

Demand for Money in Hungary: An ARDL Approach

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Abstract: This study examines the demand for money in Hungary using the autoregressive distributed lag (ARDL) cointegration framework. The results based on the bounds testing procedure confirm that a stable, long-run relationship exists between demand for money and its determinants: real income, inflation rate and nominal exchange rate. The empirical results show that there is a unique cointegrated and stable long-run relationship among M_1 real monetary aggregate, real income, inflation rate and nominal exchange rate. We find that the real income elasticity coefficient is positive while the inflation rate elasticity and nominal exchange rate are negative. This indicates that depreciation of domestic currency decreases the demand for money. Our results also reveal that after incorporating the CUSUM and CUSUMSQ tests, M_1 money demand function is stable between 1995:1 and 2010:1.

JEL Classifications: E4, E41, E44

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1. Introduction

The demand for money function creates a background to review the effectiveness of monetary policies, as an important issue in terms of the overall macroeconomic stability. Money demand is an important indicator of growth for a particular economy. The increasing money demand mostly indicates a country's improved economic situation, as opposed to the falling demand which is normally a sign of deteriorating economic climate (Maravić and Palić 2010). Monetarists underline the role of governments in controlling for the amount of money in circulation. Their view on monetary economics is that the variation on money supply has major influence on national product in the short run and on price level in the long run. Also, they claim that the objectives of monetary policy are best met by targeting the rate of increase on money supply.

Monetarism today is mainly associated with the work of Friedman, who was among the generation of economists to accept Keynesian economics and then criticize it on its own terms. Friedman argued that "inflation is always and everywhere a monetary phenomenon." Also, he advocated a central bank policy aimed at keeping the supply and demand for money in equilibrium, as measured by growth in productivity and demand. The European Central Bank officially bases its monetary policy on money supply targets. Opponents of monetarism, including neo-Keynesians, argue that demand for money is intrinsic to supply, while some conservative economists argue that demand for money cannot be predicted. Stiglitz has claimed that the relationship between inflation and money supply growth is weak when inflation is low (Friedman 1970).

In 1980s, a number of central banks world-wide adopted monetary targets as a guide for monetary policy. Central banks' effort is to describe and determine the optimum money stock which will produce (achieve) the desired macroeconomic objectives. Theoretically, central banks

had to aim between either the stock of monetary aggregates or interest rates. When money demand function was unstable, interest rate was generally the preferred target. Otherwise, money stock was the appropriate one (Poole 1970).

In 1990s, some central banks adopted numerical inflation or nominal GDP targets as guides for monetary policy in contrast to the conventional choice of interest rate or money stock adopted in the previous decade. Economic analysts attribute this change to the failure of monetary aggregates of banks as guides for monetary policy. In addition, it is assumed that money demand function is stable in the conduct and implementation of monetary policy. This is very important because money demand function is used for the purpose of controlling the total liquidity in the economy and for controlling inflation rate (Oluwole and Olugbenga 2007).

There are short-term and long-term aspects of money demand. The growing production relates to the long-term aspect of money demand or the need for money (transaction demand). This means that the increased issue of money which is consistent with price stability may solely be achieved in the long run if it follows the growth of output. In the short term, a decreasing rate of money circulation may cause the money demand to rise irrespective of the movements in real production. However, the ongoing increase in money supply, regardless of the trends in production, leads to the stronger inflationary pressures (Maravić and Palić 2010).

A stable relationship between money, a stock, and its determinants is a prerequisite for monitoring and targeting of monetary aggregates. If a stable money demand function exists, the central bank may rely on its monetary policy to affect important macroeconomic variables. Indeed, the success of the policy depends on whether there exists a steady-state relationship between money demand and its determinants (Baharumshah, et al. 2009).

After the collapse of former Soviet Union in the beginning of the 1990's and with the membership of the European Union, the Hungarian economy went through some significant structural and institutional changes. These changes included the liberalization of the external trade, the elimination of price and interest rate controls, the adoption of a managed float exchange rate system as well as the changes in monetary policy including innovations in the banking sector. It is conceivable that these developments have changed the relationship between money, income, prices and other basic economic variables making money demand function structurally unstable. Therefore, it is urgent to determine if the money demand function is stable throughout the examined period.

A considerable body of literature has investigated the stability of money demand in developing countries. The results and implications of these studies clearly depend on the data frequency, the econometric methods for stability tests, and the development stage of a country. Several studies have used ARDL cointegrating technique in examining the long run relationship between the demand for money and its determinants. Some of these studies are: Halicioglu and Ugur (2005) for Turkey, Bahmani-Oskooee and Rehman (2005) for seven Asian countries, Akinlo (2006) for Nigeria, Samreth (2008) for Cambodia, Long and Samreth (2008) for Philippines, Baharumshah, et al. (2009) for China, and Achsani, (2010) for Indonesia.

