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Stability of Money Demand Function in Bangladesh using Auto-regressive Distributed Lag Approach

N.A.M. Faisal Ahmed[1], Md. Merajul Islam[2], Mohammad Ali[3], Md. Maniruzzaman[3*] & Md. Jahanur Rahman[2]

[1]*Instutite of Education and Research, University of Rajshahi, Rajshahi-6205, Bangladesh*
[2]*Department of Statistics, University of Rajshahi, Rajshahi-6205, Bangladesh*
[3]*Statistics Discipline, Khulna University, Khulna-9208, Bangladesh*
**Corresponding author E-mail : monir.stat91@gmail.com*

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Abstract: This study investigates whether there exists a stable long-run money demand function in Bangladesh from 1996 to 2017. To achieve this goal, yearly time-series data was collected and three variables were chosen: real money, interest rate, and GDP. The auto-regressive distributed lag (ARDL) co-integration modeling approachhas been implemented to assess the long-run relationship among real money, interest rate, and GDP. ARDL resultshows a long-run association among real money, interest rate, and GDP, which is consistent with the stable money demand function. The consistency of the long-run money demand function has also been verified by the cumulative sum and cumulative sum of square tests. Finally, we concluded that the long-run as well as short-run-estimates are stable and the estimated model is more reliable in Bangladesh.

Keywords: Money demand, stability, ARDL and Bangladesh

1. Introduction

The study of money demand and its stability plays important role in macro-economic analysis, particularly in the formulation and execution of appropriate monetary policy makers (Yamden 2011). If the money demand is stable, monetary policy comprises of a monetary rule that can help stabilize the economy or eliminate monetary policy as a source of macroeconomic volatility. If the money demand does not change, then money supply targeting is also a secure way to achieve a steady inflation rate. Money demand is generally characterized by income, interest, and inflation, in developing countries that yield rates on financial assets where datasets and institutional settings are well managed (Iftekhar *et al.* 2017). Money demand has been widely studied in both developed and developing countries, including Bangladesh (Alam 2015; Gurtner 2010; Rao and Singh 2004; Hossain 2010; Hafer and Jansen 1991; Ahmed 1977). Although, the previous empirical studies in Bangladesh reported that real income and expected inflation rates are considered major factors for money demand but they provide provide indecisive evidence on the role of interest rate in determining money demand. In the previous studies, authors implemented regression model to estimate money demand function based on

their time-series data without investigating the properties of time-series as stationary of the variables in their models. The findings of a typical regression model will be true if all of the variables in model are stationary as well as the error term is uncorrelated and homoscedastic. The spurious regression model exists if the variables in model are non-stationary. As a result, findings from t-test and F-test will be meaningless and true relationship does not exist. Despite the fact that there are well-developed techniques for dealing with non-stationary time-series data, no study was found on money demand behavior based on these methods in Bangladesh. The creation of a floating exchange rate, interest rate liberalization, and the abolition of certain current account limits are all major changes in the financial market. The aim of the study is to examine the long-run equilibrium relationship among real money, interest rate, and GDP in Bangladesh andalso examine the stability of the long-run equilibrium of money demand function.While these objectives are addressed, readers find the following novelties in our current study compared to the existing studies.

(i) The present study shows the usage of yearly data from 1996 to 2017.

(ii) The autoregressive distributed lag (ARDL) bound test was used to evaluate the long-run equilibrium relationship among real money, interest rates, and GDP.

(iii) Cumulative sum (CUSUM) test and cumulative sum of square (CUSUMS-Q) test have beenadopted to verify the consistency of the long-run money demand function.

2. Review of literature

There were several existing studies in literature related to money demand function is reviewed in this section. Bahmani (2001) used quarterly data with five variables in Japan. He implemented co-integration analysis and reported that unstable for money demand function. Akinlo (2006) used quarterly data (1970Q1-2002Q4) with four variables in Nigeria. He used ARDL model and demonstrated that stable demand for money function. Bahmani and Bahmane (2012) considered time-series data from 1997 to 2007 in Iran. They applied ARDL modeling to co-integration in their study. Finally, they showed that stable money demand function. Samreth (2008) used yearly time-series data with four variables in Cambodia and utilized ARDL modeling to co-integration. He showed that structural forms of money demand function is very essential to take appropriate monetary policy and demand for money is unstable. Omer (2009) considered yearly time-series data from 1975 to 2006 in Pakistan. He utilized ARDL modeling to co-integration and revealed that stable for money demand function.Gencer and Arisoy (2013) indicated that money demand analysis and money policy applies are very essential because the main objective of the money demand was to manage the money supply and be effective on

