Demand for money in Iran: An ARDL approach

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Abstract

The objective of this study is to estimate the demand for money in Iran using the autoregressive distributed lag (ARDL) approach to cointegration analysis. The empirical results show that there is a unique cointegrated and stable long-run relationship among M_1 monetary aggregate, income, inflation and exchange rate. We find that the income elasticity and exchange rate coefficient are positive while the inflation elasticity is negative. This indicates that depreciation of domestic currency increases the demand for money, supporting the wealth effect argument and people prefer to substitute physical assets for money balances that are supporting our theoretical expectation. Our results also after incorporating the CUSUM and CUSUMSQ tests reveal that the M_1 money demand function is stable between 1985 and 2006.

JEL classification: E41; E44; E4

Keywords: Money demand; ARDL; Stability; Iran

1. Introduction

Several studies have used Johansen (1988) and Johansen and Juselius (1990) cointegrating technique in examining the long run relation between the demand for money and its determinants. Examples are Hafer and Jansen (1991), Hoffman and Rasche (1991), McNown and Wallace (1992) for the United States; Adam (1991) and Johansen (1992) for the United Kingdom; Karfakis and Parikh (1993) for Australia; von Hagen (1993), Hansen and Kim (1995) and Bahmani-Oskooee and Bohl (2000) for Germany; Bahmani-Oskooee et al. (1998) for Spain; Muscatelli and Papi (1990) for Italy; Bahmani-Oskooee and Chomsisengphet (2002) for industrial countries; Miyao (1996) and Bahmani-Oskooee and Shabsigh (1996) for Japan; and Bahmani-Oskooee and Barry (2000) for Russia; Hafer and Kutan (1994) for China; Bahmani-Oskooee and Shin (2002) for Korea; Frenkel and Taylor (1993) for Yugoslavia and Bahmani-Oskooee (1996) for Iran. A general consensus reached by most studies is that M_2 monetary aggregate is cointegrated with income and interest rate.

However, the general observation from the literature is that most studies on the money demand function and its stability have been focused on the advanced economies and few industrialized economies. Not many studies based on cointegration technique have been reported on money demand function in Middle East. Specifically in Iran, no known study has used the autoregressive distributed lag (ARDL) approach to estimate the money demand function and examine its stability.

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Bahmani-Oskooee (1996) investigated the Iranian demand for money over the period from 1959-90 using annual data. He applied Johansen's cointegration technique and demonstrated that long-run M_2 money demand function in Iran includes real income, the inflation rate, and the black market exchange rate. In addition, Tabesh (2000) used the same model specification as Bahmani-Oskooee (1996) specified in his study. He concluded that in a stable money demand function, speculation regarding the black market exchange rate, along with real income, and the rate of inflation determine the domestic demand for real cash balances.

The objectives of this paper are: One, to shed light on the cointegrating properties of M_1 and M_2 monetary aggregates, income, inflation and exchange rate using the cointegrating technique known as ARDL approach. Two, to determine the stability of M_1 and M_2 money demand function. This is important because as has been demonstrated in the literature, cointegeration may not imply stable relationship among set of variables.

The rest of this paper is organized as follow: In the following section we introduce the model and the ARDL approach. Section 3 presents the empirical results. Section 4 conclusions.

2. ARDL approach

Various factors are considered as determinants of the money demand function. The general agreement in the literature is that a money demand equation should contain a scale variable to the level of transactions in the economy and a variable representing the opportunity cost of holding money.[1] In the context of an open economy, a variable such as exchange rate, foreign interest rate or interest rate differentials reflecting the relative returns of foreign money vis-a-vis domestic money can be included in the money demand equation to reflect the impact of currency depreciation on domestic money demand.[2] Furthermore, due to absence of well-developed financial markets in most developing countries, inflation rate is used as a proxy for the opportunity cost. In Bahmani-Oskooee (1996) and Bahmani-Oskooee and Rehman (2005)'s studies it is assumed that the money demand function takes the following form:

$$LnM_t = \alpha_0 + \alpha_1 \log Y_t + \alpha_2 \pi_t + \alpha_3 \log E_t + u_t \qquad (1)$$

