of GDP also prices increased because of the second oil crises. During these period finance ministers changed frequently.

By the end of 1979, new finance minister tried to follow orthodox policy. Balance of payments deficit and budget deficit declined according to new policy but unemployment rose.

After changing finance minister in 1981, inflation rose to 130 percent. According to new policy, controlled prices kept down, exchange rates appreciated in real terms, so budget deficit deteriorate. During this period inflation was controlled and decline to 110 percent and minister announced that both prices and exchange rates were under control in order to effect inflationary expectations and reduce inflation. But, current account deteriorate, appreciation of real exchange rate was delayed until 1983.

1984 was the year of election, subsidies had grown rapidly, inflation rose about twice by the mid of 1984. Eventhough, labor union and government made an agreement about the wages and inflation, government could not solve the problem and both deficits and monetary accommodation remained inflationary. Therefore, orthodox stabilization program was considered. In general, orthodox programs favor wage restraint, emphasize monetary and fiscal restraint. In Israel, with this program both balance of payment and inflation took into consideration with shock decisions. Monetary policy was tightened, money supplies slowed down, domestic demand was tried to take under control, foreign capital attracted so foreign exchange reserves strengthen. Exchange rate devaluated by 19 percent and frozen prices were allowed to increase in certain percent.

Heterodox stabilization policies combine fiscal austerity and income policy. With heterodox policy, government credibility sustain with exchange rate and price control. Monetary aggregates slowed down. After the program, inflation dropped sharply to about 50 percent from 477 monthly figure. Then inflation was stabilized 15-20 percent. During 1986-1987 inflation sustained at low levels, growth rate increased by both the help of stabilization program and foreign aid. But in the middle of 1988, growth slowed down and turn to recession.

THE DATA AND THE PROCEDURE

The quarterly data for Turkey and Israel compromise the time period of 1978.1-1990.4 and 1977.1-1988.4 respectively (from The Central Bank of Turkey and International Financial Statistics Bulletins). During the analyzed period both Turkey and Israel experienced high and variable inflation rates. Also, there were large

changes in money supplies and volatile nominal exchange rates in both countries.

Real variables are obtained by deflating nominal variables with consumer price index. All variables except inflation rate and exchange rates are in logarithmic form. Narrow (M1) and broad (M2 M1 + quasi money) definition of money demand are used. Real output is proxied by industrial production. As a opportunity cost of holding money, exchange rate in terms of US dollar is used. All data are seasonally unadjusted.

Empirical study is performed by using PC versions of RATS 3.1 and Microfit 3.0. Since all the variables are time series, the application of the cointegration test for money demand requires the examination of time series properties of the data. Seasonal characteristics of the data are analyzed by using autocorrelation and partial autocorrelation functions. All the variables included in the cointegrating vectors should be integrated same order. The seasonal unit root hypothesis is tested by the method (HEGY) developed by Hylleberg et.al. (1990), Osborn (1990).

$$(1)\ \Delta_4\,\Delta_1 X_t = \alpha_0 + \alpha_1 (D_{1t} - D_{4t}) + \alpha_2 (D_{2t} - D_{4t}) + \alpha_3 (D_{3t} - D_{4t}) + \Pi_1 Z_{1,t-1} + \Pi_2 Z_{2,t-1} + \Pi_3 Z_{3,t-2} + \Pi_4 Z_{3,t-1} + \sum_{i=1}^{k} \phi_i\,\Delta_4\,\Delta_1 X_{t-i} + u_t$$

where,

$$Z_{1t} = (1+L+L^2+L^3)\,\Delta_1 X_t$$

$$Z_{2t} = -\,(1-L+L^2-L^3)\,\Delta_1 X_t$$

$$Z_{3t} = -\,(1-L^2)\,\Delta_1 X_t$$

L is the lag operator,

D_i's are the seasonal dummy variables; i=1,2,3,4

$$\Delta_1 \Delta_4 = S(2,1) = I(1,1) = (1-L)(1-L)(1+L+L^2+L^3)$$
$$= (1-L)(1-L^4)$$

When the seasonal unit roots are rejected, the series is classified as S(2,0). This hypothesis is tested by the Dolado, Jenkinson, Rivero (1990) approach.

