Measuring real money demand in Cambodia: an ARDL approach to cointegration

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Real money demand, error correction model, long-run model, stability tests

Abstract

The findings obtained through the ARDL approach to cointegration indicate that real income, consumer price index, and interest rate are cointegrated with real money demand. In terms of the estimated results derived from the long-run model, it is observed that real income has a statistically significant positive impact on real money demand, while the general price level and interest rate have a negative impact. The short-run dynamic model, known as the error correction model, demonstrates that all explanatory variables collectively account for the growth rate of real money balances. In the short-run, the growth rate of real income exhibits a positive relationship with the demand for real money, whereas the inflation rate and changes in interest rate have a significant negative effect on the demand for real money balances. The estimated slope coefficient of the short-run dynamic model, which measures the speed of adjustment, is projected to be 60.67%. This outcome suggests that the real money balance model takes no more than two quarters to adjust towards long-run equilibrium in response to short-run dynamic shocks. Stability tests, such as the CUSUM and CUSUMSQ tests, indicate that the real money demand function in Cambodia remains stable in the long-term. The findings derived from this study provide empirical evidence in favor of the quantity theory of money.

i. introduction

The demand for money function can be defined as the correlation between the desired quantity of money held by an individual or an economy and the various factors that influence this decision. It is a fundamental concept in the field of monetary economics that aids in understanding the demand for money within an economy. The demand for money function is influenced by multiple factors, including income levels, interest rates, and inflation. A comprehensive understanding of the demand for money function is crucial for policymakers and economists as it facilitates the development of effective monetary policies that can stabilize the economy and foster economic growth (Handa, 2009). The responsibility of monitoring the money supply and implementing monetary policy to ensure price stability and sustainable economic growth lies with the central bank. The efficacy of monetary policy is enhanced when the demand for currency within the economy can be accurately predicted. This enables the National Bank of Cambodia to more precisely determine the equilibrium point between the demand and supply of currency.

The primary aim of this research is to develop a real money demand function for Cambodia that can be effectively utilized by the monetary authority to implement monetary policy. To achieve these objectives, the Autoregressive Distributed Lag (ARDL) approach to cointegration is employed. It is posited that real money demand remains stable in the long term if the plot of the cumulative sum of the recursive residuals and cumulative sum of squares of the recursive residuals consistently remain within the critical bounds at a 5 percent significance level. The distinctive characteristic of the ARDL model lies in its analysis of the short-term dynamics and long-term effects between the explained variable and explanatory variables in the model, particularly the estimation of the speed at which adjustment occurs towards equilibrium. In order to determine the real broad money demand function, three key endogenous variables are taken into consideration, namely real income, consumer price index, and interest rate.

This study is structured into five distinct chapters. The introductory chapter provides an overview of the research topic. The second chapter presents a comprehensive review of the relevant literature.

Chapters three and four outline the research methodology employed and present the empirical findings, respectively. Finally, the concluding chapter summarizes the key findings and offers insights derived from the study.

Ii. Literature Review

Abbas (2008) examined the characteristic of demand for money M2 in a number of Asian nations from 1975 to 2002 employing the ARDL and Eagle-Granger techniques. The study employed annual panel data with 146 observations. The findings shown that money demand and its determining factors were co-integrated in the long run. In all of the Asian countries studied, income was more elastic. Meanwhile, the long-run money demand was explained by the capital mobility and currency substitution. While on the short-run, the money demand was influenced by income, inflation, and interest rate (Abbas, 2008). Likewise, Samreth (2009) explored the element that influence Cambodia's money demand. Giving the study of the factors influencing the money demand plays a vital in policymaking. For that reason, the study analyzed the data from IFS from 1994:12 to 2006:12. The studied indicated that inflation was a significant element in determining the amount of money demand stability in Cambodia, according to the findings. Additionally, the impact of output, inflation, and the exchange rate coefficient on the money demand were also positive and significant (Samreth, 2009). Similar study by Parvez, Nisar, Sami Bedi and Muhammad (2010) used the annual data from 1973 to 2007 to estimate the demand for money (M2) function in Pakistan. The study employed ARDL approach to determine the co-integrational link between the selected variables of the model. The study's finding determined that the demand for money in Pakistan from 1973 to 2007 was stable. Whereas the demand for money had a positive and negative relationship with the inflation and income, and exchange rate elasticity respectively (Parvez, Nisar, Sami, Bedi, & Muhammad, 2010).

In 2011, Suliman and Hala used the same ARDL co-integration approach to examine the demand for money in Sudan from 1960 to 2010. In the study, the aforementioned approach was applied to study the relationship of the variables in the long-run using the annual data from the Central Bank of Sudan. The empirical results indicated a significant relationship between the money demand and the chosen variables in the long-run. On the other hand, the study also indicated that the inflation and exchange rate caused an adverse effect on the money demand and people demand substitution assets. Giving that narrow money demand was being used for money policy analysis (Suliman & Hala, 2011). Another study by AL-abdlrazag and Abdullah (2011) to understand the crucial role of the money demand function in Jordan from 1971 to 2009, the study utilized the unit root ADF, IRFs, VDC approach and co-integration tests. The study used the time series data from 1971 to 2009. The findings suggested that the money demand and income were positively significant. In contrast, the money demand and the exchange rate depreciation were negatively significant (AL-Abdulrazag & Abdullah, 2011).