where M is a monetary aggregate (M_1 or M_2), Y is a measure of real income as a scale variable, π is rate of inflation, E is the exchange rate and u is error term. According to Arango and Nadiri (1981) and Bahmani-Oskooee and Pourheydarian (1990), while an estimate of α_1 is expected to be positive, an estimate of α_2 is expected to be negative. Estimation of α_3 could be negative or positive. Given that, E is defined as number of units of domestic currency per US dollar, a depreciation of the domestic currency or increase in E raises the value of the foreign assets in terms of domestic currency. If this increase is caused as an increase in wealth, then the demand for domestic money increases yielding a positive estimate of α_3. However, if an increase in E induces an expectation of further depreciation of the domestic currency, public may hold less of domestic currency and more of foreign currency. In this case, an estimate of α_3 is expected to be negative.

[1] - For more details see khan (1994), Pradhan and Subramanian (1998), James Obben (1998), Bahmani-Oskooee and Buhl (2000), Bahmani-Oskooee (2001).

[2] - For more details see Bahmani-Oskooee (1991, 1996), Tan (1997), Chowdhury (1997), Khalid (1999).

In applying the cointegration technique, we need to determine the order of cointegration of each variable. However, as noted in the literature, depending on the power of the unit root tests, different tests yield different results. In view of this problem, Pesaran and Shin (1995) and Perasan et al. (2001) introduce a new method of testing for cointegration. The approach known as the autoregressive distributed lag (ARDL) approach. This method has the advantage of avoiding the classification of variables into I(1) or I(0) and unlike standard cointegration tests, there is no need for unit root pre-testing. However, the ARDL approach is very suitable to our formulation of the demand for money because we may have a stationary variable such as inflation rate along with non-stationary variables such as money or income. The error correction version of ARDL model pertaining to the variables in Eq. 1 is as follows:

$$\begin{aligned} \Delta \log M_t &= \alpha_0 + \sum_{i=1}^{n} \alpha_{1i} \Delta \log M_{t-i} + \sum_{i=0}^{n} \alpha_{2i} \Delta \log Y_{t-i} + \sum_{i=0}^{n} \alpha_{3i} \Delta \pi_{t-i} \\ &+ \sum_{i=0}^{n} \alpha_{4i} \Delta \log E_{t-i} + \gamma_1 \log M_{t-1} + \gamma_2 \log Y_{t-1} + \gamma_3 \pi_{t-1} + \gamma_4 \log E_{t-1} + u_t \end{aligned} \qquad (2)$$

The null of no cointcgration defined by $H_0 : \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = 0$ is tested against the alternative of $H_1 : \gamma_1 \neq 0, \gamma_2 \neq 0, \gamma_3 \neq 0, \gamma_4 \neq 0$, by means of familiar F-test. However, the asymptotic distribution of this F-statistic is non-standard irrespective of whether the variables are I(0) or I(1). Pesaran et al. (2001) have tabulated two sets of appropriate critical values. One set assumes all variables are I(1) and another assumes that they are all I(0). This provides a band covering all possible classifications of the variables into I(1) and I(0) or even fractionally integrated. If the calculated F-statistic lies above the upper level of the band, the null is rejected, indicating cointegration. If the calculated F-statistic falls below the lower level of the band, the null cannot be rejected, supporting lack of cointegration. If, however, it falls within the band, the result is inconclusive.

3. Empirical results

The paper used quarterly data from CBI, Central Bank of Iran, over the period 1985:3–2006:1 to test the null of no cointegration against the alternative hypothesis. In the first step, we test for cointegration using the F-test with new critical values. According to Bahmani-Oskooee and Brooks (2003), the F-test is sensitive to the number of lags imposed on each first differenced variable. Thus, we impose two, four, six, eight and ten lags on each first differenced variable in Eq. 2. The results of the F-test for cointegration among the variables are reported in Table 1. It appears that there is F-statistic that is greater than the critical value, supporting cointegration between (M_1 and M_2), income, inflation rate, and exchange rate.

