Quarterly Journal of Quantitative Economics, Winter 2012, 8(4): 51-73

# A Comparative study between ARDL and Johansen Procedures in Narrow Money Estimation in the Iranian Economy

Mahdi Mostafavi (Ph.D.) *

Received: 2011/7/9 Accepted: 2012/3/8

***Abstract:***

***The purpose of this study is estimation of narrow money in the long run via ARDL and Johansen procedures. In doing so first econometric model has been investigated. For modeling narrow money two studies have been applied namely Rother (1999) and Bahmani Oskooee (1996). The applied model in this study deals with GDP, inflation, rates of return on foreign exchange and cars. In order to investigate the long run relationship among involved determinants in the model cointegration test has been applied via ARDL and Johansen procedures. According to trace adjusted there is only one cointegration vector for the RM1 model. Then we derived the long run coefficients for RM1 model and concluded the same results as those of the ARDL test in the light of the theory basis. Although the ARDL and Johansen use very different techniques in estimation, the former employs ordinary least squares while the latter uses the maximum likelihood estimation method. Thus, one-to-one comparison of the magnitudes of the coefficients may not be appropriate and requires some caution. Hence there is a bit difference between two mentioned results in determinants parameters magnitudes. For explain the coefficients of determinants for GDP and inflation in Johansen is more real and closed to theory in comparison to ARDL procedure.***

**JEL** classification**:*C52***

***Keywords:*** *RM1, long run, cointegration, ARDL, Johansen*



* Faculty member of economics at Ferdowsi University of Mashhad, Mashhad, Iran. Email: (mostafavimahdi@yahoo.co.uk)

## 1. Introduction

The paper's objective is to provide a comparative discussion for two different cointegration procedures ARDL, and Johansen for estimation real narrow money (RM1) in the Iranian economy.

Demand for narrow money has attracted the attention of monetary economists since the mid-eighteenth century or even earlier, because it relates to the main macroeconomic issues of inflation, unemployment, levels of income, interest rates, financial markets and the banking system. Basically, demand for money theories can be analysed under two major headings:

A. The transactions demand for money: this type of demand for narrow money happens when there is a distance of time between income and expenditures. The transaction motive of demand for money can usually be explained via real wealth, permanent income or current income (depending on the theory).

B. Opportunity cost of holding money: this type of demand occurs when an individual makes a comparison between the rate of return on narrow money and its proxies (bonds, equities, and durable goods). The opportunity cost of holding money is related to the role of money as a store of value. The rate of interest, the rate of inflation or the rate of change in the price of durable goods[1], are relevant factors here.

According to Friedman (1956) and Goldfeld (1973), the theoretical specification for the real narrow money function is given by:

$$m = f(i, Y / P) \qquad (1)$$

Where m ,Y,i, and P stand respectively for real money stock income, nominal interest rate and price level. Hence a numerous authors[2] believe that in developing countries the possible effective determinants on MR1 are GDP and inflation.

---

[1] For example some studies applied foreign exchange in their work. (See: Nazemzade (1983), Domowitz and Elbadawi (1987), Lahiri (1991), Amirsharafi (1991), Nowferesti (1995) and Emadzade (1990).

[2] See Hajeian (1989), Metin (1994), Fielding (1995), Arrau et al (1995),Qayyum (1995), Coudhery (1995), Tavakkoli (1996), Bahmani-Oskooee (1996), Pessaran (1996), and Renani (2008).

Since time series data are normally accomplished with the issue of non stationary problem, we should pay our attention to the issue of the stationarity. Time series authors believe that when two or more series are integrated of the same order, they are cointegrated, and there could be a long run relationship among them. Hence econometricians supply some procedures in order to determine the magnitude effect of appropriate factors on the dependent variable. Hence in this study we intend to discuss two major procedures, namely ARDL and Johansen among RM1 and its determinants. The result of this paper should be the determinants magnitudes and signs involved in the model.

This paper is organized in 8 sections. Section 1 is introduction. Section two devotes to theoretical debates of the topic. Section 3 discusses the methodology of the research and database. Section 4 reviews a short report of the existing studies for the topic throughout the world. Section 5 carries out the data analysis. Section 6 includes preferred model in this paper. Section 7 tries to do empirical studies via ARDL and Johansen procedure, and finally section 8 devoted to concluding remarks.

**2. Theoretical Basis**

We should define an econometric term namely cointegration. If the nonstationary yt and xt sequences are integrated of the same order and the error term is stationary, yt and xt are cointegrated (Enders, 1995: 219).

If yt and xt are cointegrated, the OLS estimation of this equation might possibly supply a super-consistent estimate of the parameters involved in the equation (Thomas, 1997: 428). The residuals of the equation constructed by yt and xt should then be calculated. If the residuals become stationary, there is a long run relationship among the mentioned cointegrated series. . the long run relationship among variables in an econometric model has been investigated via several ways. Some those conventional ways are : Engle Granger (1987), procedure, ARDL, and Johansen procedure.

