Stability of Money Demand in an Emerging Market Economy: An Error Correction and ARDL Model for Indonesia

Noer Azam Achsani
Department of Economics and Graduate School of Management and Business
Bogor Agricultural University, Indonesia
E-mail: achsani@yahoo.com (preferred) or achsani@mb.ipb.ac.id
Tel: +62-251-8313813; Fax: +62-251-8318515

Abstract

Predicting a stable money demand function is one of the key elements of monetary policy since monetary aggregates has theoretically important influences on output, interest rate and ultimate price level. By employing the vector error correction model (VECM) and autoregressive distributed lag (ARDL) approach, this paper investigates the M2 money demand for Indonesia in the period of 1990:1-2008:3.

The results indicate that the demand for real M2 money aggregate is cointegrated with real income and interest rate. The real income has positive relationship with real money demand, both in the long-run and short-run. On the other hand, interest rate has a negative influence on M2 in the short-run, but has no statistically significant relationship in the long-run. Furthermore, we find that the ARDL model is more appropriate in predicting stable money demand function of Indonesia in compare to VECM.

Keywords: Money demand, cointegration, ARDL model, stability test
JEL Classification Codes: E41, E44, G2

1. Introduction

A stable money demand function forms the core in the conduct of monetary policy as it enables a policy-driven change in monetary aggregates to have predictable influences on output, interest rate and ultimate price. Because of its importance, therefore, many studies have been carried out worldwide in the last several decades (Sriram, 1999).

Majority of the study concerned with the data from the industrial countries. Examples are Hafer and Jansen (1991), Miller (1991), McNown and Wallace (1992) and Mehra (1993) for the USA; Arize and Schwiff (1993), Miyao (1996) and Bahmani-Oskooee (2001) for Japan; Drake and Chrystal (1994) for the UK; Haug and Lucas (1996) for Canada; Lim (1993) for Australia and Orden and Fisher (1993) for New Zealand. Relatively few studies were conducted on developing countries. However, it has been increasing in recent years, primarily triggered by the concern among central banks and researchers around the world on the impact of moving toward flexible exchange rates regimes, globalization of capital markets, ongoing financial liberalization and innovation in domestic markets, and the country-specific events on the demand for money (Sriram, 1999).

As far as Indonesia is concerned, couples of studies have been conducted by employing Johannsen's error correction model. The results, however, seem to be contradictive. Price and Insukindo (1994) used quarterly data over 1969:1 – 1987:4 period. The results were based on three different methods of testing for cointegration. Eagle Grager method showed that there was weak evidence of cointegrating relationship. Furthermore Johansen's cointegration technique found up to two cointegrating vectors, but the error correction model (ECM) didn't find a significant relationship.

Dekle and Pradhan (1997) who re-examined the relation using annual data over 1974 – 1995, did not find any cointegrating relationship for any definitions of money demand.

In this paper, again we explore the M2 money demand function in Indonesia, using Johansen's standard cointegration model. As Bahmani-Oskooee and Bohl (2000) and Bahmani-Oskooee (2001), however, standard cointegration model may not imply stable relation-ships among set of variables. In this paper, therefore, we also employ the autoregressive distributed lag (ARDL) methods introduced by Pesaran and Shin (1995) and Pesaran, Shin and Smith (1996). Using the ARDL approach, we shed light not only the cointegrating properties of M2, income and interest rate, but also the stability of M2 money demand functions itself.

The rest of the paper is organized as follows. In section 2 we explain the data and also introduce the money demand function, the vector error correction model and the ARDL approach to cointegration. Section 3 gives the empirical results and discuss about the stability of the money demand function. Section 4 summarized the research findings and gives concluding remarks.

2. Data and Methodology

In this research we use secondary data of Indonesia, consisting of real M2 money demand, real output (GDP) and Interest rates (call money rates). All the data are taken from the International Financial Statistics Database.

Using quarterly data over 1990:1 – 2008:3 period, we try to test the null hypothesis of no cointegration against the alternative using two methods, namely the VECM (Johansen (1988) and Johansen and Juselius (1990)) and the ARDL model (Pesaran and Shin (1995) and Pesaran, Shin and Smith (1996)). All calculations are carried out using Microfit 4.1.