Halicioglu and Ugur (2005) analysed the stability of the narrow money demand function (M1) in Turkey using annual data over the period 1950-2002. They estimated the test for stability of Turkish M1 by employing a recent single cointegration procedure proposed by Pesaran et al. (2001) along with the CUSUM and CUSUMSQ stability tests. They demonstrated that there is a stable money demand function and it could be used as an intermediate target of monetary policy in Turkey.

Bahmani-Oskooee and Rehman (2005) used quarterly data from 1973 to 2000 to estimate the demand for money for seven Asian countries: India, Indonesia, Malaysia, Pakistan, Philippines, Singapore and Thailand. Using ARDL approach and CUSUM and CUSUMSQ tests, they found

that in some Asian countries even though real M1 or M2 monetary aggregates are cointegrated with their determinants, the estimated parameters are unstable.

Akinlo (2006) used quarterly data over the period 1970:1–2002:4 and the ARDL approach combined with CUSUM and CUSUMSQ tests, to examine the cointegrating property and stability of M2 money demand for Nigeria. The results show M2 to be cointegrated with income, interest rate and exchange rate. Moreover, the results revealed somewhat stable relation mainly with the CUSUM test.

Samreth (2008) estimated the money demand function in Cambodia using monthly data over the period 1994:12–2006:12. For the analysis of cointegration, the autoregressive distributed lag (ARDL) approach is employed. Their results indicate that there is a cointegrating relationship among variables (M1, Industrial Production Index, Consumer Price Index, and Nominal Exchange Rate) in money demand function. CUSUM and CUSUMSQ tests roughly support the stability of estimated model.

Long and Samreth (2008) re-examine the validity of both short and long run monetary models of exchange rate for the case of Philippines by using ARDL approach. The results end up to robust short and long run relationships between variables in the monetary exchange rate model of the Philippines, as well as the stability of the estimated parameters.

Baharumshah, et al. (2009) examined the demand for broad money (M2) in China using the autoregressive distributed lag (ARDL) cointegration framework and quarterly data from 1990:4 - 2007:2. The results based on the bounds testing procedure confirm that a stable, long-run relationship exists between M2 and its determinants: real income, inflation, foreign interest rates and stock prices.

Achsani (2010) used the vector error correction model (VECM) and autoregressive distributed lag (ARDL) approach, and investigated the M2 money demand for Indonesia using quarterly data over 1990:1–2008:3 period. He found that the ARDL model is more appropriate in predicting stable money demand function of Indonesia in comparison to VECM.

Finally, Claudia Bush (2001) analyses the determinants and the stability of money demand functions in Hungary and Poland using a restricted sample with monthly data for the years 1991 through mid-1998, and an error-correction model. The results of this paper suggest that long-run parameters are in line with economic theory. However, on the basis of these findings alone would be premature, the paper suggests that money demand functions can serve as a useful appropriateness of different strategies for mapping the monetary policy of the examined countries.

Our paper differs from that of Bush in the following:

- The size and the examined period for the money demand function.
- The model that we implement in relation to that of Bush. (ARDL model is applied in all variables either they are integrated $I(0)$ or integrated $I(1)$).
- Results of our paper suggest that money demand function M1 is the most suitable for Hungary for the period that we examine.

The general observation from the literature is that most studies, as far as the stability of the demand for money function is concerned, have been focused mainly on advanced economies and less on the industrialized economies.

Specifically in Hungary, (as far as we know) no study has used the autoregressive distributed lag approach (ARDL) to examine the stability of the money demand function. So, there is the need to fill this gap in the literature.

The purpose of this study is to examine whether the choice of M1 or M2 is the appropriate one by examining the underlying assumption of the stability of money demand function for Hungary.

The aim of this paper is:

- 1) To investigate the empirical relationship between M1 and M2 real monetary aggregates, real income, inflation and nominal exchange rate using the autoregressive distributed lag (ARDL) cointegration model.
- 2) To determine the stability of M1 and M2 money demand function investigated.
This is important because as it has been proved, cointegration analysis cannot determine if there is a stable relationship of variables that we examine.
- 3) To investigate the long-run stability of the real money demand function based on the fact that the stability of the money demand function has important implications for the conduct and implementation of monetary policy.

The organization of the rest of this paper is as follows: on section 2 we introduce the model and the ARDL approach. Section 3 presents the empirical results. Section 4 presents the conclusions.

2. ARDL Approach

The autoregressive distributed lag (ARDL) model deals with single cointegration and is introduced originally by Pesaran and Shin (1999) and further extended by Pesaran et al. (2001). The ARDL approach has the advantage that it does not require all variables to be I(1) as the Johansen framework and it is still applicable if we have I(0) and I(1) variables in our set.

The bounds test method cointegration has certain econometric advantages in comparison to other methods of cointegration which are the following:

- All variables of the model are assumed to be endogenous.
- Bounds test method for cointegration is being applied irrespectively the order of integration of the variable. There may be either integrated first order I(1) or I(0).
- The short-run and long-run coefficients of the model are estimated simultaneously.