some macro economic variables. Melih[17] suggested that income and interest rate were the two main variables to determine the money demand and economic activities in a country. Ahmed (1977) implemented a simple textbook function to estimate the money demand function, nominal interest rate, and real income. He indicated that the coefficients were statistically significant. Murty (1978) used generalized Box-Cox transformations to determine the required functional type of money demand function.Taslim (1984) proposed expected inflation rate instead of nominal interest rate for measuring opportunity cost variable. He observed that its was statistically significant. Hossain (1993) showed that real income, interest rate and expected inflation rate were played crucial factors of money demand function in Bangladesh.

3. Data and methodology

3.1. Source of data

This research is focused on yearly time series data from 1996 to 2017.About twenty two years long Bangladeshi data is used for analyzing money demand function empirically. Detail description of the selected variable is displayed in Table 1.

Table 1: Variable description

Variable name	*Description*
M	Real money
y	Real GDP
r	Real interest rate

3.2. The general as well as empirical model

Generally, let m^d represents the demand for real money balances, y indicates aggregate real income, and r is the opportunity cost variable. Then the demand function for real money can be written $m^d = f(y, r)$, where, f is a function relating real money to real income and the opportunity cost variable. This money demand function can be defined by the log-linear conventional statistical form as:

$$\text{md} = a + by + cr + \varepsilon \tag{1}$$

Where, y = log(real GDP(y))

m = log(real Money (M))

real Money(M)= (Broadmoney (M2)*100)/ (consumer Price index)

r = real interest rate

ε = error terms

Theoretically, we expect that $\partial m^d / \partial y = b > 0$ and $\partial m^d r = c < 0$, where ∂ is the partial differential operator.

3.3. Methodology

The co-integration analysis of the money demand function can be done using a variety of techniques. Some popular and well-established techniques like the residual-based technique which was introduced by Engle and Granger (1987) whereas, Johansen and Julius introduced maximum likelihood based technique in 1990. When some variables contain I(0) and I(1) i. e., mixed up and small data sample; ARDL model co-integration method was proposed by Nkoro and Uko (2016) performed better than other techniques.A simple linear transformation employed to convert an ARDL model to a dynamic error correction model (ECM) (Neubauer 2006). The long-run relationship can be tested using the following equation

Long-run equation-

$$\Delta \ln m_t = a_0 + \Sigma_{j=1}^{p} a_j \Delta \ln m_{t-j} + \Sigma_{j=0}^{q} b_j \Delta \ln y_{t-j} + \Sigma_{j=0}^{r} c_j \Delta r_{t-j} + \gamma_1 \ln m_{t-1} + \gamma_2 \ln y_{t-1} + \gamma_3 r_{t-1} + e_t \quad (2)$$

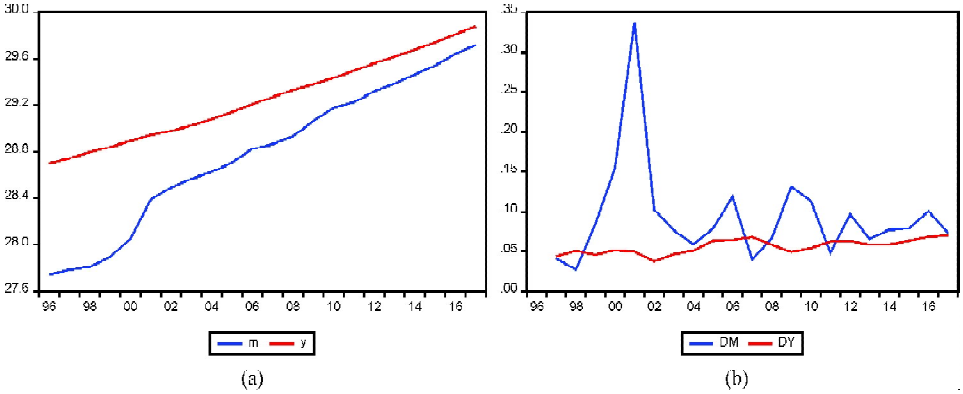
The error term ECM is obtained from the long-run model as follows:

$$\Delta \ln m_t = \delta_0 + \Sigma_{j=1}^{p} \delta_{1j} \Delta \ln m_{t-j} + \Sigma_{j=0}^{q} \delta_{2j} \Delta \ln y_{t-j} + \Sigma_{j=0}^{r} \delta_{3j} \Delta r_{t-j} + \delta_4 ECM_{t-1} + \phi_t \quad (3)$$