Augustine and Kiseok (2012) studied the relationship between the exchange rate and the money demand of seven countries from 1973 to 2007. The study indicated that that exchange rate had positive connection with the money demand. On the contrary, the domestic interest rate negatively affected the money demand in all of the seven countries. The study also went on to show that to achieve a worthwhile goal, the broad money (M2) was required by the monetary authorities (Augustine & Kiseok, 2012). A separate study done by Imran, Yasmeen and Fatima (2012) utilized the co-integration and Granger Causality methods to study the impression the monetary policy and inflation on economic growth of Pakistan using the time series data from World Bank and International Monetary Fund from 1972 to 2010. The study suggested that in the short-run only budget deficit affected the demand for money. Meanwhile, the result from Granger Causality test implied a two-way causal relationship between real GDP and the exchange rate. However, real GDP was unilaterally creating fiscal depth, household debt, and budget deficits. As a result, in the study of the Pakistan case from 1972 to 2010 indicated that the exchange rate caused fiscal depth and budget deficit (Imran, Yasmeen, & Fatima, 2012).

Muhammad and Muhammad (2013) investigated the relationship between the demand for real money and its determinants such as, the actual GDP, deposit rates, exchange rates, fiscal reforms and the total population. In the study, the ARDL approaches was used in the experimental analysis. Serving that purpose the data from 1972 to 2011 was utilized. The finding

suggested that the real GDP and exchange rate had a positive and negative relationship with the money demand in Pakistan respectively. Financial innovation and the total population led to more demand for money as the demand for more money for business also increases as the size of the population increases (Muhammad & Mohammad, 2013). Similar study by Adnan, Asad, and Kalim (2013) to determine the money demand function in Pakistan with the help of the monetary policy. The study employed the ARDL bounds testing approach to co-integration. This study used real GDP, industrial production index, CPI, inflation exchange rate, lending and own rate,short term and long-term risk premium as the determinants to define the money demand function. The findings suggested that all of the determinants, thereof were significantly correlated with the money demand in Pakistan over the selected period (Adnan, Asad, & Kalim, 2013).

A similar study in Pakistan case but employed different approach was conducted by Haroon, Masood, and Muhamad (2013) to study the significance of money demand on the financial sector and money policy from 1972 to 2007. The study employed ADF and PP unit root methods to test the stationary of the variables. While on the other hand, the ARDL co-integration was deployed to investigate the co-integration among the variables. The study concluded that the money demand had a positive and negative relationship with income and opportunity cost of holding money respectively (Haroon, Masood, & Muhamad, 2013). In 2014, ThankGod and Tamauntari attempted to determine the money demand function for Nigeria from 1971 to 2012. The study concluded that despites the structural changes, financial crisis, and irregular armed to public rules, the money demand in Nigeria remained unchanged. While the two most vital determinants of the money demand were the income and the interest rate. The study also suggested that in the short run, the money demand was significantly influenced by the transaction and precautionary motives. Last but not least, the finding of this study advised that interest rate played a vital role in long-run speculative for money demand (ThankGod & Tamarauntari, 2014).

On the same year, Muhamad and Khudija (2014) also attempted to investigate the connection between the money demand and its determinants employing the partial adjustment model from 1973 to 2013. In this study, the OLS and Breusch-Godfrey tests were adopted for analysis. The results indicated that the money demand had a positive and negative relationship with real GPD and interest rate respectively in both short and long-run (Muhammad & Khudija, 2014). A re-estimation attempt by Moses (2014) for the money demand function from 2000 to 2013 suggested that the income elasticity of M2 was relatively lower comparing to M3 and M1 which were 0.50, 0.77 and 1.04 respectively. The study also suggested that the depreciation of exchange rate, interest rate elasticity, inflation, and Treasury bill, all negatively affected the money demand except for the interest deposit that positively impact the money demand (Moses K. C., 2014).

Another parallel study on the determining factors of money demand was conducted by Moresblessing, Courage and Genius (2014). The study focus on the money demand function in some chosen Asian countries from 1990 to 2005. The GDP, interest rate and exchange rate were identified as the determinants for money demand. The study concluded that all of the aforementioned variables played a vital role in determining the money demand (Moreblessing, Courage, & Genius, 2014). Last but not least, a separate study on the relationship between the money demand and the exchange rate was also conduct on the case of Pakistan. (Muhammad, Ghulam, & Paras, 2015) The Johansen co-integration and ECM methods were adopted to test the impact of the nominal exchange rate in Pakistan. Comparing between the narrow and broad money, the empirical results suggested that M1 was co-integrated with all of the determinants, while in contrast, M2 was co-integrated with none. The significant nominal exchange rate demonstrated that individuals demand more money M1 as the local currency appreciates in the foreign market. Sambulo (2015) reported that the structural break in 1994 play a vital role in stabilizing the money demand function in South Africa. The data from World Bank and National Reserve Bank from 1970 to 2013 were used to examine the demand model for narrow and broad money in South Africa. By comparing the postand prior period of breaks Gregory Hansen's test finds that broad money demand function is not affected by these breaks. The study also advocated that the liberalization of monetary policies and floating exchange rate policy were necessary for South Africa (Sambulo, 2015).