The maximum lag length of the VAR model is tested by the following LR statistic;

(2) $(T-c)\ (\log\det \Sigma_r - \log\det \Sigma_u)$

where Σ_r and Σ_u are the restricted and unrestricted covariance matrices, T is the number of observation and c is a correction to improve small sample properties (RATS 3.0 Reference Manual).

Cointegration test of money demand performed by Johansen (1988) procedure, following the explanation of Johansen (1988) and Charemza, Deadman (1992). The VAR model with Gaussian error ε_t;

(3) $$\Delta Z_t = \sum_{i=1}^{k} \Gamma_I \Delta Z_{t-i} + \Pi Z_{t-k} + \varepsilon_t$$

where;

(4) $\Pi = I-A_1- .... - A_k$

Z_t is the nx1 vector of variables

(5) Γ_i, Π are the nxn matrices of unknown parameters

From Eq. (3) it can be concluded that, while the Z_t is stationary and variables are not, the existence of Z_{t-k} depends on the existence of stationary linear combination(s) which is (are) defined by Z_{t-k}. So

the rank of Π gains importance. If the rank of Π is equal to n, that is the number of variables contained in VAR model, the vector process Z_t is stationary. If the rank is r<n, we can write;

(6) $\Pi = \alpha \beta'$

where

α is the matrix of cointegrating vectors

β is the adjustment matrix

α and β both are nxr matrices.

Matrix β has the property that $\beta' Z_t \sim I(0)$ while $Z_t \sim I(1)$ (Charemza, Deadman (1992)).

For the estimation of β, first both ΔZ_t and Z_{t-k} regressed on ΔZ_{t-} ,...., ΔZ_{t-k+1} and residuals of both regression used to construct R_{0t} and R_{kt}. Second, the product moment matrices are obtained by;

(7) $S_{ij} = 1/T \sum_{t=1}^{T} R_{it} R'_{jt}$ i,j=0,k

T is the sample size, and

(8) $\mu S_{kk} - S_{k0} S_{00}^{-1} S_{0k} = 0$

solved for μ. This solution yields the eigenvalues $\hat{\mu}_1 > ... > \hat{\mu}_n$ and associated eigenvectors $\hat{v}_i$ which may be arranged into the matrix $\hat{V} = [\hat{v}_1, ..., \hat{v}_n]$. The eigencevtors are normalized such that $\hat{V}' S_{kk} \hat{V} = I$ so,

(9) $\hat{\beta} = (\hat{v}_1, ..., \hat{v}_n)$

(10) $\hat{\alpha} = S_{ok} \hat{\beta}$

If the cointegrating matrix β is of rank r<n, the first r eigenvectors are the cointegrating vectors (Charemza, Deadman (1992)). There are two ways to calculate r. One of them is the likelihood ratio trace statistics;

$$(11)\ LRT = -T \sum_{i=i+1}^{n} \ln (1-\mu_i)$$

In likelihood ratio trace test, the hypothesis of a most r cointegrating vector against the full rank r = n. The other test is the maximum eigenvalue statistics;

$$(12)\ ME = -T \ln (1-\hat{\mu}_r)$$

which test the null hypothesis of the existence of r cointegrating vector against the alternative of r+1 cointegrating vectors.

The stationarity of the data is tested by HEGY procedure. All of the variables do not contain a seasonal unit root, except real income. Real income is SI(1,1). Besides, most of the variables have deterministic seasonality.