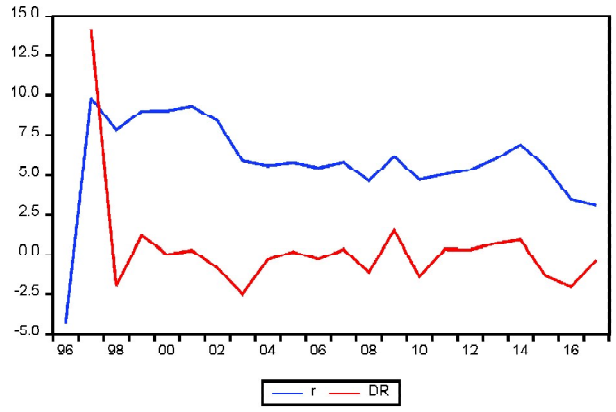
4. Results and discussion

4.1. Graphical description of data

Before applying unit root teststo our data, we presented graphical descriptions in this section. Our selected annual time series data, in levels and first differences, are displayed graphically in Figure 1 (a), (b) and (c) and clearly shows that real money (m), real GDP(y) appears to be non-stationary in levels is stationary in 1st differences and real interest rate (r) is stationary in levels. This apparent suggest that our level variables m, y might be integrated of order one i.e., I(1) and r is integrated of order zero i.e., I(0)



(a) (b)



(c)

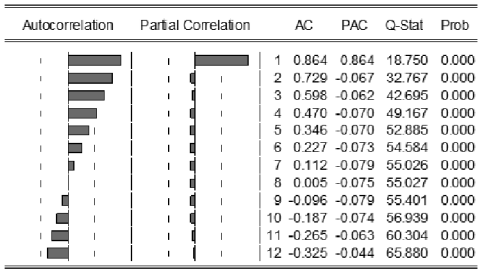
Figure 1: Level and first difference of real money (*m*), real GDP(*y*) and interest rate (*r*); (a) non-stationary for y and m at level; (b) stationary at fist difference for *y* and *m*; (c) stationery at level for *r*.

4.2. Correlogram test

Fig. 2 shows the Correlogram test of three variables (real GDP, real money, and real interest rate) and indicates that real GDP is non-stationary at level i. e., I(0) (see Fig. 2 (a)) but stationary at first difference i. e., I(1) (see Fig. 2 (b)). Similarly, real money is non-stationary at level i.e., I(0) (see Fig. 2 (c)) but stationary at first difference (see Fig. 2 (d)) while real interest rates is stationary in levels (see Fig. 2 (e)).

4.3. Unit root test

Table 1 presents the findings of ADF, DF-GLS, and KPSS tests.ADF and DF-GLS tests show that real GDP(y) and real money (m) are non-stationary to include intercept and trend. The KPSS test also founds the same results by rejecting the null hypothesis at 5% level of significance. But the variable *r* is stationary for both include intercept and trend for both ADF and DF-GLS test.



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.864	0.864	18.750	0.000
		2	0.729	-0.067	32.767	0.000
		3	0.598	-0.062	42.695	0.000
		4	0.470	-0.070	49.167	0.000
		5	0.346	-0.070	52.885	0.000
		6	0.227	-0.073	54.584	0.000
		7	0.112	-0.079	55.026	0.000
		8	0.005	-0.075	55.027	0.000
		9	-0.096	-0.079	55.401	0.000
		10	-0.187	-0.074	56.939	0.000
		11	-0.265	-0.063	60.304	0.000
		12	-0.325	-0.044	65.880	0.000

(a)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.636	0.636	9.7644	0.002
		2	0.301	-0.173	12.073	0.002
		3	0.073	-0.073	12.215	0.007
		4	0.093	0.211	12.458	0.014
		5	0.190	0.113	13.547	0.019
		6	0.089	-0.252	13.800	0.032
		7	-0.012	0.033	13.804	0.055
		8	-0.140	-0.090	14.537	0.069
		9	-0.053	0.145	14.649	0.101
		10	0.025	-0.044	14.676	0.144
		11	0.036	-0.028	14.740	0.195
		12	-0.062	-0.108	14.947	0.244