The overriding objective of monetary policy for every developing country is price and exchange rate stability. The monetary authority's strategy for inflation management is based on the view that inflation is essentially a monetary phenomenon. Because targeting money supply growth is considered as an appropriate method of targeting inflation, many central banks choose a monetary targeting policy framework to achieve the objective of price stability (Oluwole and Olugbenga, 2007).

From the policy standpoint, it is important to identify the correct measure of money as a better path to monetary policy in order to achieve price stability. For this reason we take into consideration both M1 and M2. Secondly, since the policy maker may be interested not only in the forecasting power of such estimations but also in short-run relevance of the parameters, we use quarterly data covering the period 1995:1 and 2010:1.

Following Bahmani-Oskooee (1996) and Bahmani-Oskooee and Rehman (2005) the model includes real monetary aggregate, real income, inflation rate, and exchange rate, which can be written in a semi-log linear form as:

$$LM_t = a_0 + a_1LY_t + a_2INF_t + a_3LEXR_t + u_t \quad (1)$$

Where, M is the real monetary aggregate (M1 or M2);

Y is a measure of real income (at constant factor cost 2005 prices), with expected positive elasticity;

INF is rate of inflation (base year 2005), with expected negative elasticity;

EXR is nominal effective exchange rate (forint, per US dollar), with expected positive or negative elasticity, and u is error term.

$LM=\ln M$, $LY=\ln Y$, $LEXR=\ln EXR$. (All variables, except the rate of inflation are in natural logs).

According to Arango and Nadiri (1981) and Bahmani-Oskooee and Pourheydari (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, EXR is defined as number of units of domestic currency per US dollar, or ECU, a depreciation of the domestic currency or increase in EXR 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 EXR 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 (Sharifi-Renani 2007). An ARDL representation of equation (1) is formulated as follows:

$$\begin{aligned} \Delta LM_t = & \alpha_0 + \sum_{i=1}^n \alpha_{1i} \Delta LM_{t-i} + \sum_{i=0}^n \alpha_{2i} \Delta LY_{t-i} + \sum_{i=0}^n \alpha_{3i} \Delta INF_{t-i} + \sum_{i=0}^n \alpha_{4i} \Delta LEXP_{t-i} + \\ & + \beta_1 LM_{t-1} + \beta_2 LY_{t-1} + \beta_3 INF_{t-1} + \beta_4 LEXP_{t-1} + e_t \end{aligned} \quad (2)$$

where Δ denotes the first difference operator; α_0 is the drift component, and e_t is the usual white noise residuals.

The left-hand side is the demand for money. The first until fourth expressions ($\beta_1 - \beta_4$) on the right-hand side correspond to the long-run relationship. The remaining expressions with the summation sign ($\alpha_1 - \alpha_4$) represent the short-run dynamics of the model.

To investigate the presence of long-run relationships among the LM , LY , INF , $LEXP$, bound testing under Pesaran, et al. (2001) procedure is used. The bound testing procedure is based on the F-test. The F-test is actually a test of the hypothesis of no cointegration among the variables against the existence or presence of cointegration among the variables, denoted as:

$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$, i.e., there is no cointegration among the variables.

$H_a: \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0$, i.e., there is cointegration among these variables.

This can also be denoted: $F_{LM}(LM | LY, INF, LEXP)$.

The ARDL bound test is based on the Wald-test (F-statistic). The asymptotic distribution of the Wald-test is non-standard under the null hypothesis of no cointegration among the variables. Two critical values are given by Pesaran et al. (2001) for the cointegration test. The lower critical bound assumes all the variables are $I(0)$ meaning that there is no cointegration relationship between the examined variables. The upper bound assumes that all the variables are $I(1)$ meaning that there is cointegration among the variables. When the computed F-statistic is greater than the upper bound critical value, then the H_0 is rejected (the variables are cointegrated). If the F-statistic is below the lower bound critical value, then the H_0 cannot be rejected (there is no cointegration among the variables). When the computed F-statistics falls between the lower and upper bound, then the results are inconclusive.

In the meantime, we develop the unrestricted error correction model (UECM) based on the assumption made by Pesaran et al.(2001). From the unrestricted error correction model, the long-

run elasticities are the coefficient of the one lagged explanatory variable (multiplied with a negative sign) divided by the coefficient of the one lagged dependent variable.

The ARDL has been chosen since it can be applied for a small sample size as it happens in this study. Also, it can estimate the short and long-run dynamic relationships in demand of money simultaneously. The ARDL methodology is relieved of the burden of establishing the order of integration amongst the variables. Furthermore, it can distinguish dependent and explanatory variables, and allows testing for the existence of relationship between the variables. Finally, with the ARDL it is possible that different variables have differing optimal number of lags.

