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Application of ARDL Bound Cointegration Test on Money Output Relationship in Nepalese Economy

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Abstract: The present paper examines the long run relationship between output level and money supply (M1 and M2) in Nepalese economy. In this process, I used the real GDP, Narrow money supply (M1) and Broad money supply (M2) as macroeconomic variables for the study. Yearly time series data for the period of 45 years (1974 /75 to 2018/19) are applied. Econometric tools including Unit root test, Akaike information criterion, ARDL Bound test, error correction. Residual diagnostic tests, stability tests are used to find the long run cointegrating relationship between the variables. I found all the variables are stationary at first differences, which is denoted as I (1). The AIC criteria indicated that ARDL (1,0) is the appropriate model for both cases (lnY lnM1 and lnY lnM2). In ARDL bound test, the F statistic is highly significant which indicates there is long run cointegrating between output level and money supply. The significant and negative value of past error as suggested byECM signifies the short run dynamics in the relationship which is corrected by error correction mechanism. Finally, the residual diagnostic and stability tests provide the information that the model is free from serial correlation, heteroscedasticity as well as it is stable.

INTRODUCTION

The effectiveness (or ineffectiveness) of money supply has been a continuous debate in macroeconomic literature. The quantity theory of money explained that money has no role to influence real variables. The Keynesian view was quite different and explained the role of money to determine the rate of interest through the equilibrium between demand for and supply of money (Keynes, 1936). The monetarist view advocated the direct and active role of money to determine output level in the short run and price level in the long run (Friedman, 1968). On the other hand, Policy ineffectiveness proposition propounded by Lucas (1972), Sargent &Wallace (1975) developed the New Classical doctrine also called

Neutrality theory on the role of money. This concept opined that the unanticipated part of money supply affects output level, while the anticipated part triggers the price level. It has no effect on real economic variables neither in short run nor in the long run. The alternative model of Neutrality theory was developed by Fischer (1977) and Phelps & Taylor (1977). According to them, due to the rigidities in the wage contracts, anticipated monetary shocks have strong impact on real variables at least in the short -run and termed as non-neutrality theory of money.

On this background, many empirical research works have explored the ideas on the role of money using econometric tools and methodology. Sims (1972) applied Granger causality test to detect casual direction between money and income in the post-war data (1947- 1969) of US and found unidirectional causality from Money Supply to Nominal Income. Barro (1977), Barro and Rush (1980), Attfield *et al.* (1981), Canarella& Garston (1983), Chen an Steindl (1987), Marashdeh (1993) have supported the neutrality theory. But Gordon (1982), Mishkin (1982a,1982b), McGee and Stasiak (1985), Chaudhary and Parai (1991) reinforced the non-neutrality theory.

Many other researches on the relationship between GDP and money supply have been based on econometric methodology. Jha and Donde (2002) obtained the result that anticipated monetary policy mattered whereas no significant influence from the unanticipated monetarypolicy existed in the Indian context. They used a standard two-step procedure proposed by Barro and Cointegrating VAR Framework. Both tests concluded the same results that is anticipated money supply affected output level significantly, whereas no such robust conclusionhas been drawn regarding unanticipated components of money.

Psaradakis *et al.* (2005) used VAR models with time- varying parameters and found the causal relationship between money supply and output which varies in time. An empirical research work by Huat & Tai Wai (2000) presented a causality test between money supply (M1, M2 and M3) and GDP for Singapore, using the cointegration methodology and found these variables are cointegrated. They also found a two-way causality test for M1 and GDP and unidirectional causality GDP to both M2 and M3 using Granger Causality test. Mohammad *et al.* (2009) used Johanson cointegration test to find out long run association and Granger causality test to find out bilateral and unilateral causality among M2, inflation, government expenditure and economic growth in case of Pakistan. They used the annual data from 1977 to 2007. They found broad money supply (M2) is positively impacts on economic growth in long run.

Maitra (2011) examined the effectiveness of anticipated and unanticipated money in the variations of output in Singapore over the periods 1971-72 to 2007-08. He found that money supply and output in Singapore are cointegrated but, no cointegration was found between output and anticipated money. The study examined the invariance proposition of rational expectations and found the evidence that the unanticipated part of money supply has significant role in the variations of output growth.