Although the Engle and Granger (1987) procedure is easily accessible, it has some important defects. First, the researchers using this procedure face the question of how they should chose one variable for the left-hand side as a dependent variable, leaving the other variables on the right hand side as explanatory variables. This defect occurs when the economic theory does not tell us which variable is the dependent one. As Hafer & Jansen (1991) and Kennedy (1992) state, choosing a wrong dependent variable will usually affect the estimation results. The second serious defect in this procedure is the two-step estimator. In the first step, we suppose that the variables are cointegrated and, by accepting this assumption, we obtain the residuals. In the second step, the residual sequence is examined for stationarity. But we cannot postulate that mt and yt are cointegrated unless we prove it before. Doing things in this sequence is not logical. As Dickey et al (1995:13) state, using this procedure it is difficult to reject the null hypothesis of non-stationarity for error terms.

The third defect of the Engle and Granger (1987) procedure is lack of knowledge of the correct number of long-run relationships among variables (Hafer and Jansen, 1991: 158). This problem emerges when there are more than two variables in the model, because, as Miller (1991:141) points out, the cointegration vector of two-variable equations is unique, while it is not necessarily unique when there are several variables in the model.

As a result we emphasize to two last procedures. ARDL solves the second defect of Engle Granger (1987), and Johansen solves all three defects of Engle Granger (1987). In the next stage we will explain the methodology of our procedures.

**3. Methodology and database**

In this paper in order to estimate the dependent variable, two different procedures namely ARDL and Johansen could be applied. As Charemza & Deadman(1992) state: the unrestricted ADL model for the two variables: yt and xt is as follows:

$$yt = \sum_{i=1}^{n} a_i yt\text{-}i + \sum_{j=0}^{n} \beta_j xt\text{-}j + et \quad (2)$$

where the cointegration coefficient is obtained by the formula:

$$\beta^* = \frac{\sum_{j=0}^{n} \hat{\beta}_j}{1 - \sum_{i=1}^{n} \hat{a}_i} \quad (3)$$

Now β* can take the place of β in the ECM. This is a briefly explanation of ARDL procedure. Now we should go to explain Johansen procedure.

As Harris (1995) states, the estimation of a series like RM1 in the long run will carried out via three stages as follows:

i- Estimating and evaluating vector auto-regression (VAR) models,

ii-. Testing for cointegration, (i.e. testing for the number of long run relationships among variables);

iii. Testing restrictions on β matrix;

Looking first at the available data, the data for Iran is usually presented in an annual publication called Iran Statistical Yearbook, prepared by the Statistical Centre of Iran. As for the accuracy of the data, given that the Central Bank of Iran is the oldest and most accurate data source, most of the necessary data for this study (such as M1, M2, and the price of durable goods, the CPI) and other national accounts data are taken either from the Central Bank's bulletins, or via its website: www.cbi.ir

**4. A Review of the literature**

Obviously a plenty of investigations have carried out for estimation of RM1 via the mentioned procedures throughout the world. We intend to mention some of them in here.

Metin (1994) estimated the real narrow money in the Turkish economy using quarterly data for the period 1948:1 to 1987:4. The set of explanatory variables includes GNP prices, the rate of inflation and the Central Bank nominal discount rate, the functional form being double log.

Metin (1994) applied time series and cointegration in his study. A unit root ADF test showed that narrow money, GNP, inflation and interest rate are integrated of order one, I (1). By applying the Johansen (1988) maximum likelihood method, it was found that in the long run, the income and inflation elasticities are 2.8 and –0.98 respectively. There is no statistically significant long-run effect although the interest rate coefficient in the short-run demand for money was significant during the whole period. Moreover there is a high gap between income elasticity values in the long run and short run (2.8 and 0.44). This implies that the speed of adjustment should be very slow.

Choudhry (1995) estimated the demand for narrow money in Argentina using quarterly data for the period 1935 to 1962 and 1946 to 1962. These periods coincided with important economic transitions and with high and volatile inflation. His set of inflationary variables includes income and inflation.

Choudhry used time series and cointegration in his work. His augmented Dickey Fuller test shows that all of the series are I(1). Then he performed a cointegration test. For the longer period eight lags were significant and for the shorter period four lags. Choudhry then formed two econometric models, (for M1 and for M2). He did empirical work on each of them over both the short-term and the long-term period. He concluded that there is one cointegrating vector between real narrow and broad money, real income, and the rate of inflation for each of the four cases. In all four relationships, the rate of inflation is significantly different from zero at the 1% level. Real income is significant only during the long period in both real M1 and real M2 functions. During both periods inflation rates seem to have more effect on the demand for real M2 than on real M1. Real income failed to be significant during the short period.