2.1. The M2 Money Demand, ECM and ARDL Approach of Cointegration

As is common in the literature that the basic model of money demand begins with the following functional relationships:

$M/P = f(S, OC)$

where the demand for real balances *M/P* is a function of the chosen scale variable (*S*) to represent the economic activity and the opportunity cost of holding money (*OC*). *M* stands for the selected monetary aggregates in nominal term and *P* for the price.

In empirical researches, we generally specify the money demand as a function of real balances. Using the real money balance as dependent variable will also mean that price homogeneity is explicitly imposed into the model. Additionally, there are less severe econometric problems associated with using real rather than nominal money balances as the dependent variable (Sriram, 1999).

In this paper, following Miyao (1996) and Basmani-Oskooee (2001) we consider the following M2 demand for money in Indonesia:

$$\ln M2_t = a + b \ln Y_t + c\, r_t + e_t \qquad (1)$$

where *M2* is the M2 monetary aggregate in real term, *Y* the real income, *r* the interest rate and *e* an error term.

In the first step, we employ the vector error correction model (VECM) of Johansen (1988) and Johansen and Juselius (1990). The VECM pertaining to the variables in Eq (1) can be written as follows:

$$\Delta \ln M2_t = a_0 + \sum_{j=1}^{n} b_j \Delta \ln M2_{t-j} + \sum_{j=1}^{n} c_j \Delta \ln Y_{t-j} + \sum_{j=1}^{n} d_j \Delta r_{t-j}$$
$$+ \alpha(\beta_1 \ln M2_t + \beta_2 \ln Y_t + \beta_3 r) + \varepsilon_t \qquad (2)$$

In this step, the null hypothesis of no cointegration defined by H_1: α = 0 is tested against the alternative H_1: α < 0. The β_j represents the long-run relation between the variables, while b_j, c_j and d_j

represent short-run coefficients of money, income and interest rate from the previous quarters (see Johansen (1988) and Johansen and Juselius (1990) for details).

Depending on the power of unit root test, however, different tests may yield different results. Due to this uncertainty, Pesaran and Shin (1995) and Pesaran, Shin and Smith (1996) introduced the so-called ARDL of testing for cointegration. This approach 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 (Basmani-Oskooee, 2001).

The error correction version of the ARDL model pertaining to the variables in Eq. (1) is as follows:

$$\Delta \ln M2_t = a_0 + \sum_{j=1}^{n} b_j \Delta \ln M2_{t-j} + \sum_{j=1}^{n} c_j \Delta \ln Y_{t-j} + \sum_{j=1}^{n} d_j \Delta r_{t-j} + \delta_1 \ln M2_{t-1} + \delta_2 \ln Y_{t-1} + \delta_3 r_{t-1} + \varepsilon_t \quad (3)$$

In this model, the null hypothesis of no cointegration defined by H_0: $\delta_1 = \delta_2 = \delta_3 = 0$ is tested against the alternative of H_1: $\delta_1 \neq 0, \delta_2 \neq 0, \delta_3 \neq 0$ by means of familiar F-test (see Pesaran and Shin (1995) and Pesaran, Shin and Smith (1996) for details).

3. Empirical Results and Discussion

In this section, we will present the results and their scientific explanation. Moreover, we also compare the VECM against ARDL models in order to find the best and more stable money demand function.

3.1. Vector Error Correction Model

In the first step of VECM, we test the present of unit root using DF and ADF tests, and the results are presented in Table 1. We learn from the table that the series are not stationary in level and stationary in the first difference. Therefore the concept of cointegration is relevant.

Table 1: Unit root test of Dickey-Fuller (DF) and Augmented Dickey Fuller (ADF)

Variable	DF	ADF
$\ln M2$	-1.9439	-1.7521
$\Delta \ln M2$	-7.1313*	-5.0049*
$\ln Y$	0.48381	0.50694
$\Delta \ln Y$	-8.3317*	-5.0158*
r	-1.8398	-2.3200
Δr	-7.1755*	-4.6522*

*) stationary at 5% level.