Thaker(2016) employed Pesaran Bound Testing methodology followed by Autoregressive Distributive Lags Models to find the short run and long run relationship between Money Supply, Output level and Price level on Indian annual data (1971 -2013). He found Money supply causes both output and prices in the short run while in the long run money supply does not affect the output level and prices only supporting the neutrality theory. Manikandan *et.al.* (2018) studied the association between the macroeconomic variables using time series method of pair wise Granger causality test on annual data of the Indian economy over the period 1950-51 to 2012-13. The Monetarists view was strongly supported by the result of their study.

Though there are many research works have been found on the relationship between output level and money supplies on the empirical data from advanced economies and other South Asian economies including India and Pakistan applying econometric tools and methodology, but only handful works have been found in case of Nepalese data. So, the main objective of present work to explore the cointegrating relationship between money supplies (M1 and M2) and output level applying ARDL bound test as an econometric methodology in Nepalese scenario.

RESEARCH METHODOLOGY

Data and Variables

The present work is based on the annual time series data for the period of 45 years. The macroeconomic variables (GDP, M1 and M2) over the sample period 1974/75 to 2018/19 are employed to explore the cointegrating relationship between these variables in accordance with the objective set. The data are sourced from various issues of Economic Survey (Ministry of Finance, Nepal) and current issue of Quarterly Economic Bulletin (Nepal Rastra Bank). The Nominal GDP is deflated by GDP deflator (2000/01 =100) to translate the data in Real GDP. All variables are transformed into natural logarithmic form to reduce the heteroscedasticity problems that occur in time series data.

Analytical Tools

Unit Root Test

Dickey and Fuller (1979) explored the econometric tool to test the stationarity/non stationarity for time series data and named it augmented Dickey-Fuller unit root test. The test with constant and linear trend is based on the following equation.

$$\Delta X_t = \alpha + \rho X_{t-1} + \Sigma_{i=1}^{p} \gamma \Delta X_{t-i} + \varphi t + \varepsilon_t \quad (1)$$

If $\rho = 0$, it implies that the original time series Xt contains unit root and is non stationary. If the null hypothesis is rejected, then the series become stationary.

ARDL Bound Cointegration Test

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001) developed ARDL Bound test for exploring cointegration between and among different variables which are either I(0) or I(1) or mixed order I(0) and I(1) for the validity of this model. There should be at most one cointegrating equilibrium involving the dependent variable, where only the dependent variable, and not the regressors, responds to deviations from this equilibrium. The ARDL Bound test in the present study is based on the following equation.

$$lnY_t = \gamma_0 + \alpha_1\, lnY_{t-1} + ... + \alpha_p\, lnY_{t-p} + \beta_0\, lnM1_t + \beta_1\, lnM1_{t-1} + ... + \beta_q\, M1_{t-q}\, \varepsilon_t \quad (2)$$

$$lnY_t = \gamma_0 + \alpha_1\, lnY_{t-1} + ... + \alpha_p\, lnY_{t-p} + \beta_0\, lnM2_t + \beta_1\, lnM2_{t-1} + ... + \beta_q\, M_{2t-q}\, \varepsilon_t \quad (3)$$

Where, ε_t is an *iid* error term. The null hypothesis is that there is no cointegration between dependent variable y_t and regressors M_t, ,……M_{t-q}. If variables are I (1), but not cointegrated, then lagged variables in levels, y_{t-1}, M_t, ……..M_{kt-q} should fail to explain Δy_t.

Error Correction Mechanism

After establishment of cointegrating relationship between the variables, the next step is to carry out the error correction model (ECM). Error correction term is the feedback effect which shows the extent to which disequilibrium in short run converges to the long run equilibrium. The coefficient of regressors show short run causality and coefficient of error correction term shows the long run causality and which must be negative. To test for cointegration between the variables $lnY_t - lnM1_t$ and lnY_t-lnM_{2t} with an ARDL (p, q)representation,the equation (4) is presented.

$$\Delta \ln Y_t = \gamma_1 + \rho_1 Z_{t-1} + \Sigma_{i=1}^{n} \alpha_i (\Delta \ln Y_{t-i}) + \Sigma_{i=1}^{n} \beta_i (\Delta \ln M_{t-i}) + \varepsilon_{1t} \quad (4)$$

Where, Z_{t-1} is the first lag of error correction term γ_1 is the intercept, α_i and β_i are the coefficients of lagged variables and finally ρ_1 is the coefficients of error correction term.