To examine the short- and long-term relationship between money demand and other macroeconomic variables: official exchange rate, interest rate, gross domestic product, ratio of fiscal deficit to gross domestic product, and population in rural and urban area in Pakistan, the ARDL approach to cointegration was applied using time series data for the period ranges from 1972 to 2013. While rural population and the exchange rate have a substantial negative impact on money demand in Pakistan, the empirical results demonstrate that interest rates have a negative impact on money demand in both the short and long run (Umbreen, Dawood, & Muhammad, 2016). An error correcting model known as the ARDL method was employed to implement Taylor's rule and increase monetary policy effectiveness in Nigeria between 1998:Q1 and 2014:Q4. It was assumed in this research that the Nigerian Central Bank thought that changes in money demand were caused mostly by changes in the interest rate. Monetary policy variables are following the same trend, with inflation dropping and productivity rising (Ikechukwu, Faith, & Roseline Ike-Anikwe, 2016). Money demand function for narrow (M1) and broad (M2) money based in Yemen were developed based on ARDL bounds testing approach to cointegration and error correction modeling. The period of the study was between 2001:Q1 and 2013:Q4. There were three keys explanatory variables: real income, inflation rate, and nominal exchange rate included in the short- and long-term models. M1 and M2 had been influenced positively and negatively by real income and inflation rate respectively. In addition, the two determinant variables were explained the monetary aggregates in the long-term (Essa, 2016).

The study in Turkey had indicated that real money demand was explained by real domestic output and interest rate. The estimated method of this study was different from other research because dynamic OLS was employed on two different model log-log money and interest rate and log-log real money with real income and interest rate under annually data, 1970 and 2013. More interestingly, to take into account structural break of each time series data, besides applying ADF test for unit root, Zivot and Andrews test were also conducted. Nevertheless, long-run relationship between explained and explanatory variables instead of using the Bound test, the Johansen trace test was carried out. The empirical investigate showed that logarithm of real money balance equation perform better than logarithm of money demand specifications assuming unitary income elasticities (Oguz, 2017).

In constructing demand of money function, GDP, inflation rate, foreign exchange, domestic interest rate were always be set up as independent variables, but to re-examine the demand for broad money, M2, in Nigeria, in addition to the four key variables mentioned early, the foreign interest rate and stock market index of Nigeria were also put into the ARDL approach to cointegration model with quarterly time series data time span between the first quarter of 1985 and fourth quarter of 2016. The Bound test revealed that money demand was cointegrated with its explanatory variables or had a long-run relationship. Especially, stock index had a positive significant effect on real money stock in Nigeria (Moses, Usman, Patricks, & Nurodeen, 2018). In extension the study which was conducted by (Samreth, 2009) about real money demand in Cambodia using ARDL approach to cointegration which was developed my (Pesaran, Shin, & Smith, Bounds Testing Approaches to the Analysis of Level Relationships, 2001), but instead of using monthly data, (Long, Ignatius, & Agus, 2018) applied annually data between 1996 and 2016. The log of real money demand was run with four independent variables: log of real income, inflation rate, exchange rate and dummy variable (1 for the period 1997-1998 and 0 elsewhere) which represented political turmoil in Cambodia. In addition, M2 was used instead of M1 as a proxy of money demand. The main objective of the study was to investigate the stability of money demand in Cambodia. As indicated by the CUSUM and CUSUMSQ test, the real money demand function was stable. The empirical result further showed that inflation rate and exchange rate explained real money demand.

Over the period 1970-2018, the analysis of money demand function in Malaysia under ARDL approach to cointegration had shown that financial innovation and real GDP had positive and negative significant explained real money demand, respectively. More interestingly, the depreciation of exchange rate by one unit would cause the increase in real money demand by 0.97 in the long-run, while a 1 percent increase in real GDP would decrease real money demand by 0.6395. Nevertheless, the estimated model seems to be not stable as indicated by CUSUMSQ test (Muhammad & Jauhari, 2019). The factor which determined the demand for real monetary aggregate (M1 and M2) in Indonesia such as real income, price level, domestic interest rate and foreign interest rate were found to having a long run relationship

regarding the result of the bound test. The real demand for M1 and M2 in short and long term were positively explained by inflation rate, real income and exchange rate. Moreover, domestic and foreign interest rates had a significant effect just only on M2 but had no influence on M1. As referring to CUSUM and CUSUMSQ test, the real money demand of Indonesia was not stable within the time frame between 2000:Q1 and 2019:Q4. Two particular reasons had been raised up to explain the instability of real money demand Indonesia. The first reason is due to the flexibility of inflation targeting which was always been carried by the Bank Indonesia. The second reason is because of macroeconomic stability which caused money demand being negatively affect by exchange rate (Mahrus, 2020). The monetary aggregate in Algeria had been classified into three different types: Cash, M1 and M2. The long-run equation of each real money demand was run with real GDP, Treasury bill rate, inflation rate and exchange rate. The time span of the study was between 1979 and 2019. The estimated elasticity of the scale variables was 1.019, 1.040, and 1.006 for M2, M1, and Cash respectively and each estimated parameter was statistically significant. The elasticity of inflation rate was also significant explain the three aggregate of real money demand, while Cash generated the highest one. The empirical result of this study had further revealed that real money demand for M1 and M2 were stable, while the demand for fiat money was unstable (Raouf, Mohammed, & Mohamed, 2021).