The Johansen method applies the maximum likelihood to determine the presence of cointegrating vectors in nonstationary time series. The trace test and eigenvalue test determine the number of cointegrating vectors. This implies a stationary long-run equilibrium relationships between the variables. The maximum lag length of the VAR model which is used in Johansen Procedure is determined by the Likelihood Ratio (LR) statistics. The maximum lag length of real narrow money (M1) VAR model is five., but lag of length of broad money (M2) is found as six and in all other cases four lags used in cointegrating vectors. Johansen (1988) showed that maximum likelihood estimation of the first r vector of b are the cointegrating

vectors. Test statistics for both the rank of b matrix can be found in Table 1. In both Trace and Maximum Eigenvalue tests gave the same results.

The cointegrating vectors are normalized in Table 2 by dividing all the coefficients by coefficient on money and thus, the cointegrating vectors appear as the money demand equation and long-run elasticities obtained from these normalized equations.

TEST RESULTS

Table 1 shows the trace and the maximum eigen value tests using real M1 and real M2 According to these tests, for both M1 and M2 case we have one cointegrating vector both statistically and economically significant at 1% and 5% significance level.

As can be seen from table 2, the cointegrating vector for real money M1 and real M2, consists of real income, inflation rate and exchange rate as an opportunity cost of holding money. Demand for real M1, is sensitive to real income for Turkey than Israel. Expected signs are obtained for remaining variables, but, the long run elasticity of rate of inflation and exchange rate is found to be very low for Turkey. But, for Israel. It may indicate the currency substitution.

In the first cointegrating vector of demand for real money M2, rate of depreciation of the currency against US dollar is taken as the opportunity cost of holding M2. Both for Turkey and for Israel real M2 is sensitive to real income, inflation and depreciation rate with economically meaningful signs.

CONCLUSION

The paper tried to test whether there exist a stable long-run money demand function for Turkey and Israel which experienced

high inflation during the analyzed period, by using Johansen cointegration method.

The money demand function includes real money balances, real income, the rate of inflation and the rate of change of exchange rate as opportunity cost of holding money balances. The empirical results support the long-run stationary function for both Turkey and Israel. In both narrow and broad money demand function, rate of exchange rate and inflation rate are included. All variables in the money demand equation are individually significant and signs are as expected. Exchange rate sensitivity of money demand may indicate currency substitution.

TABLE 1

TEST STATISTICS FOR COINTEGRATING VECTORS

TURKEY

TRACE TEST

		r=0	r<=1	r<=2	r<=3
M1	1.	98.75 *	18.12	9.52	4.33
M2	2.	106.3 *	25.66	17.21	8.14

MAXIMUM EIGENVALUE TEST

		r=1	r=2	r=3	r=4
M1	1.	65.84 *	15.73	7.44	4.33
M2	2.	97.52 *	20.69	9.65	8.14

ISRAEL

TRACE TEST

		r=0	r<=1	r<=2	r<=3
M1	1.	103.52 *	29.38 *	24.78	13.64
M2	2.	86.75 *	49.95 *	16.74	5.74

MAXIMUM EIGENVALUE TEST

		r=1	r=2	r=3	r=4
M1	1.	79.65 *	17.99	15.66	13.64
M2	2.	58.57 *	22.19	13.77	5.74

* Significant at 1 % and 5%

1. Tests of real money (M1), real income, inflation, exchange rate

2. Tests of real money (M2), real income, inflation, exchange rate

TABLE 2
COINTEGRATING TEST RESULTS
(NORMALIZED VALUES)

TURKEY

	REAL M1	**REAL INC.**	**INFLATION**	**EXCH.RATE**
M1	-1	0.5517	-0.314	-0.0339
	REAL M2	**REAL INC.**	**INFLATION**	**EXCH.RATE**
M2	-1	0.3032	-0.427	-0.0522

ISRAEL

	REAL M1	**REAL INC.**	**INFLATION**	**EXCH.RATE**
M1	-1	0.4812	-0.7146	-0.0489
	REAL M2	**REAL INC.**	**INFLATION**	**EXCH.RATE**
M2	-1	0.3475	-0.2311	-0.0294