In the second stage, we employ Akaike's information criterion (AIC) in selecting the lag length on each first differenced variable and Eq. 2 is re-estimated for M_1 and M_2 monetary aggregate and the results are reported in Tables 2A, 2B. In this stage, considering that real monetary aggregates (M_1 and M_2), income, inflation rate, and exchange rate are cointegrated, the error correction model Eq. 2 is estimated. The main aim here is to capture the short-run dynamics. In each table, there are two panels. Panel A reports the coefficient estimates of all lagged first differenced variables in the ARDL model (short-run coeffecient estimates). Not much interpretation could be attached to the short-run coefficients. All they show the dynamic adjustment of all variables.

Table 1. The Results of F-Test for Cointegration					
	2	4	6	8	10
M_1	17.58	21.24	32.55	23.48	21.27
M_2	4.50	5.04	4.95	4.83	4.75

Note: At the 10% level of significance, the value of the upper bound is 3.57.

In panel B, the long-run coefficients are reported. These are the coefficients of $\gamma_1 - \gamma_4$ from the ARDL model. Following the literature, we normalize these long-run elasticites on LM by dividing them by $(-\gamma_1)$.

According to Table 2A the income elasticity is 2.65, which is highly significant as reflected by a t-statistic of 10.83. The inflation rate elasticity is negative (-0.055) and significant supporting our theoretical expectation. Since the exchange rate coefficient is positive and highly significant, it appears that a depreciation of Rial in Iran increases the demand for money supporting the wealth effect argument provided in the previous section. The long-run model of the corresponding ARDL (9, 8, 1, 3) for the demand for money can be written as follows:

$$\begin{aligned} log\ M_t &= -24.27 + 2.65\ log\ Y_t - 0.055\ \pi_t + 0.67\ log\ E_t \\ &\quad (-10.84) \quad (10.83) \quad (-3.51) \quad (10.22) \end{aligned} \tag{3}$$

Table 2A. Full-information Estimate of Eq. 2 (M_1 monetary aggregate)

Panel A: Short-Run Coefficient Estimates

Lag Order	*ΔLn M_1*	*ΔLn Y*	Δ π	*ΔLn E*
0		-0.043	-0.001	0.135
		(-0.44)	(-0.67)	(4.44)
1	-0.250	-0.146	0.004	-0.025
	(-2.01)[a]	(-1.05)	(2.22)	(-0.83)
2	0.263	0.030		-0.044
	(2.05)	(0.24)		(-1.43)
3	0.157	-0.113		-0.068
	(1.23)	(-0.31)		(-2.12)
4	0.547	-0.619		
	(4.66)	(-1.15)		
5	0.004	-0.420		
	(0.03)	(-1.03)		
6	0.025	-0.014		
	(0.20)	(-0.03)		
7	0.127	0.823		
	(1.00)	(1.77)		
8	0.376	-0.800		
	(3.32)	(-2.45)		
9	0.220			
	(1.95)			

Panel B: Long-Run Coefficient Estimates and Diagnostics

C	*Ln Y*	π	*Ln E*	R^2	EC_{t-1}	*LM*[b]	*REST*[c]
-24.27	2.65	-0.055	0.67	0.99	-0.16	6.83	1.30
(-10.84)	(10.83)	(-3.52)	(10.22)		(-4.87)		

Notes: a. Number inside the parenthesis is the absolute value of the t-ratio.
b. LM is the lagrange multiplier test for serial correlation. It has a χ^2 distribution with four degrees of freedom. The critical value at the 5% level of significance is 9.48.
c. RESET is Ramsey's specification test. It has a χ^2 distribution with only one degree of freedom. The critical value at the 5% level of significance is 3.84.

Panel B also reports some diagnostic statistics. Kremer et al. (1992) has shown that the significant lagged error correction term is a more efficient way of establishing cointegration. We use estimates of $\gamma_1 - \gamma_4$ to form a lagged error correction term, $EC_{t-1} = \gamma_1 \log M_{t-1} + \gamma_2 \log Y_{t-1} + \gamma_3 \pi_{t-1} + \gamma_4 \log E_{t-1}$. After replacing the linear combination of the lagged level of variables in the ARDL model Eq. 1 by EC_{t-1}, we re-estimate the model by imposing the same lag structure selected by the AIC criterion, and look for the significance of EC_{t-1}. A negative and significant coefficient of EC_{t-1} will be an indication of cointegration. As can be seen from panel B, the EC_{t-1} carries an expected negative sign, which is highly significant, indicating that, M_1, income, inflation rate, and exchange rate are cointegrated. We also report the Lagrange Multiplier (LM) statistic, which is distributed as χ^2 with four degrees of freedom. Since our calculated LM statistic of 6.829 is less than the critical value of 9.48, we conclude that the residuals of the estimated ARDL are free from serial correlation. In panel B, we also report Ramsey's RESET test for functional specification, which is distributed as χ^2 with only one degree of freedom. Again, since our calculated RESET statistic is less than its critical value of 3.84, we conclude that the ARDL model is correctly specified.