Thus, equation (2) in the ARDL version of the error correction model can be expressed as equation (3): The error correction version of ARDL model pertaining to the variables in equation (2) is as follows:

$$\Delta LM_t = \alpha_0 + \sum_{i=1}^n \alpha_{1i} \Delta LM_{t-i} + \sum_{i=0}^n \alpha_{2i} \Delta LY_{t-i} + \sum_{i=0}^n \alpha_{3i} \Delta INF_{t-i} + \sum_{i=0}^n \alpha_{4i} \Delta LEXP_{t-i} + \lambda EC_{t-1} + u_t \quad (3)$$

where λ is the speed of adjustment parameter and EC is the residuals that are obtained from the estimated cointegration model of equation (2).

3. Empirical Results

The paper used quarterly data from IMF (International Monetary Fund) over the period 1995:1–2010:1 to test the null of no cointegration against the alternative hypothesis. The first practice in applying any cointegration technique is to determine the degree of integration of each variable. For this reason, the ADF test was employed. The test results are presented in table 1 below.

Table 1. Results of ADF tests

Variables	Level		First Differences	
	Constant	Constant and Trend	Constant	Constant and Trend
LM1	-2.702(6)*	1.538(6)	-2.960(3)**	-3.567(5)**
LM2	-2.248(4)	0.858(4)	-2.638(3)*	-3.295(3)**
LY	-3.435(4)**	-5.110(3)***	-3.275(3)**	-4.081(3)**
INF	-0.838(5)	-2.532(5)	-2.885(4)*	-3.802(4)**
LEXR	-2.480(1)	-2.512(2)	-5.290(1)***	-5.739(1)***

Notes: 1. ***, **, * imply significance at the 1%, 5% and 10% level, respectively;

2. The numbers within parentheses for the ADF (Dickey-Fuller 1979) statistics represents the lag length of the dependent variable used to obtain white noise residuals;

3. The lag length for the ADF was selected using Akaike Information Criterion (AIC).

The results of table 1 indicate that, the variables are integrated I(0) and I(1). For this reason ARDL approach is used for the cointegration of the model.

The main advantage of this approach lies on the fact that it obviates the need to classify variables into I(1) or I(0). Moreover, compared to standard cointegration, there is no need for unit root pre-testing (Akinlo 2006).

The ARDL cointegration test, assumed that only one long run relationship exists between the dependent variable and the exogenous variables (Pesaran, Shin and Smith, 2001, assumption 3). To test whether this is really appropriate in the current application, we change the entire variable to be dependent variable in order to compute the F-statistic for the respective joint significance in the ARDL models (Ahmad Abd Halim et al. 2008).

In table 2 below, we present the cointegration results of the variables used in equation 2, using F-test with the new critical values (Pesaran et al. 2001), as well as the Narayan critical values (2005), which are quoted in small samples. According to Bahmani-Oskooee and Brooks (2003), the F-test is sensitive to the number of lags imposed on each first differenced variable. Given that we are using quarterly data (observations), we experimented up to ten lags (2.5 years) on the first-differences and computed F-statistics for the joint significance of lagged levels of variables in equation 2.

Table 2. The Results of F-Test for Cointegration

Order of Lag	1	2	3	4	5	6	7	8	9	10
M1	9.93***	8.34***	6.87***	7.79***	6.19***	5.62***	4.40**	4.12*	3.13	2.15
M2	8.15***	8.04***	5.55**	6.05***	5.58**	5.52**	4.76**	5.45**	5.06**	3.86*

- Notes:** 1. The relevant critical value bounds are obtained from Table C1.iii (with an unrestricted intercept and no trend; with three regressors $k=3$) in Pesaran et al. (2001). They are 2.72 - 3.77 at 90%, 3.23 - 4.35 at 95%, and 4.29 - 5.61 at 99%;
2. * denotes that the F-statistic falls above the 90% upper bound, ** above the 95% upper bound, and *** above the 99% upper bound, respectively;
3. According to Narayan (2005), the existing critical values reported in Pesaran et al. (2001) cannot be used for small sample sizes because they are based on large sample sizes. Narayan (2005) provides a set of critical values for sample sizes ranging from 30 to 80 observations. They are 2.496 - 3.346 at 90%, 2.962 - 3.910 at 95%, and 4.068 - 5.250 at 99%.

The results of table 2 show that, F-statistic is greater than critical values, indicating that there is cointegration between M1 and M2 variables, real income, rate of inflation and nominal exchange rate. The computed F-statistic was also compared with the critical values that account for small sample sizes provided by Narayan (2005). In the second stage, we employ Akaike's information criterion (AIC) in selecting the lag length on each first differenced variable and equation 2 is re-estimated for M1 and M2 real monetary aggregate and the results are reported in Tables 3a, 3b.

According to Table 3a, the real income elasticity is 1.78, which is highly significant as reflected by a t-statistic of 10.83. The inflation rate elasticity is negative (-2.568) and significant supporting our theoretical expectation. And, since the nominal exchange rate coefficient is negative (-0.445) and highly significant, it appears that a depreciation of forint in Hungary (HUF) decreases the demand for money.