Bahmani-Oskooee (1996) uses a model to estimate RM1. His study has at least two advantages over the most of the others. First, it chooses a black market exchange rate, whereas most researchers either did not apply this factor or employed the official rate along with it. In fact, the actual rate for hard currency

effective in RM1 is its rate in the free-market, as the dollar is available to everybody in this market. The second advantage of this study is that it pays attention to the question of stationarity. Since the factors involved in the demand for money model, (which are on the levels), are not usually stationary, and the differences on variables should be applied in the model. Bahmani-Oskooee (1996) suggested RM1model as follows:

$$RM1_t = a + bY_t + c\,Inf_t + d\,EX_t + e_t \qquad (4)$$

Where: M is the demand for real cash balances; Y is the real GDP, Inf is inflation, and EX is the exchange rate defined as the number of Iranian Rials per US dollar. In this model, the order of integration for the entire involved factor `should be determined. The common method for determining the order of integration is the ADF test. Bahmani-Oskooee (1996) argues however that graphs for the factors involved in his model show the presence of a structural break, (due to the revolution), in each series around 1978, except in the case of the official exchange rate, which is almost constant during most of the period. Hence Bahmani-Oskooee (1996) has applied the ADF test for the official exchange rate, (OEX), and has also applied a modified version by Perron (1989) who incorporated a structural break for other factors in the model. The results for all variables involved in the model are I (1). Thus, by using the first difference for all variables, the author can obtain the stationary factors.

In order to determine the long-run relationship among variables, Bahmani-Oskooee (1996) has then applied the Johansen & Juselius (1990) procedure. He has examined it, using two likelihood ratio tests, known as trace tests. The results of these tests for different groups of factors, shows that, when OEX was included in the RM1model, there is one cointegrating vector, but, when the black market exchange rate (BEX) is included, there are two cointegrating vectors in the RM1 equation.

Tavakkoli (1996) estimates the narrow real money function using quarterly data from 1972:1-1990:1. The set of explanatory

variables includes real GDP and the inflation rate. Since quarterly data for GDP is not available, Tavakkoli converts annual data to quarterly through Lisman and Sandee's method.

He uses time series and cointegration. Unit root tests indicate that narrow money and real GDP are integrated at frequency one I(1), and that the inflation rate is stationary. The results from cointegration analysis through the Johansen (1988) maximum likelihood method show that only one cointegrating vector exists between the real money stock and its determinants. The long-run GDP elasticity of narrow money is 0.106. The estimated coefficient for the inflation rate is equal to –5.67. Although these two figures have the correct signs, the former has a low value while the latter's value is high.

There are three problems with Tavakkoli's work relating to data conversion from annual to quarterly, to cointegration regression and to data analysis, which we would concern to mention first of them in here.

Tavakkoli has applied the procedure of Lisman & Sandee (1964)[3]. Yet as Bruggeman (1995) argues, this procedure is highly arbitrary. Tavakkoli has not used GDP components information, while quarterly data for GDP components like oil, agriculture, industry and services are available.

Sharifi-Renani (2008) estimates RM1 using quarterly data for the years 1983 through 2005. The set of explanatory variables in this work includes real income, exchange rate and inflation rate. First he has tested the stability of the model via CUSUM and CUSUMSQ tests. He succeeded in those tests. Then he has tested the stationarity of the variables and concluded the all of them are I(1) via Dickey-Fuller test. Then he has estimated the MR1 in the long run via ARDL. He concluded that the elasticities for the real income, exchange rate and inflation rate 2.65, 0.67 and -0.05 respectively.

In justification of the explanatory variable signs he state that the positive sign for real income is due to its substitution for

[3] see Tavakkoli,1996:124.

fiscal assets. He also believes that the positive sign of the BEX coefficient could be justified by the wealth effect in the literature. Thus in the long-run this equation holds:

$$RM_{1t} = 2.67Y_t - 0.05\ Inf_t + 0.675\ BEX_t + u_t \quad (5)$$

The major defect of this study is its use of the exchange rate rather than the rate of return of foreign exchange. Inflation is rate of change in the consumption price index, which the author has been applied in my study. Hence the appropriate determinant matched with inflation should be changes in the exchange rate.

**5. Date analysis**

As mentioned before we should first determine the order of integration for all series involved in this study. Those series are RM1, GDP, rate of return on cars and hard currency and inflation. Hence first we should do unit root test. The most conventional procedures for this issue in econometrics is Dickey Fuller test which we will do it below.

**5.1. Dickey Fuller test**

In the ACF method, = 1 in the model xt = xt-1 + t has been tested. Subtracting xt-1 from the two sides of this equation gives:

$$x_t - x_{t-1} = (\ -1)\ x_{t-1} + \ _t \quad (6)$$

This equation is equivalent to:

$$x_t = \gamma x_{t-1} + \ _t \quad (7)$$

when - 1 = γ. Dickey and Fuller (1979) consider two other regression.

equations, which can be applied in testing for a unit root. These equations are:

$$X_t = a_0 + \gamma X_{t-1} + \ _t \quad (8)$$

$$X_t = a_0 + \gamma X_{t-1} + a_2 t + \ _t \quad (9)$$

The differences in these equations are related to the deterministic components. The first equation, (7), is a random walk if the null hypothesis (γ = 0) cannot be rejected. The second equation, (8), is a random walk with drift or a random walk with an intercept. The third equation includes both a drift and linear time trends.