Regarding the monetary economic theory, real demand for money is a function of income and interest rate, but in practice the demand for money could be determined by not just only income and interest rate, but it could be explained by other variables as well such as nominal exchange rate and consumer price index as well. As referred to the above literature reviews, the empirical result from different countries generated different conclusion regarding the variables which had a significant effect on money demand. The causes of the different might have explained by different characteristic of each country economic structure or the behavior of economic agents react toward the demand for money. In addition, despite using the same model as such ARDL model to investigate or construct a real demand for money function, but different time series data set would produce different result.

As show earlier in this literature reviews, a real money demand function in Cambodia was firstly established in 2009 and then again in 2018 by Samreth (2009) and Long et. al (2018). To construct a real narrow based money (M1), the first paper used monthly time series data between December 1994 and December 2006, but there were only three keys macroeconomic variables: real income, inflation rate and exchange and one dummy variable to control for political upheaval during 1997-1998 which included in the ARDL approach. The second paper replicated the first paper since the research methodology was exactly the same, but instead of determining the real narrow based money demand function, this study created a real broad money (M2) demand function. Despite using the same methodology as the first paper, but annually data were employed between 1996 and 2016. These two research articles did not take into account one of the most important macroeconomic indicator which was interest rate. Thus, to fill out this gap, interest rate variable is incorporated into the ARDL approach to cointegration in order to develop a real broad money demand function for Cambodia. In addition, quarterly time series data between 2012:Q1 and 2022:Q4 are applied.

As demonstrated in previous literature reviews, the establishment of a real money demand function in Cambodia occurred in 2009 by Samreth (2009) and was subsequently revisited in 2018 by Long et. al (2018). The initial paper utilized monthly time series data from December 1994 to December 2006, incorporating three key macroeconomic variables: real income, inflation rate, and exchange rate, along with a dummy variable to account for political upheaval during 1997-1998. This approach was employed within the ARDL framework to construct a real narrow-based money (M1) demand function. The second paper replicated the methodology of the first paper, but instead focused on determining the real broad money (M2) demand function. However, despite utilizing the same methodology, the second paper employed annual data from 1996 to 2016. Notably, both research articles overlooked the inclusion of a crucial macroeconomic indicator, namely the interest rate. In order to address this gap, the ARDL approach to cointegration was augmented with the incorporation of the interest rate variable, enabling the development of a money demand function for Cambodia. Furthermore, quarterly time series data spanning from 2012:Q1 to 2022:Q4 were utilized in this study.

Iii. Methodology

ARDL approach to cointegration is applied in order to determine a long-run relationship between dependent and independent variables which was developed by Pesaran and Shin (1998). A real money demand function which is the ratio between broad money (M2) and price level, in Cambodia is constructed as a function of consumer price index (CPI) and interest rate (R). The reasons that this study applies ARDL approach to construct real money demand function because this technique provides three ways of economic analyses: cointegration analysis, long-run relationship analysis, short-run dynamic analysis and especially the analysis the speed of adjustment which are different from the other models which could not perform the three analyses at the same time. Cointegration represents the existence of the long-run relationship between the real money demand (dependent variable) and its independent variables—real income, consumer price index and interest rate. In econometrics theory, a spurious result will not be produced, if a regression of time series data in level is deployed between explained variable and explanatory variables regardless each series has a unit root or non-stationary. In summary, the estimated result can't be generated, if cointegration on long-run relationship between dependent variable and independent variables does not exist. In this case, only short-run dynamic regression result is estimated and presented. The estimated parameters which are made from ARDL regression result are technically used for developing diagnostic and cointegration tests not for making any economic interpretation. The interpretation is made just only on long and short run regression result. The short-run dynamic model is so called a model at different level of variables which is different from long-run model which is estimated based on at level variables. ARDL model and long-run equation as well as error correction model specification are presented in equation (1) and (2) respectively.

ARDL Model and Long-Run Equation

$$DlnM2_t = \delta_0 + \sum_{j=1}^{q} \varpi_j DlnM2_{t-j} + \sum_{j=1}^{p} \theta_j DlnGDP_{t-j} + \sum_{j=1}^{l} \tau_j DlnCPI_{t-j} + \sum_{j=1}^{d} \varphi_j DR_{t-j} + \delta_1 lnM2_{t-1} + \delta_2 lnGDP_{t-1} + \delta_3 lnCPI_{t-1} + \delta_4 R_{t-1} + \nu_t \quad (1)$$

All variables are expressed as a natural logarithm which is denoted as ln except interest rate, R. D represents first difference and the first difference of log is interpreted as growth rate. $\delta, \varpi, \theta, \tau,$ and φ are the parameters to be estimated and ν is the error term of the model. The optimal lags length of the model is determined using Schwarz Bayesian Criterion (SBC). The lower the SBC, the better the model. To fulfill the requirement of the model a diagnostic tests including Lagrange Multiplier (LM) test for the nth order of autocorrelation, Ramsey's test (RESET) for functional form misspecification, Jarque-Bera (JB) test for normality of the residuals term, and White's test for heteroscedasticity (HET) are performed.