(b)

Figure 2: The Correlagram test of three variables (real GDP, money, and interest rate)

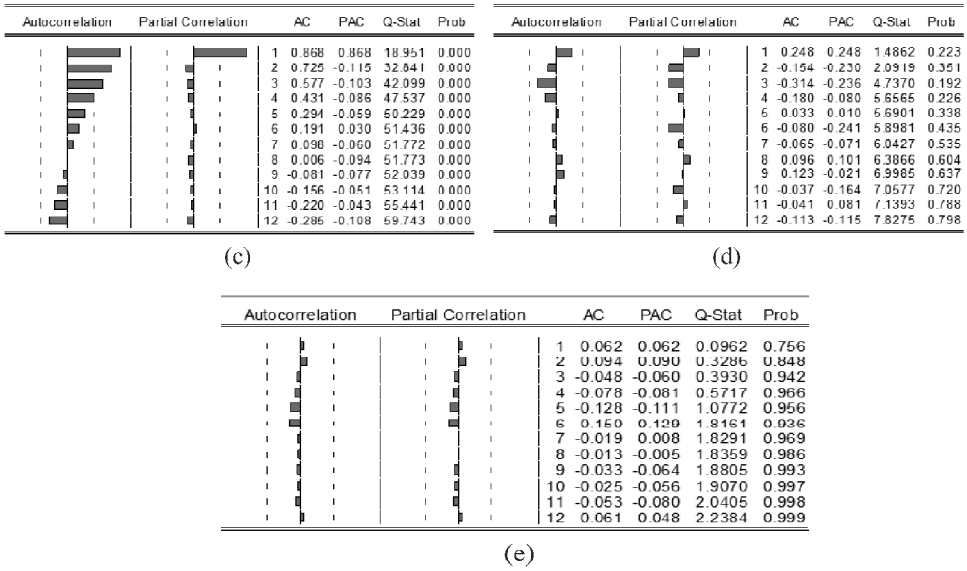


Figure 2: The Correlagram test of three variables (real GDP, money, and interest rate)

KPSS test also support the same result. For difference series, real GDP(y) is non-stationary to include intercept and trend by ADF test, but for DF-GLS test stationary for intercept and trend at 5% level of significance but for intercept is non-stationary. KPSS test conclude that real money (m) are stationary in difference. Thus, it is deduced that the real GDP(y) and real money (m) are I (1) and real interest rate(r) is I (0) (see Table 1). So, ARDL bound test will be performed.

Table 1: Result of the unit root tests

Variables	*ADF*		*DF-GLS*		*KPSS*	
	Intercept	*Intercept & Trend*	*Intercept*	*Intercept & Trend*	*Intercept*	*Intercept & Trend*
			Level			
y	2.58(2)	-1.43(2)	0.044(1)	-1.22(1)	0.66**(3)	0.17**(3)
m	-3.20(4)	-2.27(1)	-0.45(1)	-2.47(1)	0.65**(3)	0.15**(2)
r	-6.39***(0)	-11.26*** (0)	-2.89***(0)	-5.28***(0)	0.19(1)	0.08(0)
			First difference			
Δy	-1.56(1)	-3.26(1)	-1.50(1)	-3.50** (1)	0.57(2)	0.08(0)
Δm	-3.34**(0)	-3.41*(0)	-3.28***(0)	-3.51**(0)	0.13(0)	0.056(1)

The lag length values are shown in parentheses. *, ** and *** indicated statistically significance at 10%, 5% and 1%, respectively. SIC was used to calculate the lag time, with a maximum of 10 lags being considered. AIC and HQC shows different lags, but show almost qualitatively same results.

4.4. Model selection criterion

The optimal lag length was examine based on Akaike information criterion (AIC). Fig. 3 shows the criteria for determining variable lag order and illustrates that ARDL (1, 2, 4) is the best model for this study among the top 20 models.