Further analysis using λ_{max} and *Trace* tests show that there are at least two cointegrating vectors between *M2, Y* and *r*. Here we simulated the model up to time-lag = 8 and the results are robust for all choice of lag order. It is, however, not easy to find a significant long-run relationships among the variables. We find a significant relationships at 5% level only in the VECM(5) as seen in Table 2.

Table 2: Coefficients of VECM(5) for Money demand function of Indonesia: 1990:1-2008:3.

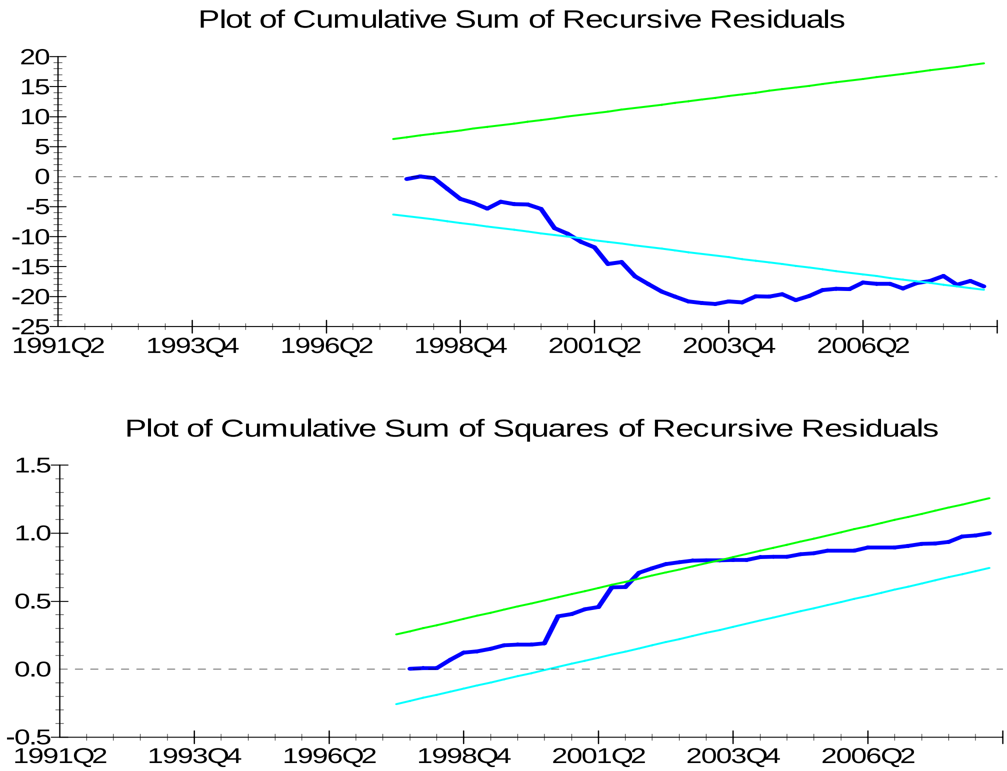
A. Short-run coefficients			
Regressor	**Coefficient**	**Standard Error**	**T-Ratio[Prob]**
Intercept	-.95540	.22005	-4.3417[.000]
Δln*M2(-1)*	-.31522	.14050	-2.2436[.029]
Δln*M2(-2)*	-.47080	.16564	-2.8424[.006]
Δln*M2(-3)*	-.52565	.15638	-3.3614[.001]
Δln*M2(-4)*	-.21127	.13799	-1.5311[.131]
Δln*Y(-1)*	.46383	.15502	2.9921[.004]
Δln*Y(-2)*	.15579	.14987	1.0395[.303]
Δln*Y(-3)*	.30905	.15198	2.0335[.047]
Δln*Y(-4)*	.15557	.16366	.95056[.346]
Δ*r(-1)*	-.0020945	.0011056	-1.8945[.063]
Δ*r(-2)*	.0016233	.8712E-3	1.8633[.068]
Δ*r(-3)*	.0016990	.9104E-3	1.8663[.067]
Δ*r(-4)*	-.4830E-3	.9384E-3	-.51469[.609]
ecm1(-1)	.15012	.032997	4.5495[.000]
DUMMY	-.093329	.020338	-4.5888[.000]
B. Long-run coefficients			
ln*Y*	.64533 (13.8159)*		
r	.026675 (.57109)		
Intercept	-6.2781 (-134.4069)		

*) Numbers in parenthesis are the coefficients normalized to ln*M2*.