After ARDL bound test with ECM is carried out the next step is to check residual diagnostic and stability diagnostic test for goodness of fit of the selected ARDL model. Residuals diagnostics include Breusch-Godfrey Serial Correlation LM and Breusch-Pagan-Godfrey (B-P-G) approach of heteroscedasticity test. Finally, the stability test includes Ramsey RESET test and CUSUM test and CUSUM of squares test.

RESULTS AND DISCUSSION

Augmented Dickey-Fuller Unit Root Test

The results from ADF unit root test are presented through Table 1.

Table 1
Augmented Dickey-Fuller Unit Root Test

Variables	*ADF test statistic*	*Test critical value at 1 % level*	*Probability*
lnY	2.684	-4.180911	1.0000
ΔlnY	-5.013	-4.186481	0.0010
lnM1	-1.505	-4.180911	1.0000
Δ lnM1	-6.249	-4.186481	0.0000
lnM2	-2.267	-4.186481	0.4420
Δ lnM2	-5.291	-4.186481	0.0005

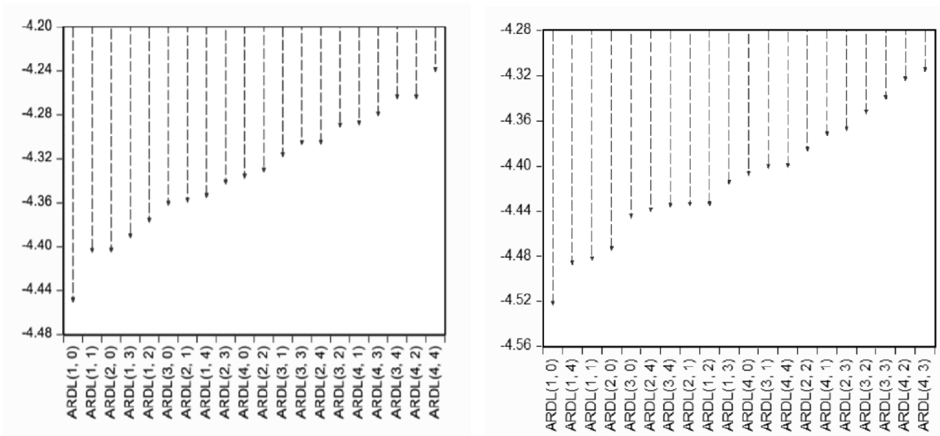
Source: Author's calculation based on time-series data using E-Views 10

From Table 2, it is observed that the variables are not significant at level forms as reported by the corresponding probability values at 1 % level of significance. The null hypothesis for all variables is not rejected in level forms. Hence, these variables are non-stationary (has a unit root) at level forms. However, the hypothesis for the variables is rejected at their first differences implying that the variables are stationary at their first differences. Hence, the variables are integrated as I (1).

Akaike Information Criterion

Present study focused on the ARDL Bounds cointegration test using the data set of GDP and M1 initially and thereafter GDP and M2. The test starts from the model selection criterion. The Akaike information criterion provides the information for model selection. The results obtained for Akaike information Criterion for appropriate model are presented through Figure 1.

Figure 1: Model Selection for ARDL: Akaike Information Criteria (GDP M1 and GDP M2)



Source: Author's calculation based on time-series data using E-Views 10

On the basis of this criterion (AIC), ARDL (1,0) is suitable model for both cases. The figure presents the spikes for 20 models. Among them ARDL (1,0) has the highest negative (minimum AIC) as reported by largest negativespike.Hence,ARDL (1,0) models for both cases lnY and lnM1 and lnY and nM2 are selected as the appropriate and best models.

Long Run ARDL (1,0)

After selecting the appropriate ARDL model based on AIC, the next step is to estimate the long run coefficients of regressors with corresponding standard errors, t-statistic and p-values. These coefficients are the money supply elasticities of outputvalues and are presented through the Table 2.