**5.2. Augmented Dickey-Fuller Tests**

In some cases, there may be an auto-correlation among the error terms. In this circumstance, the OLS method does not provide efficient estimated values for the parameters in the model. One solution is to include some lags of dependent variables in the model. The usual specification of this model is:

$$x_t = \gamma x_{t-1} + \sum_{i=1}^{k} \gamma_i \quad x_{t-i} + \quad _t \qquad (10)$$

We should include so many lags as to make the error term become white noise[4] the error terms. Doornik and Hendry (1994a) have provided a procedure to find the appropriate number of lags and contemporaneously the existence of the unit root. [See Charmeza & Deadman (1992:135) and Banerjee et al (1994:107)]. As a first step, a fairly large number of lags is selected (k = 20 to 30 is chosen in this study) and then they are dropped one by one, until the null hypothesis for the parameter of lagged variables cannot be rejected. As the result the optimum number of lags for Rex and Rcar are 10 and zero respectively. Also the correspondent number of lags for DRM1, DGDP, and DD4Inf are 0,3 and 7 respectively.



[4] White noise is a time series which is completely random all lagged correlations being zero; its expectrum density is constant.

**Table1:** DF & ADF test for Integration Order

| Variable | Calculated Value | 95% level of confidence | 99% level of confidence | Constant | Trend | No. of Lags | Result |
|---|---|---|---|---|---|---|---|
| Rcar | -8.47 | -2.91 | -3.56 | * | - | 0 | S |
| Rex | -6.33 | -2.90 | -3.54 | * | - | 10 | S |
| GDP | -1.79 | -3.48 | -4.12 | * | * | 4 | NS |
| GDP | -0.88 | -2.91 | -3.54 | * | - | 4 | NS |
| DGDP | -4.01 | -2.91 | -3.54 | * | - | 3 | S |
| Inf | -2.33 | -2.91 | -3.57 | * | - | 4 | NS |
| D4Inf | -2.83 | -2.91 | -3.57 | * | - | 10 | NS |
| DD4Inf | -4.19 | -2.91 | -3.57 | * | - | 7 | S |
| RM1 | -2.82 | -3.48 | -4.12 | * | * | 4 | NS |
| DRM1 | -7.34 | -2.91 | -3.54 | * | - | 0 | S |

* stands for existence of constant or trend

Table 1 shows the corresponding t-statistic values for 1% and 5% levels from DF or ADF tests. The number of lags for the dependent variable is in the seventh column. This table includes deterministic components. Real money, GDP, and inflation are shows to be I (1), but the rates of return on cars and hard currency are shows to be stationary.

**6. The Preferred Model**

As for the model applied to my study, I made use both of the studies of Bahmani-Oskooee (1996) and those of Rother (1999). In other words, three explanatory variables are taken from the model of Bahmani-Oskooee (1996). Another one was taken from Rother (1999), who uses the changes in the price of gold as an important index for denoting inflation in the countries of West Africa, I use changes in car prices as she does for gold prices. Throughout the period 1992-2008 the path of inflation was upward, and Iranians speculated in durable goods such as new or used cars. As Ghatak (1995:25) has shown, the wealth holders in developing countries tend either to hold money or real physical assets like buildings and durable goods. Hence the rate of return on cars can help to explain the changes in real money and is to be

included in the model. Thus the model selected for this study has one equation, called RM1 equation based on monetarists viewpoints such as Friedman (1956) and Goldfeld (1973). The determinants in this equation are real GDP, inflation, the rate of return on foreign exchange, and the rate of return on cars. The first determinant shows transaction demand for M1 and the rest ones show opportunity cost for M1.

**6.1. The Money demand model used in this study**

By paying attention to the previous empirical works in section 4 findings and also theoretical discussions, the money demand function is expressed thus:

$$(M1 / p)_t = a_o + a_1 RGDP_t + a_2 Inf_t + a_3 REx_t + a_4 RCar_t + u_t \quad (11)$$

Where M1/P stands for real narrow money, RGDP is real gross domestic product, Inf stands for inflation, REx and RCar stand for rate of return on foreign exchange and rate of return on cars respectively. This equation is used to explain the RM1process in Iran. Money stock and GDP are in logarithms, but the remaining variables are not, since negative figures have no logarithm, and because Ln (1+ /100) is approximately equal to /100[5].

**7. Empirical Studies:**

Now we should go on the research by the estimation of the RM1 via ARDL procedure.