Based on the results from Table 2, we try to examine three issues. The first issue is to establish cointegration among *M2, Y* and *r*. Our result shows that the coefficient of lagged error-correction-model term is statistically significant at 5% level. That means *M2, Y* and *r* in Indonesia in the period of study are cointegrated. Unfortunately, this result is not robust to the choice of the lag-order. We could not find any other significant coefficient for ECM terms at 5% level for the model with lag-order 6, 7 or 8. All the coefficients of the lagged-ECM terms in the three models are insignificant.

The second issue is the stability of the money demand function. Here we employ the CUSUM and CUSUMSQ tests proposed by Brown, Durbin and Evans (1975). The tests are applied to the residuals of the model. The CUSUM test is based on the cumulative sum of residuals based on first set of n observations. It is updated recursively and is plotted against the break points. If the plot of CUSUM stays within 5% significance level (portrayed by two straight lines whose equations are given in Brown *et. al* (1975), then the coefficient estimates are said to be stable. Similar procedure is used to carry out the CUSUMSQ which is based on the squares recursive residuals. Graphical representations of these two tests for the above model are provided in Figure 1

Figure 1: Plot of CUSUM (above) and CUSUMSQ (below) statistics for the model VECM(5).



From the figures, we learn that both CUSUM and CUSUMSQ statistics are not stay in the critical intervals. It suggests that there is stability problem during the period of 2001:3 – 2004:1. We, therefore, conclude that the Indonesian M2 money demand function based on VECM(5) is instable over the period of study.

The third issue from the Table 1 is an inference about the short-run and long-run coefficient estimates of M2 money demand function. As expected, the income has a significant impact on the money demand, both in the short-run and long-run. Its positive relation suggests that the increase of output will be followed by the increase in money demand. On the other hand, the interest rate has no significant impact, both in the short run and the long-run as well. Therefore, we conclude that income seems to have stronger influence comparing to the interest rate.

3.2. Autoregressive Distributed lag (ARDL)

In the second stage, we employ the ARDL approach to the same data. We impose up to maximum eight lags on each first differenced term in the ARDL model. We estimate the model based on R-Bar-Square, Akaike Information Criterion (AIC) and Schwarz Bayesian (SB) and Hannan-Quinn (HQ). As Bahmani-Oskooee (2001) noted, only an appropriate lag selection will be able to identify the true dynamic of the model.

Generally, all selection criteria give similar results. The AIC, SB and HQ suggest that the most appropriate model is ARDL(5,2,7), whereas the R-Bar-Square choose the ARDL(5,6,7) model. Our further analysis using R-Square and Adjusted-R-Square shows that the ARDL(5,6,7) model is the most appropriate one. The full information estimates of the ARDL(5,6,7) is presented in Table 3, whereas the estimates of the ARDL(5,2,7) is presented in Appendix 1.