Table 2
Results from ARDL (1,0) Model with lnYt (Dependent Variable), Sample (adjusted): 1975 2018

Explanatory Variables	*Coefficients*	*Standard Errors*	*t-Statistic*	*Probability*
$\ln Y_{t-1}$	0.7773	0.1005	7.7336	0.0000
$\ln M_1$	0.0742	0.0324	2.2922	0.0271
γ_0	1.5951	0.7118	2.2411	0.0305
Dynamic Regressors (4 lags, Automatic) ,ln M_2 is independent variable				
$\ln Y_{t-1}$	0.7269	0.1072	6.7829	0.0000
$\ln M_2$	0.0780	0.0298	2.6203	0.0123
γ_0	2.003	0.7784	2.5735	0.0138

Included observations: 44 (after adjustments) Maximum dependent lags: 4 (Automatic selection)

From the first part of the table, the dependent variable (ln Yt) is explained by the first lag of the same variable at 1% level and narrow money supply (M1) at 5% level of significance. The GDP is affected through its own first lag by 77.73%. Similarly, the coefficient of M1 (=ln M1) is significant at 5 % level indicating that this variable has also positive impact to GDP. The Narrow money supply (M1) affects GDP by 7.42%. Same conclusion can be drawn for GDP and broad money supply (M2) from the second part of the table. The GDP is caused by its own first lag by 72.69% with 1% level of significance. The Coefficient of lnM2 indicates that there is strong positive impact broad money supply on GDP. It is significant at 5% level and caused GDP by 7.8% which is higher than narrow money supply (M1).

Results of ARDL Bound Test

The results of ARDL Bound test has been presented through the Table 4.

Table 3
F-Bound Test (ln M1) Null Hypothesis: No Levels Relationship

Test Statistic	*Value*	*Significance*	*I (0)*	*I (1)*
F-statistic	54.0316	10%	3.02	3.51
k	1	5%	3.62	4.16
		2.5%	4.18	4.79
		1%	4.94	5.58
ln M2			*Asymptotic N =1000*	
F-statistic	56.3911	10%	3.02	3.51
k	1	5%	3.62	4.16
		2.5%	4.18	4.79
		1%	4.94	5.58

The table presents the value of F-statistic for both models (for M1 and M2 separately). From the first model, the value of F-statisticis 54.0316 and from the second model it is 56.3911.The F-statistic is much greater than all critical values atI(1). The null hypothesis is strongly rejected at all levels (1%, 2.5%, 5% and 10%) of significance. Hence, the null hypothesis level relationship between the variables. The ARDL bound test shows the cointegration between the lnY_t and $lnM1_t$. Same result has been drawn for lnY_t and $lnM2_t$.

Error Correction Mechanism

As the long run relationship between GDP and money supplies has been established, next step is to estimate coefficient of cointegration equation for error correction mechanism. It is presented through the Table 3.

Table 4
Error Correction Mechanism for ARDL (1,0) with Dependent Variable D(lnY)

Variable	*Coefficients*	*Standard Errors*	*t-Statistic*	*Probability*
Z_{1t-1} (lnM1)	-0.2227	0.0171	-13.0385	0.0000
Z_{2t-1*} (lnM2)	-0.2730	0.0205	-13.3201	0.0000

*p-value incompatible with t-Bounds distribution. Restricted Constant and No Trend

In the table, the values of the coefficients of two cointegrating equations have been presented representing equation (4). It shows the system is in the state of short run dynamics. The coefficients are highly significant indicating the past error on the long run relationship between output level and money supplies has been corrected significantly. The negative sign shows that the change in the value of real output level depends inversely on the past error (deviation of actual value from its long run equilibrium path). The departure from the long-term growth path due to short run shocks is adjusted by 22.27% in first model (ln M1) and 27.30% in second model (lnM2) over the next year. The result indicates that the short run shocks significantly affect long run equilibrium between economic growth money supplies.

Residuals Diagnostics and Stability Tests

I checked the strength of the estimated ARDL (1,0) model byusing serial correlation, heteroscedasticityand Ramsey RESET tests. Breusch-Godfrey approach and Breusch-Pagan-Godfrey (B-P-G) approach were used to check the serial correlation and heteroscedasticity respectively in the residuals of the estimated ARDL. Iobserved the stability test of the estimated model using Ramsey's RESET test. The residuals diagnostic and stability test for estimated ARDL (1,0) model has been presented through the Tables 6 and 7.