**7.1. Autoregressive distributed lag models (ARDL)**

As mentioned above, β* could be arrival at through estimating equation (2), We have used Microfit 4 to calculate this estimator, for real narrow money. According to both the Akaike Information criterion and the Schwarz Bayesian criterion the maximum number of lags in RM1 equation is four. The results of the ARDL tests are shown in the following equations.

$$\widehat{RM1} = -0.04\, t + 0.38\, GDP - 0.19\, Inf \quad (12)$$

[5] See: Thomas, 1997:456

As these estimations show the sign of GDP in model is positive and consistent with theory. The inflation coefficient in the model is negative, meaning that in inflationary conditions, people do not wish to hold money because the purchasing power of money is declining.

### 7.2. The Johansen Procedure

A useful way to illustrate the Johansen methodology is to implement it by the following three steps.

#### 7.2.1. To estimate the VAR model

In order to test the existence of cointegration among the variables, various VAR models of the following type are estimated:

$$X_t = \mu + t + A_1X_{t-1} + ... + A_kX_{t-k} + \quad _0 z_t + \quad _1 z_{t-1} + \ldots + \quad _k z_{t-k} + u_t \qquad t = 1, .... T \qquad (13)$$

Where k is the number of lags; X is a vector comprising I(1) variables which contain real narrow money (RM1), GDP and inflation, (Inf); Z is a vector comprising I(0) variables which are the rates of return on foreign exchange and cars; is a constant vector; and t is a trend vector. This model can be written as a vector of an error correction model:

$$X_t = \quad + \alpha t + \Gamma_1 \Delta X_{t-1} + \Gamma_2 \quad X_{t-2} + \ldots + \quad _{k-1} \quad X_{t-k+1} + \quad X_{t-1} + \quad _0 z_t + \quad _1 z_{t-1} + \ldots + \quad _k z_{t-k} + U_t \qquad (14)$$

There are several points to consider before estimating the model:

The first point concerns the selection of appropriate deterministic components for the VAR model. Equation (14) is applied but with an unrestricted constant and a trend imposed onto the cointegration space, so in accordance to the fourth model suggested by Harris, 1995: This is preferred because the first difference series do not have a linear mean. The second point is that since rates of return on foreign exchange and cars are

stationary, they are regarded as non-modeled[6] and do not enter in the cointegration space (Banerjee et al, 1994 and Thomas, 1997). For this reason we used these variables and their lags in the model as unrestricted. The third point is the differing order of integration in these series. RM1, GDP, and inflation are I (1), while the rates of return on foreign exchange and cars are stationary. According to Enders (1995:396), forms of the Johansen test can detect differing orders of integration. As shown in our econometric model, we have included nonstationary series in the "X" vector and stationary series in the "Z" vector. The fourth point concerns the appropriate number of lags in this model. As Table 2 indicates, four lags must be added in the model to remove the error terms autocorrelation, since even with three lags the autocorrelation problem occures (Fau (36, 77) =2.69**). Moreover, this table indicates a significant four lagged values for real narrow money and inflation. Therefore, four lags of all variables enter into the model, owing to the necessity of an equal lag among all cointegration relationships (Harris, 1995:82). As a result we formed a VAR model on the basis of these points, and the diagnostics are reported in Table 2. The single equation diagnostic in this table indicates that there is no error autocorrelation (Fau, from lag 1 to 4); that there is no autoregressive conditional heteroscedasticity (Farch, , from lag 1 to 4); and that there is no heteroscedasticity problem.

In addition multivariate tests in Table 2 indicate that the VAR model has no autocorrelation, and also no heteroscedasticity. Finally, Fun indicates the significance of fundamental determinants involved in the model (Fun (39, 95) = 144.88**). The only diagnostic test that fails is the normality test for GDP and for the system, and the normality assumption is not so serious for conclusion (Johansen, 1995:29). This implies that the model as a whole is statistically acceptable.

[6] This term means that they cannot be considered as dependent variable.

**Table 2:** Model Evaluation Diagnostic

| Statistic | RM1 | GDP | Inf |
|---|---|---|---|
| Fk=1(3,32) | 1.80 | 22.09** | 34.78** |
| Fk=2(3,32) | 0.30 | 0.28 | 6.31** |
| Fk=3(3,32) | 2.06 | 0.41 | 24.03** |
| Fk=4(3,32) | 5.67** | 1.68 | 14.24** |
| Fau(4,30) | 0.93 | 2.22 | 0.30 |
| Farch(4,26) | 1.45 | 0.46 | 0.75 |
| Fhet(26,7) | 0.39 | 0.35 | 0.13 |
| Normality | 0.26 | 24.75** | 1.57 |

**Notes:**

1.* Rejects null hypothesis at 95% significance level, ** rejects null hypothesis at 99% significance level.