Table 2B reports the results for real M_2 monetary aggregate. As can be seen, there is lack of cointegration as indicated by the insignificant coefficient attached to EC_{t-1} or by insignificant long-run coefficient estimates reported in Panel B. Thus, it may be concluded that M_1 is a better monetary aggregate in terms of formulating monetary policy.

The existence of a stable and predictable relationship between the demand for money and its determinants is considered a necessary condition for the formulation of monetary policy strategies based on intermediate monetary targeting. In the third stage the stability of the long-run coefficients are used to form the error-correction term in conjunction with the short run dynamics. As pointed by Laidler (1993) and noted by Bahmani-Oskooee (2001), some of the problems of instability could stem from inadequate modeling of the short-run dynamics characterizing departures from the long run relationship. Hence, it is expedient to incorporate the short run dynamics for constancy of long run parameters. In view of this we apply the CUSUM and CUSUMSQ tests proposed by Brown, Dublin and Evans (1975).

Table 2B. Full-information Estimate of Eq. 2 (M_2 monetary aggregate)

Panel A: Short-Run Coefficient Estimates

Lag Order	$\Delta Ln\ M_1$	$\Delta Ln\ Y$	$\Delta\ \pi$	$\Delta Ln\ E$
0		0.065	0.001	0.004
		0.65	(0.51)	(0.11)
1	-0.687			
	(-5.60)[a]			
2	-0.439			
	(-3.26)			
3	-0.197			
	(-1.63)			

Panel B: Long-Run Coefficient Estimates and Diagnostics

C	*Ln Y*	π	*Ln E*	R^2	EC_{t-1}	LM^b	$REST^c$
-129.02	14.50	0.28	0.81	0.99	-0.004	1.93	1.63
(-0.17)	(0.17)	(0.13)	(0.19)		(-0.14)		

Notes: a. Number inside the parenthesis is the absolute value of the t-ratio.
b. LM is the lagrange multiplier test for serial correlation. It has a χ^2 distribution with four degrees of freedom. The critical value at the 5% level of significance is 9.48.
c. RESET is Ramsey's specification test. It has a χ^2 distribution with only one degree of freedom. The critical value at the 5% level of significance is 3.84.

The CUSUM test is based on the cumulative sum of recursive residuals based on the first set of n observations. It is updated recursively and is plotted against the break points. If the plot of CUSUM statistic stays within 5% significance level[3] , then estimated coeffients are said to be stable. Similar procedure is used to carry out the CUSUMSQ that is based on the squared recursive residuals. A graphical presentation of these two tests is provided in Figs. 1- 4.

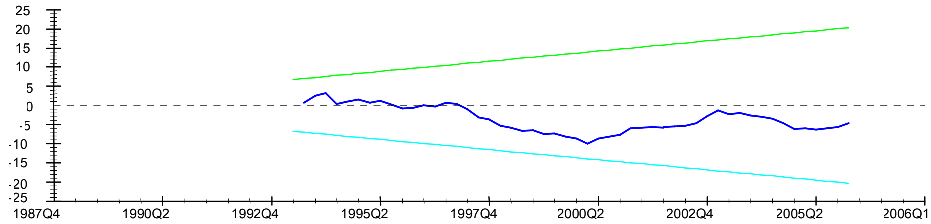

Fig. 1. Cumulative Sum of Recursive Residuals (M_1)