The long-run model of the corresponding ARDL(4, 1, 0, 0) for the demand of money (M1) can be written as follows:

$$LM1_t = 2.607 + 1.783LY_t - 2.568INF_t - 0.445LEXR_t$$

(0.000) (0.000) (0.0024) (0.000)

Table 3a. ARDL Estimations (Dependent variable LM1)

Dependent variable LM1				
Panel A: the long-run Coefficient Estimates				
Constant	LY	INF	LEXR	R²
2.6071 (7.828)	1.7836 (39.551)	-2.5687 (-3.179)	-0.4458 (-8.1625)	0.9812
Panel B: the short-run Coefficient Estimates				
Lag Order	ΔLM1	ΔLY	ΔINF	ΔLEXR
0		0.1202 (0.5945)	-1.5235 (-4.2073)	0.0907 (0.7300)
1	0.1475 (1.0009)	-0.6546 (-3.2214)		
2	0.1512 (1.0397)			
3	-0.1511 (-1.6341)			
4	0.7490 (8.0653)			

Notes: Number inside the parenthesis is the value of the t-ratio

Table 3b. ARDL Estimations (Dependent variable LM2)

Dependent variable LM2				
Panel A: the long-run Coefficient Estimates				
Constant	LY	INF	LEXR	R²
3.5728 (14.340)	1.7644 (52.297)	-1.8769 (-3.1048)	-0.4650 (-11.380)	0.9888
Panel B: the short-run Coefficient Estimates				
Lag Order	ΔLM2	ΔLY	ΔINF	ΔLEXR
0		0.0651 (0.5044)	-1.3574 (-3.4504)	0.0982 (1.3617)
1	0.0536 (0.1422)	-0.2517 (-2.1199)	-1.1713 (-3.6122)	
2	0.0308 (0.3057)	0.2836 (2.3235)	-0.8813 (-2.2639)	
3	-0.0258 (-0.2520)	0.3054 (2.5672)	-0.0364 (-0.1255)	
4	0.7843 (7.3418)			

Notes: Number inside the parenthesis is the value of the t-ratio

According to Table 3b, the real income elasticity is 1.76, which is highly significant as reflected by a t-statistic of 52.29. The inflation rate elasticity is negative (-1.876) and significant supporting our theoretical expectation. And, since the nominal exchange rate coefficient is negative (-0.465) and highly significant, it appears that a depreciation of forint in Hungary (HUF) decreases the demand for money.

The long-run model of the corresponding ARDL(4, 3, 3, 0) for the demand for money (M2) can be written as follows:

$$LM2_t = 3.572 + 1.764LY_t - 1.876INF_t - 0.465LEXR_t$$

(0.000) (0.000) (0.003) (0.000)

High coefficients of long run income elasticity turn to be opposite with the hypothesis of economies of scale in money holding predicted by the transactions. This can be interpreted mainly in the case where we use a broader definition of money M2 which includes some advantages such as time deposits and savings. It is important to point out that when income elasticity is larger than one, an outstanding matter appears in the literature both for developed and developing countries. Inflation is negatively correlated to real demand for money, meaning that the higher the inflation rate the lower is the demand for money. The coefficient of the expecting exchange rate is negative and at the same time statistical significant both for M1 and M2. The statistically significant negative coefficient of the expected exchange rate indicates the existence of the currency substitution in Hungary.

In order to examine the short-run demand for money for a simpler specification, we test for weak exogeneity among the cointegrating relationship. Since one cointegrating relationship has been identified, the weak exogeneity tests are evaluated under the assumption of rank one (Pradhan and Subramanian, 2003). The null hypothesis is the existence of weak exogeneity. The results presented in Tables 3c and 3d below show that, the weak exogeneity is rejected for both LM1 and LM2 at 5% significance level.

Table 3c. Test for weak exogeneity for LM1

Variables	$a_i = 0$	$\chi^2(l)$
LM1	0.237	6.13[0.0215]**
LY	0.543	3.94[0.1162]
INF	-0.212	1.83[0.0913]
LEXR	-0.104	0.47 [0.4127]

Notes: * and ** reject the null hypotheses at 10% and 5% significance level, respectively.

Table 3d. Test for weak exogeneity for LM2

Variables	$a_i = 0$	$\chi^2(l)$
LM2	0.215	5.49 [0.0302]**
LY	0.562	3.86 [0.1093]
INF	-0.224	1.72 [0.0857]
LEXR	-0.098	0.36[0.3826]

Notes: * and ** reject the null hypotheses at 10% and 5% significance level, respectively.

At this stage, considering that real monetary aggregates (M1 and M2), real income, inflation rate, and nominal exchange rate are cointegrated, the error correction model in equation 2 is estimated (Engle and Granger 1987). The main aim here is to capture the short-run dynamics. In the short-run, deviations from this long-run equilibrium can occur due to shocks in any of the variables of the model. In addition, the dynamics governing the short-run behaviour of real broad money demand are different from those in the long-run.