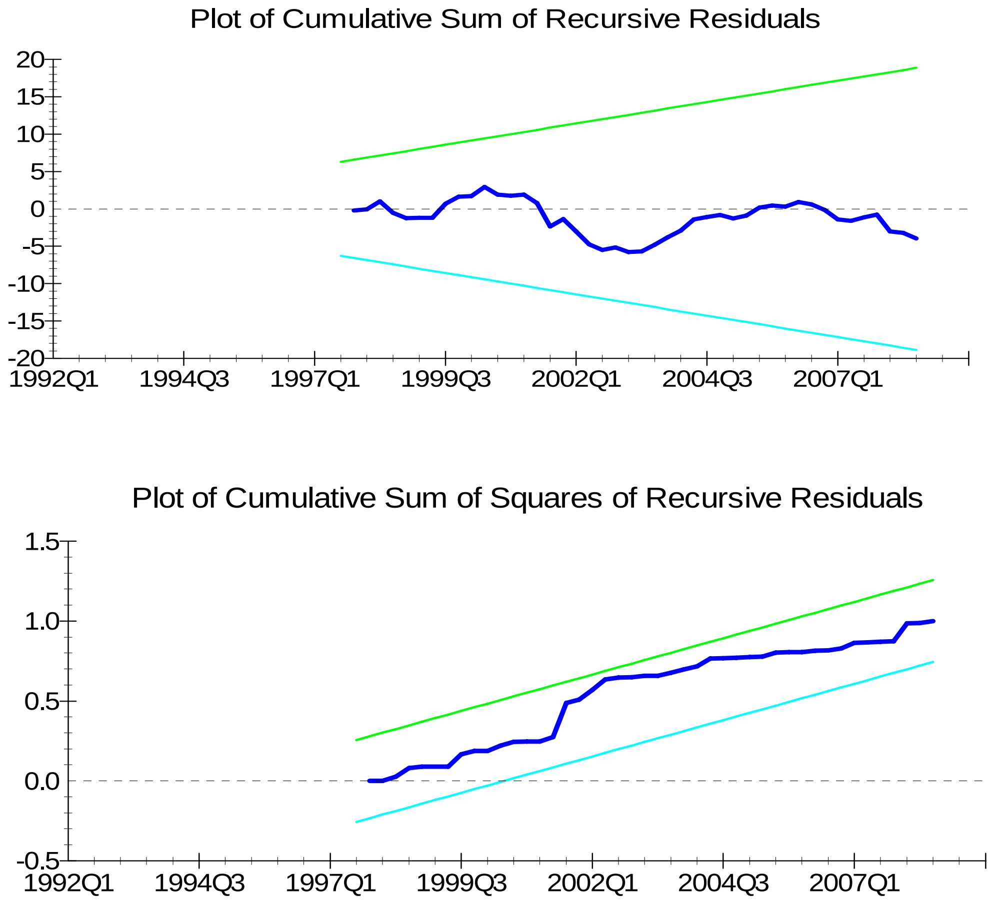
Table 3: Full information estimate of ARDL(5,6,7) model ($\Delta\ln M2_t$ as dependent variable) based on R-Bar-Square.

A. Short-run coefficients			
Regressor	**Coefficient**	**Standard Error**	**T-Ratio[Prob]**
Intercept	-1.2411	.87906	-1.4118[.165]
$\Delta\ln M2(-1)$	-.44280	.15100	-2.9325[.005]
$\Delta\ln M2(-2)$	-.22590	.15878	-1.4227[.161]
$\Delta\ln M2(-3)$	-.60530	.13690	-4.4214[.000]
$\Delta\ln M2(-4)$	-.29224	.13945	-2.0956[.042]
$\Delta\ln Y$	.13564	.16288	.83278[.409]
$\Delta\ln Y(-1)$	.76731	.23055	3.3282[.002]
$\Delta\ln Y(-2)$	.09821	.18336	.53564[.595]
$\Delta\ln Y(-3)$	.29341	.18662	1.5723[.123]
$\Delta\ln Y(-4)$	.15979	.14787	1.0806[.285]
$\Delta\ln Y(-5)$	-.15509	.15099	-1.0272[.310]
Δr	.0022161	.0010712	2.0688[.044]
$\Delta r(-1)$	-.0031215	.0011690	-2.6702[.010]
$\Delta r(-2)$	.9546E-3	.0011769	.81116[.421]
$\Delta r(-3)$	.0029501	.0010067	2.9306[.005]
$\Delta r(-4)$	.1533E-4	.9792E-3	.015655[.988]
$\Delta r(-5)$	-.9510E-3	.0010500	-.90570[.370]
$\Delta r(-6)$	.0025687	.9415E-3	2.7283[.009]
DUMMY	-.046665	.038799	-1.2027[.235]
ecm(-1)	-.055192	.043409	-1.2714[.210]
B. Long-run coefficients			
$\ln Y$	3.2040 (3.0640)*		
r	.081970 (1.2720)		
Intercept	-22.4865 (-2.0265)*		

Note: Numbers in parenthesis are the coefficients normalized to ln*M2*.
*) statistically significant at 5% level.