2. Fau stands for error autocorrelation test, Farch for autoregressive conditional heteroscedasticity, Fhet for White's functional form/heteroscedasticity test and 2n for White's normality test.

| Multivariate tests: |
|---|
| Fau(36, 59)= 1.28 |
| Fhet(156, 19)= 0.12 |
| 2n(6)= 25.69** |
| Fun(39,95)= 144.88** |

### 7.2.2. Testing for cointegration

Testing for cointegration by the Johansen method requires testing for the reduced rank or for the number of cointegration vectors. In fact the rank of the matrix can be determined by testing whether or not its eigenvalues ( ) are statistically different from zero. There are two test statistics to be used for that purpose: the trace statistic and the maximal eigenvalues statistic. The eigenvalues obtained from the VAR models, the test statistics and critical values are presented in Table 3. The table also shows Reimers' adjusted test statistics for small sample bias. Reimers (1992), by using the Monte Carlo studies, suggests taking

account of the number of parameters to be estimated in the model, and making an adjustment for the degrees of freedom by replacing T in (15) and (16) and the next formula by T-nk , where T is the number of observations, n is the number of variables, and k is the number of lags.

$$\lambda_{trace} = -T \sum_{i=r+1}^{n} Ln(1-\hat{}_i) \quad (15)$$

$$_{max}(r, r+1) = -T\, Ln(1-\hat{}_{r+1}) \quad (16)$$

Where $\hat{}_i$ are estimated eigenvalues and T equals the number of employed observations.

Table 3 contains eight columns. From the left, the first column represents the rank number. The second shows the values of characteristic roots and eigenvalues corresponding to three combinations of the underlying variables, which are ordered from the greatest value to the smallest. The third column is max which has already been described. The next column is the adjusted (Reimers 1992) value and the fifth column is the critical value for the max with 95% level of confidence. The last three columns correspond to the third, fourth and fifth columns, as applied to trace. The first line of Table 3 is to test the null hypothesis of no cointegration with the -max statistic, i.e.

*$H_0 : r = 0$ versus $H_A : r = 1$.*

Since for r = 0, the -max statistic is 76.45, which is higher than the critical value of 25.5, we reject the null of no cointegration. The adjusted value of 60.63 being higher than its critical value, it can supports that result as in max. Consequently, the null hypothesis (H0: r = 0) can be rejected at the 95% level of confidence for both max and max adjusted. Then we proceed to test.

*$H_0 : r = 1$ versus $H_A : r = 2$.*

The max statistic is 21.18, which is higher than the critical value of 19, so we can reject the null hypothesis that there is a single cointegration vector. The adjusted value of 16.8 being

lower than its critical value, it cannot support that result as in max.

Now, using the trace statistic, we test

$H_0 : r = 0$ *versus* $H_A : r \quad 1.$

Since the trace statistic = 106.3>42.4 (the critical value for λtrace) we reject the null hypothesis of no cointegration. Proceeding to test

$H_0 : r = 1$ *versus* $H_A : r \geq 2$

indicates that we can reject the null of one cointegration vector at 99% significance level since $\lambda_{trace} = 29.89 > 25.3$.

Reimers' adjusted tests confirms the first result which is that the null hypothesis cannot be rejected when r = 0, since 84.34 > 42.4 (the critical value for trace). For the next test.

$H_0 : r = 1$ *versus* $H_A : r \quad 2$

Since the calculated value, 23.71, is less than its critical value, 25.3, we cannot reject the null hypothesis.

To sum up, the different tests for the reduced rank produce different results. To be precise, the *max* statistic and the trace statistic indicate the presence of two cointegration vectors, while the trace statistic adjusted and also the *max* adjusted suggest the presence of one cointegrating vector. Such a contradiction in the tests for cointegration is not unusual. However, Reimers (1992) in the Monte Carlo study points out that in small samples the Johansen procedure over rejects the null hypothesis and these contradictory results emerge. He states that this problem can be remedied by a modification proposed by Reisel and Ahn (1988). Their suggestion of using T – nk rather than T adjusts the test statistic consistent with small sample size. However, if 63 observations are not a sufficient sample size, the appropriate diagnostic for denoting the rank number of the matrix is the adjusted $\lambda_{trace}$. The result is that there is only one cointegration relationship between RM1, GDP, and inflation.