The results of the short-run dynamic real broad money demand (M1 and M2) models and the various diagnostic tests are presented in Tables 4a and 4b. 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 coefficient estimates). Not much interpretation could be attached to the short-run coefficients. All show the dynamic adjustment of all variables. A negative and significant coefficient of EC_{t-1} will be an indication of cointegration. Panel B also reports some diagnostic statistics. The diagnostic tests include the test of serial autocorrelation (X^2_{Auto}), normality (X^2_{Norm}), heteroscedasticity (X^2_{White}), omitted variables/functional form (X^2_{RESET}) and the test for forecasting ($X^2_{Forecast}$).

Table 4a. Error Correction Representations of ARDL Model, ARDL(4,1,0,0)

Panel A: Dependent variable $\Delta LM1$	
Regressors	ARDL (4,1,0,0)
Constant	0.0036 (0.4057)
$\Delta LM1 (-1)$	0.2331 (2.1752)
$\Delta LM1 (-2)$	0.2003 (2.0057)
$\Delta LM1 (-3)$	-0.1882 (-1.7228)
$\Delta LM1 (-4)$	0.6385 (6.3399)
ΔLY	-0.0019 (-0.0110)
$\Delta LY (-1)$	-0.2270 (-1.2909)
ΔINF	-1.2330 (-2.5815)
$\Delta LEXR$	0.0085 (0.1045)
$EC1 (-1)$	-0.1295 (-2.2219)
Adjusted R-squared	0.7207
F-statistic Prob(F-statistic)	16.776 [0.000]
DW-statistic	1.9470
RSS	0.0389
Panel B: Diagnostic test	
$X^2_{Auto}(2)$	1.189 [0.551]
$X^2_{Norm}(2)$	0.459 [0.794]
$X^2_{White}(18)$	24.276 [0.146]
$X^2_{RESET}(2)$	1.608 [0.447]
$X^2_{Forecast}(5)$	5.090 [0.404]

Notes: 1. The values of t-ratios are in parentheses.

2. The values in brackets are probabilities.

3. RSS stands for residual sum of squares.

4. $X^2_{Auto}(2)$ is the Breusch–Godfrey LM test for autocorrelation.

5. $X^2_{Norm}(2)$ is the Jarque–Bera normality test.

6. $X^2_{White}(18)$ is the White test for heteroscedasticity.

7. $X^2_{RESET}(2)$ is the Ramsey test for omitted variables/functional.

8. $X^2_{Forecast}(5)$ is the Chow predictive failure test (when calculating this test, 2009Q1 was chosen as the starting point for forecasting).

As can be seen from Table 4a at panel A, the EC_{t-1} carries an expected negative sign, which is highly significant, indicating that, M1, real income, inflation rate, and nominal exchange rate are cointegrated. The absolute value of the coefficient of the error-correction term indicates that about 13 percent of the disequilibrium in the real M1 demand is offset by short-run adjustment in each quarterly. This means that excess money is followed in the next period by a reduction in the level of money balances, which people would desire to hold. Thus, it is important to reduce the existing disequilibrium over time in order to maintain long-run equilibrium.

The diagnostic tests presented in the lower panel B of Table 4a show that there is no evidence of diagnostic problem with the model. Measuring the explanatory power of the equations by their adjusted R-squared shows that, roughly 72% of the variation in money demand can be explained. The Lagrange Multiplier (LM) test of autocorrelation suggests that the residuals are not serially correlated. According to the Jarque-Bera (JB) test, the null hypothesis of normally distributed residuals cannot be rejected. The White heteroscedasticity test suggests that the disturbance term in the equation is homoskedastic. The Ramsey RESET test result shows that the calculated X^2 -value is less than the critical value at the five percent level of significance. This is an indication that there is no specification error. Finally, the Chow predictive failure test shows that the model may be used for forecasting.

Table 4b. Error Correction Representations of ARDL Model, ARDL(4,3,3,0)

Panel A: Dependent variable $\Delta LM2$	
Regressors	ARDL (4,3,3,0)
Constant	0.0074 (0.7327)
$\Delta LM2 (-1)$	-0.0207 (-0.1320)
$\Delta LM2(-2)$	0.2134 (1.3282)
$\Delta LM2(-3)$	-0.0743 (-0.4918)
$\Delta LM2(-4)$	0.4891 (3.0119)
ΔLY	-0.1151 (-0.8243)
$\Delta LY(-1)$	-0.1047 (-0.8032)
$\Delta LY(-2)$	0.1670 (1.2620)
$\Delta LY(-3)$	0.0258 (0.1940)
ΔINF	-0.4602 (-1.1030)
$\Delta INF(-1)$	-0.7770 (-1.7037)
$\Delta INF(-2)$	-0.5155 (-1.1607)
$\Delta INF(-3)$	-0.0831 (-0.1969)
$\Delta LEXR$	0.0696 (1.2041)
$EC2(-1)$	-0.0618 (-1.0423)
Adjusted R-squared	0.5994
F-statistic Prob(F-statistic)	6.8783 [0.000]
DW-statistic	1.8903
RSS	0.0169
Panel B: Diagnostic test	
$X^2_{Auto}(2)$	0.361 [0.834]
$X^2_{Norm}(2)$	2.057 [0.357]
$X^2_{White}(18)$	29.380 [0.393]
$X^2_{RESET}(2)$	0.494 [0.780]
$X^2_{Forecast}(5)$	26.293 [0.000]