REFERENCES

Abel, Andrew, R. Dournbusch, J. Huizinga, A. Marcus. "Money Demand During Hyperinflation", Journal of Monetary Economics,5, 1979:97-104

Ahumada, H. "A Dynamic Model of the demand for Currency: Argentina 1977-1988", Journal of Political Modeling, 14(3), 1992: 335-61

Aysoy C., C Izgi Kogar."Cointegration Test for Money Demand with Turkish Data: 1978Q1-1992Q4", Journal of Economics & Finance Papers and Proceedings, Vol 17, 1993, pp. 415-424

Bruno M., G. Tella, R. Dornbush, S. Fisher, "Inflation Stabilization: The experience of Israel, Argentina, Brazil, Bolivia and Mexica", MIT Press, 1989.

The Central Bank of the Republic Bank of Turkey, Varies Quarterly and Annual Reports, 1970-1991.

Cheremza W., D. Deadman. "New Directions in Econometric Practice: General to Specific Modeling, Cointegration and Vector Autoregression", E. Elgar Publishing Ltd. 1992.

D.A., W.A.Fuller "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root", Econometrica, 49,(July 1981):1057-72

Dickey D.A., D.Jansen,D. Thronton "A Primer Cointegration with an Application to Money and Income" Federal Reserve Bank of St. Louis, (March-April 1991) :58-77

Dolado J.J., T. Rivero. "Cointegration and Unit Root",Journal of Economic Surveys,4,n.3,1990:249-73

Dornbush R., M. Simonsen, "Inflation Stabilization with Income Policy Support", Group of Thirty, Newyork & London, 1987

Frenkel, Jacob "The Forward Exchange Rate, Expectation , and the Demand for Money: The German Hyperinflation" American Economic Review 67, Sept 1977:653-70

---------. "The forward Exchange Rate, Expectation, and the Demand for Money- The German Hyperinflation:Repl" American Economic Review 70, Sept 1980:771-75

Friedman, M.' The Quantity Theory of Money: A Restatement" In Studies in the Quantity Theory of Money, edited by M. Friedman. Chicago: University of Chicago Press, 1956

Gordon R. "The short-run Demand for Money: A Reconsideration", Journal of Money, Credit and Banking, November,1984: 403-432

Hafer R.W., D. Jenson "The Demand for Money in the United States: Evidence from Cointegration Tests" Journal of Money, Credit and Banking,v.20,n.2, May 1991: 155-68

Hall S.G. "Maximum Likelihood Estimation of Cointegration Vectors" Oxford Bulletin of Economics and Statistics., 1989: 213-220

Hendry D., N. Ericsson. "Modelling Demand for Money in the UK and US" North-Holland Press, 1991: 833-876

Hylleberg S., R.F. Engle, C.W.J. Granger, B.S. Yoo " Seasonal Integration and Cointegration", Journal of Econometrics, 44, 1990:215-38

Johansen S., "Statistical Analysis of Cointegrating Vectors" Journal of Economic Dynamics and Control, 12,1988: 231-54

Johansen S., K. Juselius " Maximum Likelihood Estimation and Inference on Cointegration-with Applicationsto the Demand for Money" Oxford Bulletin of Economics and Statistics, 52.2, 1990: 169-210

McNown R.,M . Wallace"Cointegration Tests of LR Relation Between Money Demand and Effective Exchange Rate", Journal of International Money and Finance, 11,1992:107-114

Mehra Y." In Search of Stable , Short-run M1 Demand Function", Federal Reserve Bank of Richmond Economic Review May-June 1992

Osborn D.R. ," A Survey of Seasonality in UK Macroeconomic Variables", International Journal of Forecasting, 6, 1990:327-36

Osborn D.R.,A.P.L. Chui, J.P.Smith, C.R. Birchenhall "Seasonality and the Order of Integration for Consumption" Oxford Bulletin of Economics and Statistics.v.50, n. 4, 1988 : 361-77

Porath Y." The Israeli Economy" Havard Press, 1986