**Table 3:** Test of cointegration rank on the variables

| Ho: r | I | max | Adjusted | 95% | trace | Adjusted | 95% |
|---|---|---|---|---|---|---|---|
| r=0 | 0.73 | 76.45** | 60.63** | 25.5 | 106.3** | 84.34** | 42.4 |
| r=1 | 0.30 | 21.18* | 16.08 | 19 | 29.89* | 23.71 | 25.3 |
| r=2 | 0.13 | 8.70 | 6.90 | 12.3 | 8.71 | 6.91 | 12.3 |

**.Note:** * Rejects null hypothesis at 5% significance level, ** rejects null hypothesis at 1% significance level.

### 7.2.3. β Matrix and Testing for Cointegration Coefficients

The associated eigenvectors are represented in the rows of Table 4. This table confirms long run coefficients after normalising[7], and contains cointegration vectors (i.e. long-run relationship coefficients). The first row of the table shows the inverse of the signs of variables. The GDP coefficient is positive, because when people obtain more money they tend to hold more real money for spending. This is consistent with all of the conventional theories. The inflation coefficient is negative (meaning that in inflationary conditions, people do not wish to hold money, because the value of the domestic currency is declining)[8]. Since GDP and inflation are not modeled in the system, they do not need to be interpreted.

$$\widehat{RM1} = 0.043t + 0.64GDP \quad 0.31\text{inf} \qquad (17)$$

**Table 4:** Normalised Characteristic Vectors, ( $\hat{\beta}$ , )

| RM1 | GDP | Inflation | Trend |
|---|---|---|---|
| 1.00 | -0.64 | 0.31 | 0.04 |
| -7.97 | 1.00 | 0.54 | -0.37 |
| -44.28 | 188 | 1.00 | -3.39 |



[7] This term means that dividing all coefficients by dependent variable coefficient.

[8] We should suppose that the world inflation is constant.

### 7.3. Comparison and evaluation of the empirical results from two alternative estimation techniques

We have tried to model of narrow money stock through both autoregressive distributed lag (ADL) and VAR. ADL is more appropriate for single equations while VAR is more appropriate for a system. Since GDP and inflation have not been modeled in the system, the estimation of the model by the ADL and Johansen techniques produce strikingly similar results both in the long-run and in the short-run, indicating its robustness to the estimation techniques. It should be acknowledged here that the ADL and Johansen use very different techniques in estimation. The former employs ordinary least squares while the latter uses the maximum likelihood estimation method. Thus, one-to-one comparison of the magnitudes of the coefficients may not be appropriate and requires some caution. Re-writing the long-run equilibrium relationships, ADL estimates:

$$\widehat{RM1} = -0.04\,t + 0.38\,GDP - 0.19\,Inf \qquad (18)$$

While Johansen estimates:

$$\widehat{RM1} = -0.04\,t + 0.64\,GDP - 0.31\,Inf \qquad (19)$$

First of all, both equations have a significant constant term. All coefficients have reasonable signs as expected by the underlying theory. Hence both procedures led to similar results. The maximum number of lags in both procedures is four, and the magnitude of coefficients is very close to each other.

### 8. Concluding Remarks

The first part of this paper discussed the concept of cointegration and its testing by the ADL procedure. Following the convention, this procedure was then applied to Iranian data in order to investigate the existence of a relationship between RM1and its fundamental determinants. The estimation results indicate that real narrow money, GDP and inflation form a stable long-run relationship, and that all economic variables have sensible signs and magnitudes, as expected by theory. Then we moved to the Johansen procedure. First we tried the number of lags and

concluded that it is four. We then specified deterministic components and we concluded that the fourth model of Harris, 1995 is the appropriate model. Then we tried a cointegration test. According to $_{trace}$ adjusted there is only one cointegration vector for the RM1 model. Then we derived the long run coefficients for RM1 models and concluded the same results as those of the ADL test.

## Reference:

Amirsharafi, H. (1991) A Estimation of Demand for Money in Iran and Interest Rate problems 1967-1986. Shahid Beheshti University, Iran, MS Dissertation (in Persian).

Arrau,P., J. De Gregorio, C.M. Reinhart & P. Wickman. (1995). The Demand for Money in Developing Countries Assessing the role of financial innovation. Journal of Development Economics, 46: 317-340.

Bahmani-Oskooee, M. (1996) .The Black Market Exchange Rate and Demand for Money in Iran. Journal of Economics, 18(1): 171-176.

Banerjee, A., J. Dolado, J.W. Galbraith & D.F. Hendry. (1994) Cointegration, Error Correction, and the Econometric Analysis of Non-Stationary Data. New York, Oxford University Press

Bank Markazi (Central Bank) of I.R.I. (1991).National Accounts of Iran, 1353-1366. Tehran (in Persian).

Bank Markazi (Central Bank) of I.R.I. (1992).National Accounts of Iran, 1367-1369. Tehran (in Persian).

Bruggeman, A. (1995) .Disaggregating Annual Real GDP Data into Quarterly figures. Report 95/331, NOB. 1995, Universitaire Faculteiten St-Ignatias , Prinsstraat 13-13 2000 Antwerpen.

Charemza W.W. & D.F. Deadman. (1992). New Directions in Econometrics Practice. UK, Edward Elgar.

Choudrhry, T. (1995). Long-run Money Demand Function in Argentina During 1935-1962: Evidence from Cointegration and Error Correction Models. Applied Economics, 27:661-667.