- Notes:** 1. The values of t-ratios are in parentheses.
 2. The values in brackets are probabilities.
 3. RSS stands for residual sum of squares.
 4. $X^2_{\text{Auto}}(2)$ is the Breusch–Godfrey LM test for autocorrelation.
 5. $X^2_{\text{Norm}}(2)$ is the Jarque–Bera normality test.
 6. $X^2_{\text{White}}(18)$ is the White test for heteroscedasticity.
 7. $X^2_{\text{RESET}}(2)$ is the Ramsey test for omitted variables/functional.
 8. $X^2_{\text{Forecast}}(5)$ is the Chow predictive failure test (when calculating this test, 2009Q1 was chosen as the starting point for forecasting).

Table 4b reports the results for real M2 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. Thus, it may be concluded that M1 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 (Sharifi-Renani 2007). The stability of the long-run coefficients are used to form the error-correction term in conjunction with the short run dynamics. Some of the problems of instability could stem from inadequate modelling 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, which Brown et al. (1975) developed.

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, then estimated coefficients 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 Figures 1- 4 below.

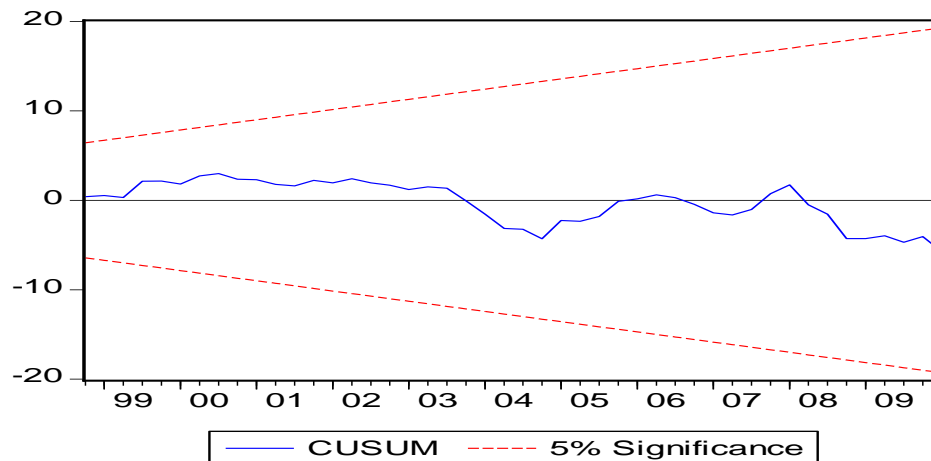


Figure 1. Cumulative Sum of Recursive Residuals (M1)

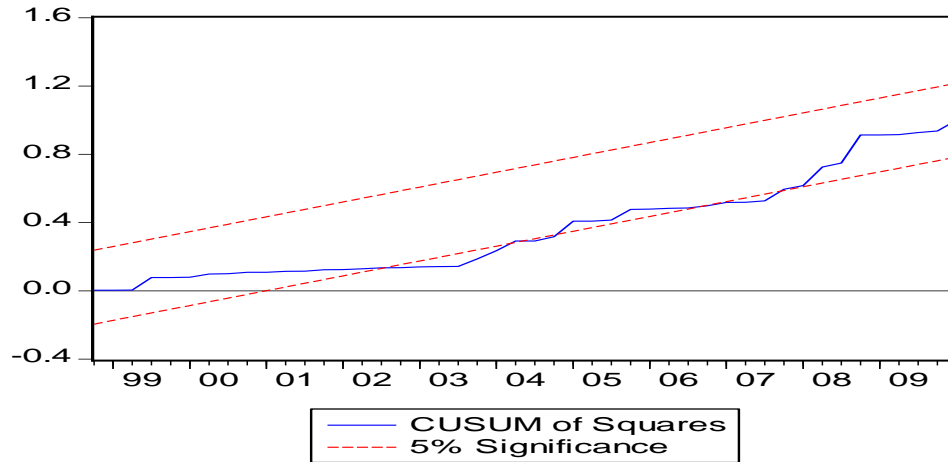


Figure 2. Cumulative Sum of Squares of Recursive Residuals (M1)