Table 6
Residuals Diagnostic and Stability Test for Estimated ARDL (1,0) Model (ln M1)

Test Statistic	*B-G Serial Correlation*	*B-P-G Heteroscedasticity*	*Ramsey's RESET*		
F-statistic	0. 5907	0. 4618	4.0365		
Degree of Freedom	(1,40)	(2,41)	(1,40)		
Probability	0. 4467	0. 6334	0.0513		
N* R2	0.6403	0.9693		t-Test	
Probability χ^2	0.4236 (1)	0.6159 (2)	t-statistic	DF	Probability
Scaled- ESS		1.3141	2.0091	40	0.0513
Prob. $\chi^2(2)$		0.5184			

Table 7
Residuals Diagnostic and Stability Test for Estimated ARDL (1,0) Model (lnM2)

Test Statistic	*B-G Serial Correlation*	*B-P-G Heteroscedasticity*	*Ramsey's RESET*		
F-statistic	0. 3466	0.2234	1.1377		
Degreeof Freedom	(1,40)	(2,41)	(1,40)		
Probability	0.5594	0. 8008	0.2925		
N* R2	0.3780	0.4743		t-Test	
Probability χ^2	0.5387	0.7889	t-statistic	DF	Probability
	(1)	(2)			
Scaled- ESS Prob. χ^2 (2)		0.6224 0.7326	1.0666	40	0.2925

From both Tables, we found the F-statistic is insignificant. The value of ($N \times R^2$) and probability value of χ^2 under Breusch-Godfrey Serial Correlation LM test imply that the null hypothesis of no serial correlation is accepted. Hence, the residuals of estimated ARDL are not serially correlated in both models. Likewise, the residuals are also free from heteroscedasticity problem as indicated by F-statistic. The value of ($N \times R^2$) and corresponding probability value of χ^2 under B-P-G. Finally, the t-statistic and F-statistic under Ramsey's RESET test for the first model (when lnM1is regressor) is insignificant at 5% level. It is insignificant even at 10% for the second model (when lnM2 is regressor). The estimated ARDL is correctly specified bearing the property of linearity and hence it is stable equation.

Stability Diagnostic test using CUSUM and CUSUM square

The stability of the model is further checked by applying graphical plot of CUSUM and CUSUM square. It is presented through the Figure 2.

In both cases (CUSUM and CUSUM square) the line graph is in the boundary of. This signifies the model is stable at 5% significance level. The graphical plot is for first model (when M1 is regressor). Same conclusion has been drawn for second model (when M2 is regressor). The graphical presentation has been shown through Figure 3.

CONCLUSION AND POLICY IMPLICATION

The present work was focused mainly to find the long run relationship between output level (GDP) and money supplies (M1 and M2). In this process, I applied ARDL bound test as the main econometric methodology. ARDL (1,0) was the best to interpret the relationships based on AIC criterion. The F statistic was highly significant which indicatedthere is long run