Bound test was developed by Pesaran et al. (2001) to define a long-term relationship between explained and explanatory variable in the model. The test was developed based on the *F*-Statistic. As referring to equation (1), the null hypothesis of no cointegration which is $H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$ against the alternative hypothesis of cointegration which is $H_A: \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq 0$, among variables under investigation are created. The null hypothesis is rejected when the calculated *F*-Statistic is greater than critical bound *F*-Statistic. In addition to the diagnostic tests and the bound test of the ARDL model, the Cumulative Sum (CUSUM) of the recursive residuals and Cumulative Sum of Squares (CUSUMSQ) of the recursive residuals tests which was developed by Brown et al. (1975) are employed to check the stability of real money demand function. After obtaining the empirical estimate of ARDL model and long-run equation, a short-run dynamic model known as error correction model (ECM) is established. The purpose of this model is to examine the impact of the growth rate of real domestic output, inflation rate, and change in interest rate on the growth rate of real money demand. Specifically, it aims to estimate the speed of adjustment, which elucidates the rate at which the economy adapts towards long-term equilibrium in response to any shock that disrupts the short-term dynamic model's equilibrium. The equation (2) below presents the ECM.

Error Correction Model (ECM)

$$DlnM2_t = \alpha + \gamma\left(lnM2_{t-1} - \hat{\tau} - \hat{\zeta} lnGDP_{t-1} - \hat{\lambda} lnCPI_{t-1} - \hat{\xi} R_{t-1}\right) + \sum_{j=0}^{q} \psi_j DlnM2_{t-j} + \sum_{j=0}^{p} \pi_j DlnGDP_{t-j} + \sum_{j=0}^{l} \phi_j DlnCPI_{t-j} + \sum_{j=0}^{d} \eta_j DR_{t-j} + \varepsilon_t \quad (2)$$

Where α is intercept, γ is speed of adjustment, $\psi, \pi, \phi,$ and η are slope of each respected explanatory variables. The estimated coefficients: $\hat{\tau}, \hat{\zeta}, \hat{\lambda},$ and $\hat{\xi}$ are extracted from long-run equation, equation (2).

Table 1. Expected sign of long-run effect of real money demand function

Explanatory variables	Expected sign
Real income	+
Price level	-/+
Interest rate	-

The anticipated indication, which illustrates the impact of each individual variable on the long-term real money demand function as presented in Table 1, has been formulated based on the characteristics of the Cambodian economy.

Data

This research utilizes quarterly time series data spanning from 2012:Q1 to 2022:Q4. The data on broad money and interest rates are sourced from the International Financial Statistics (IFS) of the International Monetary Fund (IMF), while consumer price indexes are obtained from the website of the National Bank of Cambodia (NBC). Unfortunately, quarterly gross domestic product data is not available for the study period. To address this, a quadratic interpolation technique is employed to disaggregate the annually reported real gross domestic product data from the Asian Development Bank (ADB) into quarterly time series data (Asian Development Bank, 2023). Given the use of time series data, an Augmented Dickey-Fuller (ADF) test is conducted to test for unit root.

Iv. Empirical Result

This section has been subdivided into three primary components, namely descriptive statistics, unit root test, and the estimated outcomes of the long-run and short-run equations derived from the ARDL approach to cointegration.

Table 2. Descriptive Statistics

	DLNM2	DLNGDP	DLNCPI	R
Mean	4.149403	1.361369	0.701537	11.34722
Median	4.551028	1.699658	0.825294	11.00744
Maximum	18.09134	3.148886	3.370533	13.37000
Minimum	-9.116375	-3.419739	-2.339795	10.12400
Std. Dev.	4.055339	0.955468	0.972400	1.032327
Skewness	0.607752	-3.085566	-0.605368	0.692247
Kurtosis	7.941438	15.75687	5.574898	2.115814
Jarque-Bera	47.47464	368.1710	14.84263	4.947453
Probability	0.000000	0.000000	0.000598	0.084270
Sum	182.5737	59.90024	30.86764	499.2777
Sum Sq. Dev.	707.1684	39.25551	40.65918	45.82504
Observations	44	44	44	44

During the study period spanning from the first quarter of 2012 to the fourth quarter of 2022, a total of 44 observations were included in the sample. The average quarterly growth rate of real broad money

amounted to 4.15 percent. Concurrently, real income experienced a growth rate of 1.36 percent, while the inflation rate stood at 0.70 percent. Notably, the average interest rate was notably high, approximately 11.35 percent per annum. According to the Jarque-Bera test, it was observed that the series for broad money, real GDP, and inflation rate did not follow a normal distribution, as the probability values obtained from the test were all below 5%. Conversely, the interest rate series exhibited a normal distribution, as the null hypothesis of the Jarque-Bera test failed to be rejected at the 5% significance level.