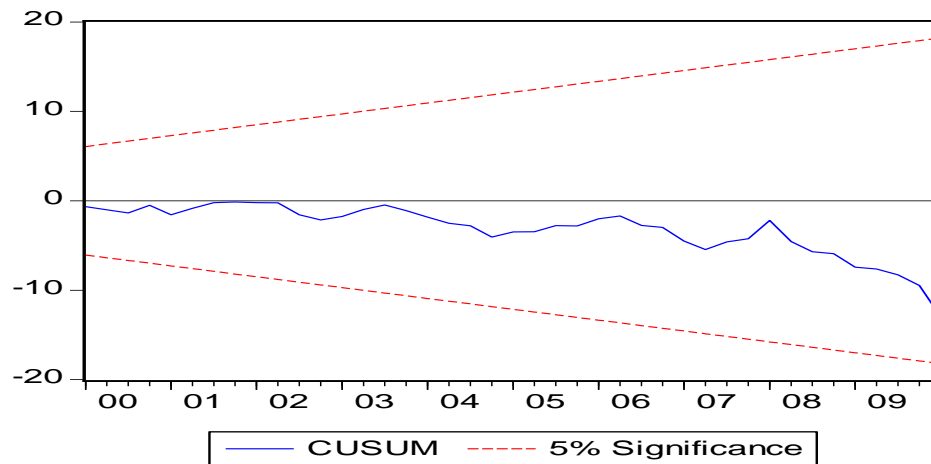


Figure 3. Cumulative Sum of Recursive Residuals (M2)

Since the plots of CUSUM and CUSUMSQ statistic for M1 marginally cross the critical value lines, we are safe to conclude that M1 money demand is stable. However, the plot of CUSUMSQ statistic for M2 crosses the critical value line, indicating some instability in M2 money demand. However, this finding could be an indication of the fact that M1 must be the monetary aggregate that central banks should control.

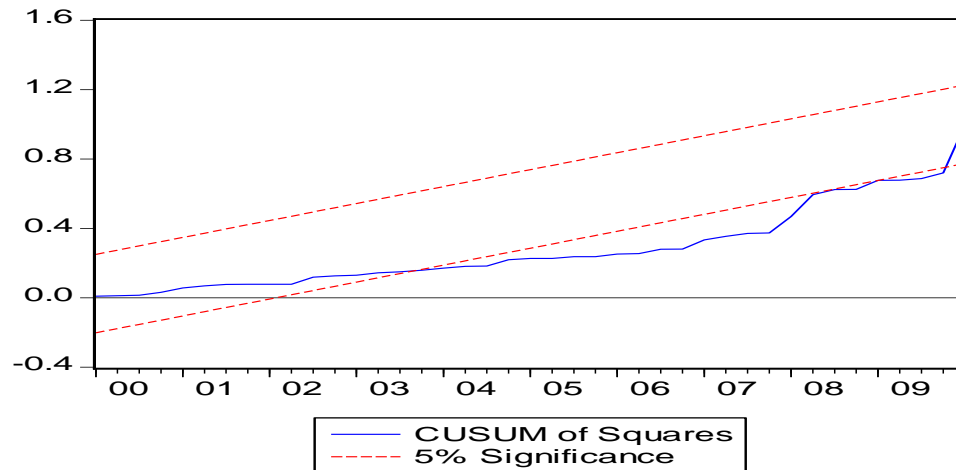


Figure 4. Cumulative Sum of Squares of Recursive Residuals (M2)

4. Conclusions

In this study, the demand for money in Hungary has been estimated using ARDL approach to cointegration analysis of Perasan et al. (2001). The ARDL method does not generally require knowledge of the order of integration of variables. The empirical results have shown that, most of the variables in the model are statistically significant and consistent with the demand theory both in the long-run as well as in the short-run. However, some variables are found to be slightly inconsistent with the demand theory. In most instances there are explanations for this incidence.

The empirical analysis based on the bounds test, supports the stable money demand model (M1) for Hungary. In fact, we show that the existence of the long-run money demand equation can only be firmly established when inflation rate, exchange rate, and GNP are included in the model. The results reveal that GNP (Y) is positively associated with M1 and M2 while inflation rate (INF), and exchange rate (EXR), negatively affect M1 and M2. The negative effect of inflation rate on M1 and M2 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 negative effect of exchange rate on M1 and M2 indicates that depreciation of domestic money decreases the demand for money.

Furthermore, by applying the CUSUM and CUSUMSQ tests to the model, we show that long-run M1 money demand model in Hungary is more stable if inflation rate, exchange rate, and GNP are included in the model. By incorporating CUSUM and CUSUMSQ tests into cointegration analysis, it is revealed that while M1 money demand is stable, M2 is not. Thus, it may be concluded that M1 is a better monetary aggregate in terms of formulating monetary policy and central banks control.

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Appendix:

All data are quarterly over the period 1995:1 to 2010:1 and collected from the International Statistical Yearbook (IMF).

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

M_2 is M_1 plus private savings deposits.

INF is inflation rate, which is defined as $\frac{CPI - CPI(-1)}{CPI(-1)}$, where CPI is the Consumer Price Index (2005 price).

EXP 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 price (2005 price).