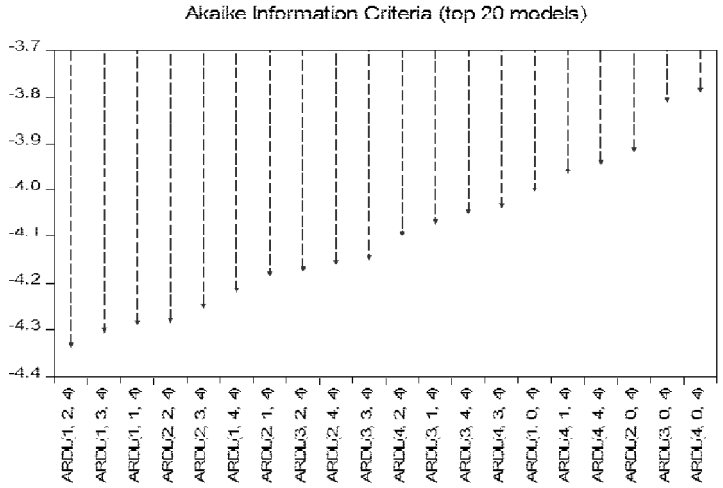


Figure 3: Top 20 ARDL models

4.5. ARDL bounds tests

ARDL bounds test is adopted to examine the long-run relationship among real GDP (y), money (m), and interest rates (r). Table 2 shows the results of the bounds test. It is noted that there is a long-run relationship among real GDP (y), money (m), and interest rates (r). The short-run and long-run equations can then be used to calculate the coefficients of short-run and long–run.

Table 2: F-statistics (bounds test result)
F-statistics = 32.13

Significance level (%)	*Lower bound value*	*Upper bound value*
10	2.63	3.35
5	3.1	3.87
2.5	3.55	4.38
1	4.13	5.0

The coefficient of real GDP has found to significant contributor to money demand in Bangladesh, 1% increase in real interest rate tend to decrease in money demand by 0.00609%. However, the estimated long run money demand function for real money aggregate is:

$$ln\ m_t = -14.04 + 1.47\ ln\ y_t - 0.006r_t \quad (4)$$

The parameter estimates of co-integrating regression presented in Table 3 are therefore consistent. The coefficients that are estimated on y are close to unity, as implied by the money demand function.The algebraic signs of the estimated coefficient are consistent with the theory and are highly significant except the interest rate.

Table 3: Estimated long run results

Variable	*Coef.*	*SE*	*t-statistics*	*p-value*
y	1.4772	0.047092	31.368	0.0000
r	-0.00609	0.0144	-0.421	0.6843
c	-14.04	1.42	-9.83	0.000

ARDL co-integration test, it can be seen that m, y and r have long-run equilibrium relation which is consistent the stable money demand function exist in Bangladesh. Although, the algebraic signs are consistent with the theory, interest rate does not have any role in the long-run and level of money changes proportionally higher than changes in real GDP. We draw the conclusion from the procedures that income elasticity's are substantially greater than unity and interest rate does not work well in Bangladesh economy. This indicates ineffective monetary policy of Bangladesh.

Table 4: Short-run estimation and ECM

Variable	*Coef.*	*SE*	*t-statistics*	*p-value*
D(Y)	-0.998	0.812	-1.22	0.254
D(y(-1))	-1.411	0.849	-1.66	0.1352
D(R)	-0.004	0.004	-0.822	0.4344
D(R(-1))	0.005	0.004	1.08	0.3096
D(R(-2))	-0.006	0.005	-1.18	0.2692
D(R(-3))	-0.016	0.002	-7.43	0.000
CointEq(-1)*	-0.8080	0.060	-13.29	0.000

Table 4 indicates that the error coefficient (EC) is statistically significant at 1% and indicates the co-integration and should have negative. The predicted value of the ECM (-1) model is -0.8080. The absolute value of the ECM's coefficient (-1) is very high, suggesting a rapid return to equilibrium following short-run shocks, with around 80.80% of the disequilibrium induced by previous period shocks reverting to long-run equilibrium in just one period.

4.6. Autocorrelation diagnostic checking

In this study, we have used Lagrange multiplier (LM) test to check whether or not the autocorrelation exists. The results of LM test with two lags are presented in Table 6. Table 6 indicates that there is no autocorrelation in the model residuals.

Table 6: LM with different lag (1, 2)

Lag	*LM F-statistic*	*p-value*
1	1.37	0.2791
2	0.759	0.5080

4.7. Correlogram Q-statistics

The Q-statistics of the Correlogram up to 16 lags indicate that none of the statistics are significant. This result also supports the results of the Breusch-Godfrey Serial Correlation LM test, which indicates that the residuals have no serial correlation. Fig. 4 shows the Correlogram Q-statistics probabilities compared to 12 lags.