Table 3. ADF Unit Root Test

		At Level			
		LNM2	LNGDP	LNCPI	R
With Constant	t-Statistic	-1.6441	-1.4840	0.4810	-2.3868
	Prob.	0.4519	0.5319	0.9840	0.1514
		n0	n0	n0	n0
With Constant & Trend	t-Statistic	-0.9637	-1.6743	-3.0595	1.0962
	Prob.	0.9385	0.7450	0.1288	0.9999
		n0	n0	n0	n0
Without Constant & Trend	t-Statistic	4.9103	2.3765	4.5689	-2.4623
	Prob.	1.0000	0.9950	1.0000	0.0150
		n0	n0	n0	**
		At First Difference			
		DLNM2	DLNGDP	DLNCPI	DR
With Constant	t-Statistic	-7.2475	-2.9976	-5.7905	-11.8870
	Prob.	0.0000	0.0433	0.0000	0.0000
		***	**	***	***
With Constant & Trend	t-Statistic	-7.6384	-3.1932	-5.7784	-6.6919
	Prob.	0.0000	0.0996	0.0001	0.0000
		***	*	***	***
Without Constant & Trend	t-Statistic	-2.0905	-1.6753	-4.3909	-11.1432
	Prob.	0.0365	0.0884	0.0000	0.0000
		**	*	***	***

Notes:

a: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1% and (no) Not Significant

b: Lag Length based on SIC

c: Probability based on MacKinnon (1996) one-sided p-values

The Augmented Dickey-Fuller (ADF) tests were conducted on each time series data being investigated using three different regression models: a model with a constant, a model with a constant and trend, and a model without a constant and trend. The results of these tests can be found in Table 3. At the chosen significance level, the null hypothesis for real broad money, real GDP, and the consumer price index cannot be rejected for any of the three models of the ADF test. This suggests that these variables have a unit root. However, when considering the model with a constant and the model with a constant and trend, the interest rate variable does have a unit root. On the other hand, when using the model without a constant and trend, the interest rate variable is stationary. When taking the first difference of the data series, all variables exhibit no unit root or stationarity, as the null hypothesis of the test for each variable is rejected. In summary, all variables under investigation are integrated of order one, denoted as I(1).

The subsequent step involves the implementation of the ARDL approach to cointegration. The optimal length of lags for the model selection criterion is determined by the Schwarz Bayesian Information Criterion (SBC). The order of the model regressors is arranged in the following sequence: real broad money expressed in lag term, real income, price level, and interest rate. The estimation of the model

is expressed as ARDL(q,p,l,d), where q, p, l, and d represent the optimal lag length with respect to the order of each respective variable set up above. Based on the SBC, the optimal lag length of the model is ARDL(1,0,0,1). The estimated parameters indicated in Table 4 serve three primary objectives, namely, to perform a stability test of the real money demand function, to test for the existence of a level relationship among the variables in the ARDL model, and to generate a long-run model of real money demand, which will be subsequently used to establish a short-run model, known as the error correction model, especially to predict the speed of adjustment.

Table 4. Autoregressive Distributed Lag Estimates

ARDL(1,0,0,1) selected based on Schwarz Bayesian Criterion

Dependent variable is LNM2

44 observations used for estimation from 2012Q1 to 2022Q4

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
LNM2(-1)	0.3933	0.1397	2.8158[.008]
LNGDP	0.5816	0.1474	3.9461[.000]
LNCPI	-0.5403	0.2658	-2.0326[.049]
R	-0.0581	0.0144	-4.0431[.000]
R(-1)	0.0263	0.0139	1.8900[.066]
TREND	0.0181	0.0042	4.3279[.000]

R-Squared	0.9977	R-Bar-Squared	0.99744
S.E. of Regression	0.0267	F-Stat. F(5,38)	3345.9[.000]
Mean of Dependent Variable	6.0445	S.D. of Dependent Variable	0.52762
Residual Sum of Squares	0.0271	Equation Log-likelihood	100.1769
Akaike Info. Criterion	94.1769	Schwarz Bayesian Criterion	88.8243
DW-statistic	1.7209	Durbin's h-statistic	2.4606[.014]

Table 5 displays the diagnostic tests for this model. The interpretation of these tests is based on the Lagrange Multiplier (LM) Version, which relies on the assumption of a Chi-square distribution. With regards to the serial correlation test, at a 5% significant level, the null hypothesis that the residual terms are serially uncorrelated cannot be rejected. Furthermore, the Ramsey's RESET test, which uses the square of the fitted values, has indicated that the ARDL model is correctly specified, as the probability of the calculated Chi-square is 94.3%, which is greater than the 5% significant level. However, the residual terms of the estimated model do not follow a normal distribution, as the probability of the normality test is less than the 5% significant level. The White's test for heteroskedasticity has shown that the variance of the error term is constant or homoskedastic. In summary, the estimated results of the ARDL approach to cointegration have passed all diagnostic tests. Furthermore, it is noteworthy that all slope coefficients collectively account for the dependent variable, as evidenced by the *F*-statistical probability of 0.000, which falls below the 1% level of significance. Of particular interest, the model explains 99.77% of the variance in the fitted data within the regression model.