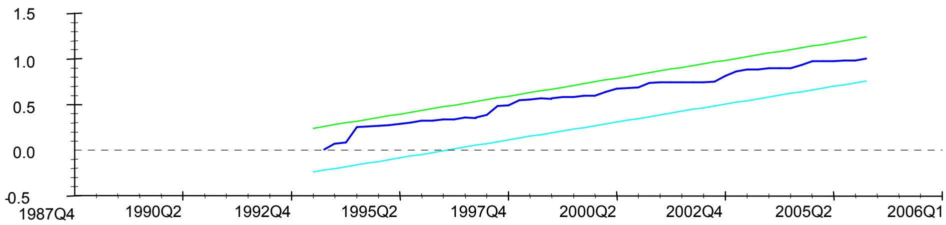

Fig. 2. Cumulative Sum of Squares of Recursive Residuals (M_1)

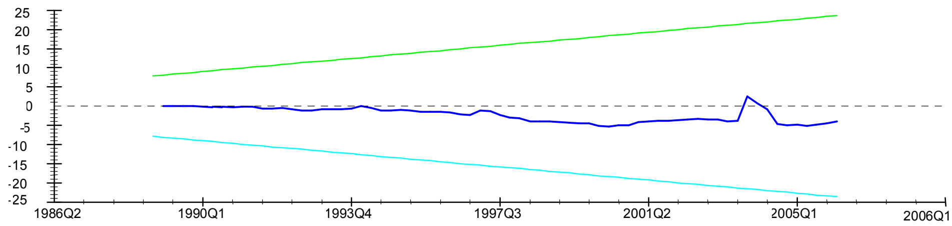

Fig. 3. Cumulative Sum of Recursive Residuals (M_2)

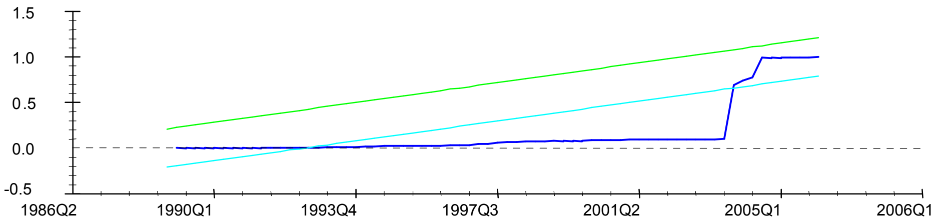

Fig. 4. Cumulative Sum of Squares of Recursive Residuals (M_2)

3 -That is portrayed by two straight lines whose equations arc given in Brown et al. (1975, Section 2.3).

Since the plots of CUSUM and CUSUMSQ statistic for M_1 do not cross the critical value lines, we are safe to conclude that M_1 money demand is stable. However, the plot of CUSUMSQ statistic for M_2 crosses the critical value line, indicating some instability in M_2 money demand. However, this finding could be an indication of the fact that M_1 must be the monetary aggregate that central banks should control.

4. Conclusions

In this study, the demand for money in Iran has been estimated using ARDL approach to cointegration analysis of Pesaran and Shin (1998) and Perasan et al. (2001). The ARDL method does not generally require knowledge of the order of integration of variables.

The results reveal that Y and E are positively associated with M_1 while π negatively affects M_1. The negative effect of inflation rate on M_1 supports our theoretical expectation that as the inflation rate rises, the demand for money falls. This indicates that people prefer to substitute physical assets for money balances. The positive effect of exchange rate on M_1 indicates that depreciation of domestic money increases the demand for money, supporting the wealth effect argument.

Following recent trends in cointegration analysis, this paper demonstrates that cointegration does not imply stability. By incorporating CUSUM and CUSUMSQ tests into cointegration analysis, it is revealed that while M_1 money demand is stable, M_2 is not. Thus, it may be concluded that M_1 is a better monetary aggregate in terms of formulating monetary policy and central banks control.

Appendix

All data are quarterly over the period 1985:3 and 2006:1 and collected from the Central Bank of Iran, Quarterly Statistical Bulletin, various issues.

M_1 is money supply consisting of currency in circulation plus demand deposits.

M_2 is M_1 plus private savings deposits.

π is inflation rate, is defined as $[CPI - CPI(-1) / CPI(-1)]$, where CPI is the Consumer Price Index (1995 prices).

E is exchange rate that is defined as number of units of domestic currency per US dollar. Thus, an increase reflects a depreciation of domestic currency.

Y is GNP at constant prices (1995 prices).

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