Figure 2: CUSUM and CUSUM of Squares (Recursive estimates): lnYln M1

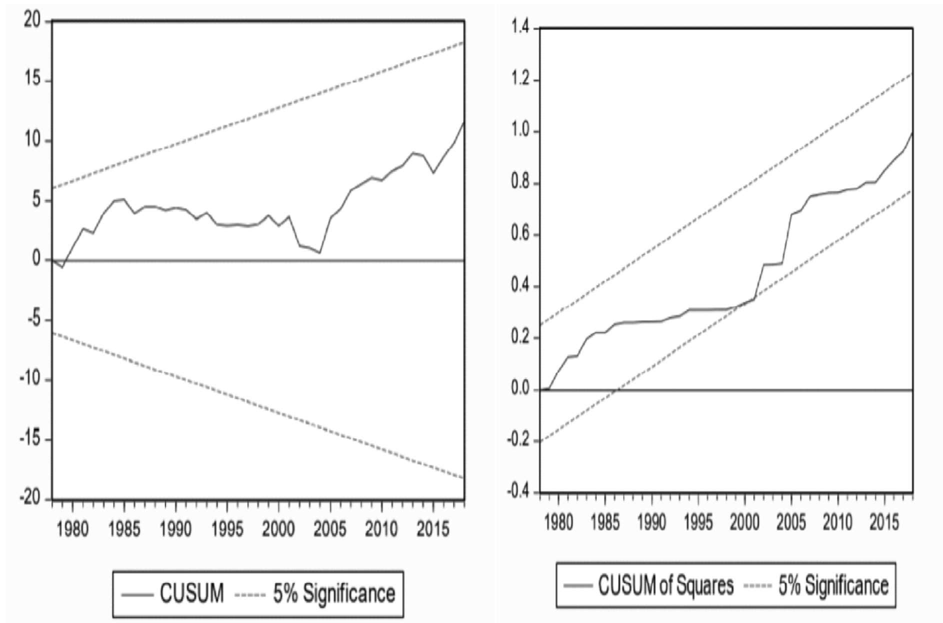
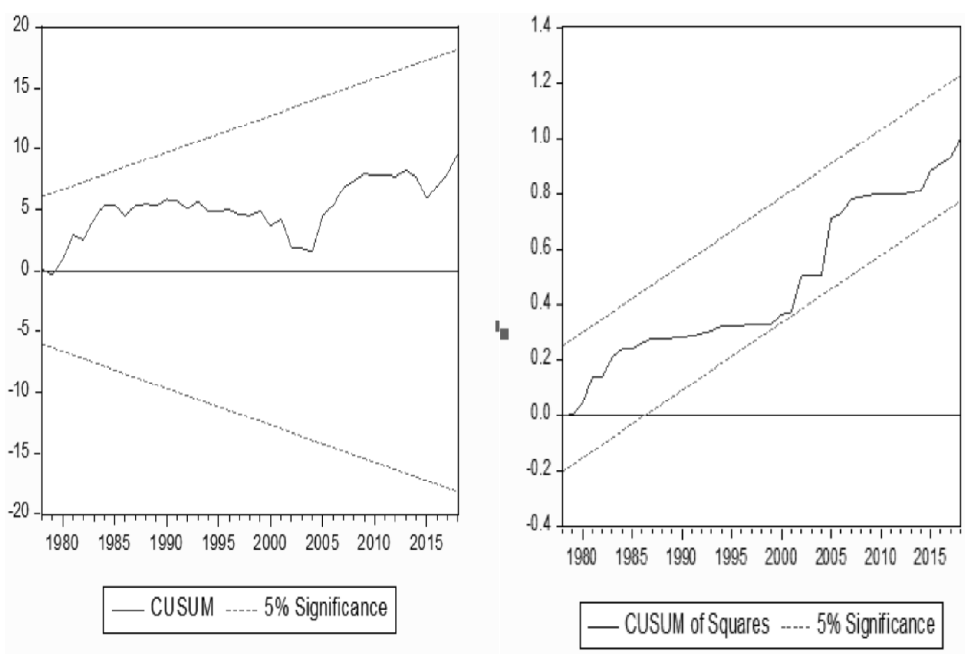


Figure 3: CUSUM and CUSUM of Squares: lnYln M2



cointegrating between output level and money supply in Nepalese economy. The significant negative value of past error in cointegrating equation signified the short run dynamics in the relationship which is corrected through error correction mechanism. The residual diagnostic and Stability tests provided the information that the model was free from serial correlation, heteroscedasticity as well as it was stable. On the basis of this analysis, I conclude that the economic growth of Nepalese economy has been enhanced by money supply (M1 and M2). The overall conclusion of the present analysis is in the support of the monetarist approach.

Regarding policy implication from the analysis, I would like to suggest to adopt and implement expansionary monetary policy. This policy is effective to address the economic growth at present situation also. Currently Nepalese economy is experiencing severely slow economic growth and high unemployment due to pandemic of Covid-19 and other economic and non-economic influences. In such a situation, effective monetary policy more focusing on M2 can address the economic slowdown. It is because M2 is powerful than M1 to affect the output level in Nepalese economy. So, with effective expansionary monetary policy of the central bank of Nepal (Nepal RastraBank), the adverse scenario can be corrected.

Note

1. (a) Null hypothesis: The *variable has a unit root (b) Exogenous: constant and Linear Trend (c) Lag length: 0 (Automatic- based on SIC, max lag =9)*

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