Table 5. Diagnostic Tests

Test Statistics	LM Verstion			F Version		
A:Serial Correlation	CHSQ(4)	=	2.6359[.620]	F(4,27)	=	0.5417[.706]
B:Functional Form	CHSQ(1)	=	0.0051[.943]	F(1,30)	=	0.0043[.948]
C:Normality	CHSQ(2)	=	16.7029[.000]	Not applicable		
D:Heteroscedasticity	CHSQ(1)	=	2.6650[.103]	F(1,40)	=	2.7079[.107]

A:Lagrange multiplier test of residual serial correlation

B:Ramsey's RESET test using the square of the fitted values

C:Based on a test of skewness and kurtosis of residuals

D:Based on the regression of squared residuals on squared fitted values

In order to check for the existing of a level relationship or cointegration among the variables in the ARDL model, bound test is carried out. There are two different type tests of statistics, *F*-statistic and *W*-statistic, using within the bound test. In each test of statistic, the lower and upper bound at 90 percent and 95 percent confident level are provided. The null (H_0) hypothesis and alternative (H_A) hypothesis are written as follow. H_0 is rejected when the *F*-statistic or *W*-statistic is greater than the upper bound.

$$H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$$
$$H_A: \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq 0$$

The outcome of the bound test, as displayed in Table 6, indicates that the 95 percent lower and upper bounds are 3.5447 and 4.7921, respectively. This is due to the fact that the *F*-statistic, which stands at 7.7798, significantly exceeds the upper bound value. Consequently, the null hypothesis, which suggests the absence of a level relationship or cointegration among the real broad money, real income, price level, and interest rate in the ARDL model, is rejected. The consistency between the *F*-statistic and *W*-statistic further supports this conclusion.

Table 5. Testing for existence of a level relationship among the variables in the ARDL model

F-statistic	95% Lower Bound	95% Upper Bound	90% Lower Bound	90% Upper Bound
7.7798	3.5447	4.7921	2.9124	4.0304
W-statistic	95% Lower Bound	95% Upper Bound	90% Lower Bound	90% Upper Bound
31.1191	14.1786	19.1684	11.6497	16.1215

In the long-term, the demand for real money in Cambodia exhibits a positive correlation with real income at a significant level of 1 percent. This empirical finding aligns with the theory of real money demand, which suggests that as people's real income increases, their demand for money also increases. Additionally, in the long-term, the demand for real money demonstrates a negative relationship with the general price level at a significant level of 10 percent. This implies that an increase in prices leads to a decrease in the demand for money. As anticipated, the interest rate has a negative impact on the demand for real money, and this impact is statistically significant at a level of 5 percent. Specifically, as the interest rate rises, the demand for real money decreases.

Table 6. Estimated Long Run Coefficients using the ARDL Approach
ARDL(1,0,0,1) selected based on Schwarz Bayesian Criterion

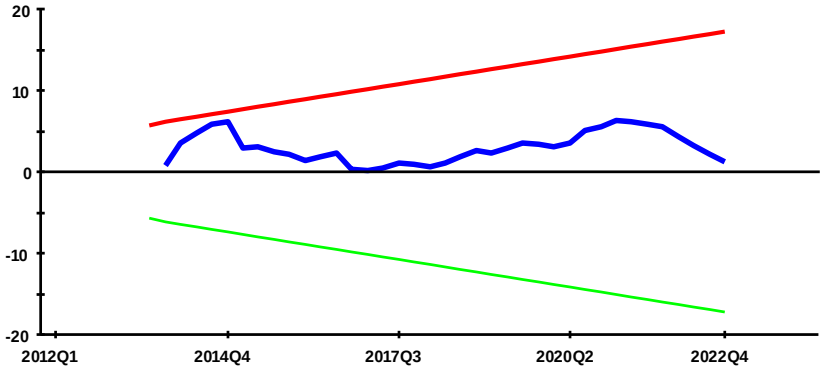
Dependent variable is LNM2

44 observations used for estimation from 2012Q1 to 2022Q4

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
LNGDP	0.9587	0.1920	4.9932[.000]
LNCPI	-0.8905	0.4553	-1.9557[.058]
R	-0.0524	0.0253	-2.0697[.045]
TREND	0.0299	0.0026	11.5524[.000]

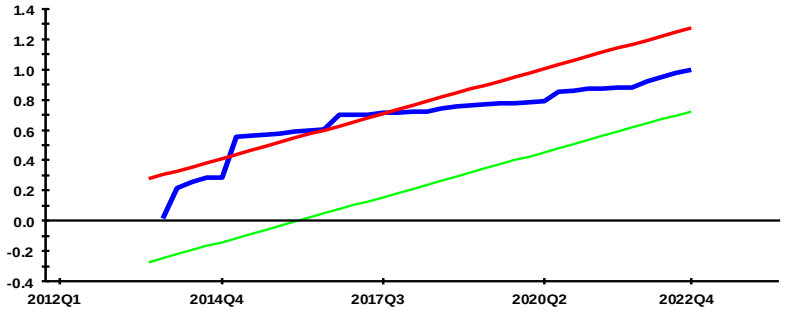
In order to check the stability of real money demand function, the cumulative sum (CUSUM) and cumulative sum of square (CUSUMSQ) recursive residuals tests are employed. As showed in Graph 1 and Graph 2, the plot of CUSUM and CUSUMSQ are statistically smoothly stay in the critical bounds at 5 percent significant level which claimed that the real broad money demand is stable.