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

Dickey, D. A., D. W Jansen. & S. L Thornton. (1995) A Primer on Cointegration with an Application to Money and Income. in Rao, B.. ed. (1995).

Domowitz, I. & I. Elbadawi. (1987) An Error-correction Approach to Money Demand the Case of Sudan. Journal Development Economics, 26: 257-275

Doornik, J.A. & D.F. Hendry. (1994a) PcGive 8.0 An International Econometrics Modeling System", UK International Thomson Publishing.

Doornik, J.A. and Hendry, D.F. (1994b) "Pc fiml 8.0 An Interactive Econometrics Modeling of dynamic Systems. UK International Thomas Publishing.

Emadzade, M. (1990). The Optimum Model of Money demand for Iranian Economy in Relation with Monetary Policies. Tehran, Ph.D. Thesis (in Persian).

Enders, W.(1995). Applied econometric Time Series" US, Wiley.

Engle, R. & C. Granger. (1987). Cointegration and Error Correction: Representation, Estimation and Testing. Econometrica, 55: 25-76.
Fielding, D. (1994). Money Demand in 4 African Countries. Journal of Economic Studies, 21(1): 3-37.
Friedman, M. (1956).The Quality Theory of Money: A Restatement, in Friedman, M(ed), Studies in the Quantity Theory of Money. The University of Chicago Press, Chicago, 67(6): 327-351.
Ghatak, S. (1995). Monetary Economics in Developing Countries. UK, Macmillan Press, Second Edition.
Goldfeld, S. M. (1973). The Demand for Money Revisited. Brooking Papers on Economic Activity, 3: 577-638.
Hafer, R.W. & D.W. Jansen. (1991).The Demand for Money in the US : Evidence from Cointegration Test. JOURNAL of Money Credit and Banking, 23(2): 155-168.
Hajean, M. R., (1989).A Study for the Nature of Monetary Policy in Iran 1968-1985. Tehran University, Iran, MS Dissertation, (in Persian).
Harris, R.I.D. (1995). Using Cointegration Analysis in Econometric Modeling. UK, Hall/Harvester Wheatsheaf.
Johansen, S. & K. Juselius. (1990).Maximum Likelihood Estimation and Inference on Cointegration with Application to the Demand for Money. Oxford Bulletin of Economics and Statistics, 52: 169-210.
Johansen, S. (1988). Statistical Analysis of Cointegration Vectors. Journal of Economic Dynamic and Control,12: 231-254.
Johansen, S. (1995). Likelihood-Based Interference in Coinregrated Vector Autoregressive Models. Oxford University Press.
Kennedy, P. (1992). A Guide to Econometrics. UK, Blackwell.
Lahiri, A.K. (1991). Money and Inflation in Yugoslavia. IMF Staff Papers, 38(4): 751-788.
Lismon, J. H. C. & J. Sandec. (1964). Derivation of Quarterly Figures from Annual Data. Applied Statistics, XIII, 2: 87-90.
Metin, K. (1994). Modeling the Demand for Narrow Money in Turkey. METU Studies in Development, 21(2): 231- 256.
Miller, S.M. (1991). Money Dynamics: An Application of Cointegration and Error-Correction Modeling. Journal of Money, Credit and Banking, 23:1-139.
Nazemzade, A. (1983). Demand for Money in Developing Countries Cases of Iran, Nigeria and Venezuela. The Florida State Univ. Ph.D. Thesis.
Nowferesti, M. (1995). The Relationship Among Money Demand, Exchange Rate and the Rate of Inflation. Plan and Development 11:1-14 (in Persian).
Perron, P. (1989) The Great Crash, The Oil Rice Shock, and the Unit Root Hypothesis. Econometrica, 57(6): 1361-1401.
Pesaran, H. M., Y. Shin & R. J. Smith.(1996). Testing for the Existence of a Long Run Relationship. DAE working papers Amalgamated Series, 9622, University of Cambridge.

Qayyum, A. (1995). A Cointegration of Demand for Money in a Developing Country (Pakistan). UK, University of Bradford, PhD Thesis.
Reimers, H. E. (1992). Comparisons of Tests for Multivariative cointegration. Statistical Papers, 33: 335-59.
Reinsel, G. C. & S. K. Ahn. (1988). Asymptotic Distribution of the Likelihood Ratio Test for Ciontegration in the Nonstationary Vector AR Model. Technical Report, University of Wisconsin.
Rother, P.C. (1999). Money Demand in the west African :the problems of aggregation. Journal of African Economies, 8(3): 422-47.
Sharifi Renani, H. (2008). Demand for Money in Iran: An ARDL Approach. mpra.ub.uni-muenchen. MPRA paper-8224.
Tavakkoli, A. (1996). Causes of Inflation in The Iranian Economy 1972-1990. University of Nottingham, Ph.D. Thesis.
Thomas, R.L. (1997). Modern Econometrics an Introduction. Addison Wesley Longman.