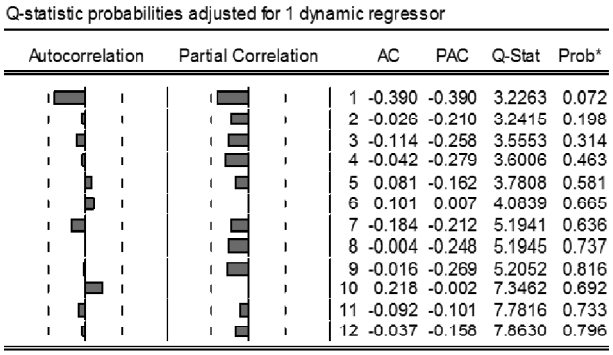


Figure 4: Plot of the Correlogram Q-statistics

4.8. Heteroskedasticity Test

Breusch-Pagon-Godfrey test is implemented to determine if the conditional variations of errors are constant or change over time. The results of the Breusch-Pagon-Godfrey test for heteroskedasticity are shown in Table 6. It is observed that there is no heteroskedasticity problem for the selected lag.

Table 6: Breusch-Pagon-Godfrey test for heteroskedasticity

Lag	*F-statistic*	*p-value*
1	0.447	0.8736

4.9. Normality test

It is noted that the probability value of the Jarque-Bera test is 0.698899, which is statistically insignificant at 5% level of significance and suggests that the result of the residual follows the normality test (see Table 7).

Table 7: Result of the Jarque-Bera test

Jarque-Bera	0.716499
p-value	0.698899

4.10. Model specification test

In this study, the correctness of the specification of a model is checked based on the Ramsey regression specific error test (RESET). Table 8 presents the results of the RESET test and shows that null hypothesis of excluded variables cannot be rejected at a 5% level of significance. That implies that the model is fitted well without any quadratic forms of regressors.

Table 8: Model specification test

Excluded variables	*F-statistic*	*p-value*
Squares of regressors'	1.249	0.3006

4.11. Stability test

The stability of the long-run is examined using CUSUM and CUSUMS-Q tests and the results of which are depicted in Fig. 6[(a) for CUSUM and 6(b)for CUSUMS-Q]. There exists a significant stable relationship over time if the findings remain with a 5% level (represented by two straight lines) (Brown *et al.*, 1975).The plot of CUSUM and CUSUMS-Q of squares along with 5% significance level is presented in Fig. 6 and indicates that the coefficient is stable both in the long-run and short-run and the estimated model is more accurate.

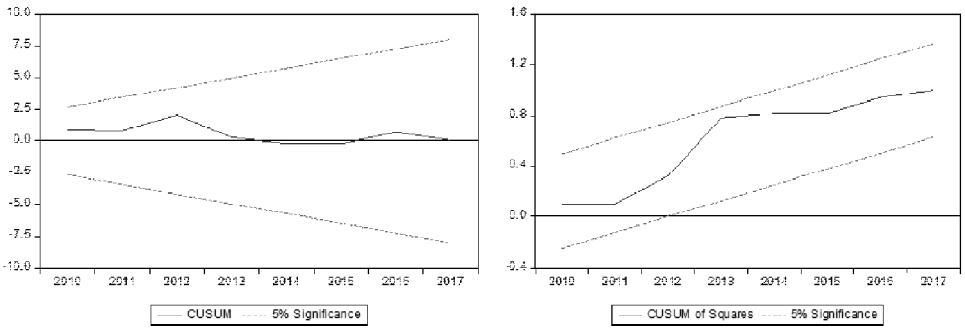


Figure 6: Plot of CUSUM and CUSUMS-Q statistics

5. Conclusion

The aimed is to investigate the long-run relationship among real money, interest rates, and GDP. This study also investigates the market for money holdings' long-run stability. In this work, we implemented the ARDL model to ascertain the co-integration of both long-run and short-run dynamics. Results show that there exists a co-integration among real GDP, money, and interest rates.Results also show that in the long-run interest rates have a negative impact on money and are statistically insignificant. The CUSUM and CUSUMS-Q tests have verified the stability of the long-run money demand functions. Therefore, long-run and short-run estimates are stable and the required model is more reliable in Bangladesh.

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Conflict of interest

None

Reference

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