From the Table 3, we learn that there is significant cointegration among *M2, Y* and *r*. We also find the similar relations between the three variables in compare to those of VECM. The coefficient estimates of income are positive and statistically significant, both short-run and long-run. Furthermore, in Figure 2 we present the graphical representation of CUSUM and CUSUMSQ test for the ARDL(5,6,7) based on R-Bar-Square. The similar results are also found from the ARDL(5,2,7) model based on AIC, SB and HQ. Thus, no matter which criteria we used, the M2 money demand functions based on ARDL approach are stable.

Figure 2: Plot of CUSUM (above) and CUSUMSQ (below) statistics for the model ARDL (based on R-Bar-Square).



Comparing the results of VECM and ARDL models, we generally find similar results. However, the ARDL model is better that those of the VECM. The money demand model based on ARDL is stable, while the ARDL model is not stable. Moreover, the ARDL also resulted in better indicators in term of R-Square and Adjusted R-Square. They are 0.78 and 0.68 respectively, in compare to 0.71 and 0.58 for the VECM model. Therefore the ARDL model can explain more variability of money demand in compare to the VECM model.

4. Concluding Remarks

The objective of this research was to estimate the Indonesian M2 money demand using vector error correction (VECM) and autoregressive distributed lag (ARDL) model. The results suggested that there was cointegrating relationship among real money aggregate, real income and interest rate in Indonesia during the period of study. The real income had significant influence on the real money balance. The impact was also stronger in compare to those of the interest rates.

The results also showed that the ARDL model was better than VECM. Furthermore, the result also showed that the ARDL model was stable, while the VECM model was not stable. Therefore, we should find and interpret the model carefully when we use the VECM. The wrong choice of the lag-order may lead us to a misleading conclusion.

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Appendix 1

Full information estimate of ARDL(5,2,7) model ($\Delta \ln M2_t$ as dependent variable) based on Schwarz-Bayes, Akaike Information Criterion and Hannan-Quinn.

A. Short-run coefficients			
Regressor	**Coefficient**	**Standard Error**	**T-Ratio[Prob]**
Intercept	-1.9682	.65972	-2.9834[.004]
$\Delta \ln M2(-1)$	-.46687	.13540	-3.4482[.001]
$\Delta \ln M2(-2)$	-.19872	.14000	-1.4195[.162]
$\Delta \ln M2(-3)$	-.53642	.11264	-4.7622[.000]
$\Delta \ln M2(-4)$	-.40255	.11472	-3.5091[.001]
$\Delta \ln Y$	.061110	.13119	.46581[.643]
$\Delta \ln Y(-1)$	.49807	.15905	3.1317[.003]
Δr	.0026623	.9959E-3	2.6733[.010]
$\Delta r(-1)$	-.0032680	.9335E-3	-3.5008[.001]
$\Delta r(-2)$	-.1823E-3	.8891E-3	-.20505[.838]
$\Delta r(-3)$	.0024788	.8841E-3	2.8036[.007]
$\Delta r(-4)$	-.5339E-3	.7765E-3	-.68762[.495]
$\Delta r(-5)$	-.0019842	.7063E-3	-2.8093[.007]
$\Delta r(-6)$	.0015540	.7424E-3	2.0931[.041]
DUMMY	-.060173	.036380	-1.6540[.104]
ecm(-1)	-.076439	.038759	-1.9721[.054]
B. Long-run coefficients			
$\ln Y$	3.4816 (4.2268)*		
r	.0661 (1.8790)		
Intercept	-25.7492 (-2.9451)*		

Note: Numbers in parenthesis are the coefficients normalized to $\ln M2$.
*) statistically significant at 5% level.