Graph 1. Plot of Cumulative Sum of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

Graph 2. Plot of Cumulative Sum of Squares of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

The findings presented in Table 8 indicate that there is a positive correlation between the growth rate of real GDP and the real growth rate of money demand. The sample parameter for this relationship is 0.5816, which is statistically significant at the 99% confidence level, as the p-value is lower than 0.01 (0.000). On the other hand, the inflation rate and changes in interest rate have a negative impact on the real growth rate of money demand, with significance levels of 5% and 1% respectively. These results are consistent with the long-run model, which suggest that these factors have a negative effect on money demand.

According to the findings of the same model, it has been observed that the slope coefficient of the error correction term is -0.6067, which aligns with the principles of econometric theory. It is worth noting that this coefficient holds great significance at the 1 percent level. In the field of economics, the estimated parameter of the error correction term is utilized to gauge the rate at which variables within the model adjust in response to short-term dynamic shocks that may influence the long-run equilibrium. Specifically, the estimated parameter of the error correction term indicates the time required for the long-run real money demand function to converge towards equilibrium if the short-term dynamic equation deviates from equilibrium. The projected speed of adjustment is estimated to be 60.67% per quarter, implying that in the event of any economic shock affecting the short-term dynamic growth rate of the real money demand function, the time needed to readjust towards long-run equilibrium would not exceed two quarters. This outcome accurately reflects the current state of Cambodia's economy, where the National Bank of Cambodia, also known as the central bank, consistently formulates comprehensive strategies to address any adverse effects on the economy, particularly concerning money demand and supply.

Table 8. Error Correction Representation for the Selected ARDL Model

ARDL(1,0,0,1) selected based on Schwarz Bayesian Criterion

Dependent variable is DLNM2

44 observations used for estimation from 2012Q1 to 2022Q4

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
DLNGDP	0.5816	0.1474	3.9461[.000]
DLNCPI	-0.5403	0.2658	-2.0326[.049]
DR	-0.0581	0.0144	-4.0431[.000]
DTREND	0.0181	0.0042	4.3279[.000]
ecm(-1)	-0.6067	0.1397	-4.3434[.000]
R-Squared	0.6164	R-Bar-Squared	0.5659
S.E. of Regression	0.0267	F-Stat. F(4,39)	15.264[.000]
Mean of Dependent Variable	0.0415	S.D. of Dependent Variable	0.0406
Residual Sum of Squares	0.0271	Equation Log-likelihood	100.1769
Akaike Info. Criterion	94.1769	Schwarz Bayesian Criterion	88.8243
DW-statistic	1.7209		

Furthermore, the study also includes a simultaneous test to determine the significance of the population parameters of the regressor in explaining the growth rate of real broad money demand. This is done using the *F*-statistic. The results, as presented in Table 8, indicate that the calculated *F*-statistic is 15.264, with a test probability of 0.000, which is less than 1 percent. Based on these findings, it can be concluded that all slope coefficients in the error correction model collectively contribute to explaining the growth rate of real money demand. This implies that both the independent and dependent variables are highly statistically significant. Additionally, the *R*-square value of 0.6164 indicates that the model accounts for 61.64% of the variation in the fitted data within the regression model.

V. Conclusion

In this study, the ARDL approach is adopted to study the cointegration between variables. The result indicated that the real GDP, consumer price index and interest rate have a long-run relationship with real money demand. In other word, meaning that all observed variables are cointegrated. Moreover, the result of the study also demonstrated that in the long-run, the real income, general price level, and interest rate are significant to explain the real money demand. Furthermore, the stability tests, CUSUM and CUSUMSQ tests in this study have also revealed that the real money demand in Cambodia is stable.

Additionally, the short-run dynamic model, ECM, suggests that all variables incorporate to explain the growth rate of real broad money as demonstrated in *F*-test. In the short-run, the growth rate of real GDP still has a positive relationship with the demand for real money, while the inflation rate and changes in interest rate have negative relationship. It has been observed that the slope coefficient of the error correction term is -0.6067, which is consistent with the principles of econometric theory. It is important to note that this coefficient holds significant value at the 1 percent level. In the field of economics, the estimated parameter of the error correction term is used to measure the rate at which variables in the model adjust in response to short-term dynamic shocks that may impact the long-run equilibrium. Specifically, the estimated parameter of the error correction term indicates the time it takes for the long-run real money demand function to converge towards equilibrium if the short-term dynamic equation deviates from equilibrium. The projected speed of adjustment is estimated to be 60.67% per quarter, suggesting that in the event of any economic shock affecting the short-term dynamic growth rate of the real money demand function, the time required to readjust towards long-run equilibrium would not

exceed two quarters. The findings derived from this study provide empirical evidence in favor of the quantity theory of money

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