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An Examination of Monetary Aggregates in Cambodia: A Vector Autoregressive Model

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ABSTRACT

In order to investigate the movement of monetary aggregate in Cambodia, a system of equations known as the Vector Autoregression (*VAR*) model was adopted. The model included four endogenous variables, namely broad money, inflation rate, exchange rate, and interest rate. The study period covered from January 2002 to March 2023. The Augmented Dickey-Fuller test indicated that the money supply and consumer price index series were integrated of order one, *I(1)*, while the exchange rate and interest rate were integrated of order zero, *I(0)*. To avoid spurious results, all data series were transformed to first differences and the *VAR* model was run. The optimal lag length of the model was determined to be one lag, as indicated by the Schwarz Information Criterion. The impulse response function revealed that inflation rate had a positive impact on the movement of monetary aggregate, while exchange rate depreciation had a negative impact on monetary aggregate. In contrast, the movement of interest rate had a less significant influence on money supply. The forecast error variance decomposition over twelve months into the future showed that the variation of monetary aggregate was mainly explained by exchange rate fluctuation, followed by inflation rate, and the least variation was caused by interest rate.

Keywords: Monetary Agreegate, Inflation Rate, Exchange Rate, Interest Rate, *VAR* Model

1. INTRODUCTION

In 2013, the monetary aggregate, as measured by *M2*, amounted to 34,553.45 billion Riel. By 2022, this figure had increased to 171,962.13 billion Riel. Over the ten-year period from 2013 to 2022, the average growth rate of the money supply was 19.9%. Simultaneously, the average exchange rate, expressed as Riel per US Dollar, stood at 4,064.76. The average annual deposit rate, serving as a measure of interest, was 1.43%, while the growth rate of the consumer price index, indicating inflation, was 2.96%. In 2013, the annual interest rate was 1.34%, and the average exchange rate was 4,027.25 Riel per US Dollar. Between 2013 and 2023, the interest rate increased to 1.50% per annum, and the exchange rate rose to 4,102.04 Riel per US Dollar. (International Monetary Fund, 2023).

Sovannroeun (2009) examined the diverse factors that had an impact on the demand for money in Cambodia. The investigation of the determinants of money demand holds significant importance in the development of efficient policies. As a result, the study thoroughly analyzed data obtained from the International Monetary Fund's International Financial Statistics (*IFS*) covering the timeframe from December 1994 to December 2006. The findings of the study indicated that

inflation played a prominent role in determining the stability of money demand within the Cambodian context. Additionally, the impacts of; output, inflation, and the exchange rate coefficient on money demand were also positive and significant (Sovannroeun, 2009). Vorlak et al. (2018) expanded upon Sovannroeun's study by employing the *ARDL* approach to cointegration developed by Pesaran et al. (2001). However, instead of utilizing monthly data, they utilized annual data spanning from 1996 to 2016. The logarithm of real money demand was regressed against four independent variables: the logarithm of real income, the inflation rate, the exchange rate, and a dummy variable, 1 for the period 1997-1998 and 0 for all other periods, which represented a period of political turmoil in Cambodia. Furthermore, *M2* was employed as a proxy for money demand instead of *M1*. The *ARDL* model, employed in prior studies, was limited in its ability to evaluate the interconnectedness of variables within the study. To address this research gap, the primary aim of the current study is to employ a system of equations known as the Vector Autoregressive (*VAR*) model. This approach will enable an examination of the monetary aggregate in Cambodia by incorporating four variables: monetary aggregate, consumer price index, exchange rate, and interest rate.

The purpose of this study is to find an answer to the following research question: Which variable among the general price level, nominal exchange rate, and interest rate is most responsible for the fluctuations in the monetary aggregate in Cambodia? Is the exchange rate between the Khmer Riel and the U.S. dollar still the policy variable for the central bank?

This study is organized into five distinct chapters. The first chapter serves as an introduction, providing an overview of the research topic. The second chapter offers a comprehensive review of the pertinent literature. Chapters three and four delineate the research methodology utilized and present the empirical findings, respectively. Lastly, the concluding chapter succinctly summarizes the principal findings and provides insights derived from the study.

2. LITERATURE REVIEW

Adnan, Asad, and Kalim (2013) utilized a single equation model in order to ascertain the money demand function in Pakistan, with the assistance of monetary policy. This study incorporated various determinants, such as real *GDP*, industrial production index, consumer price index (*CPI*), inflation exchange rate, lending and own rate, as well as short-term and long-term risk premium, to define the money demand function. The results indicated that all of these determinants exhibited significant correlations with money demand in Pakistan during the selected period (Adnan, Asad, & Kalim, 2013). A similar study, conducted by Haroon, Masood, and Muhamad (2013), examined the significance of money demand on the financial sector and monetary policy in Pakistan. However, this study employed a different approach and analyzed data from 1972 to 2007. The study utilized the Augmented Dickey-Fuller (*ADF*) and Phillips Perron (*PP*) unit root tests to assess the stationarity of the variables. Additionally, the *ARDL* cointegration method was employed to investigate the presence of cointegration among the variables. The study concluded that money demand exhibited a positive relationship with income, while demonstrating a negative relationship with the opportunity cost of holding money (Haroon, Masood, & Muhamad, 2013).

Muhammad and Khudija (2014) utilized the Ordinary Least Squares (*OLS*) and Breusch-Godfrey tests to investigate the relationship between money demand and its determinants in Nigeria. The study employed the partial adjustment model on data spanning from 1973 to 2013. The findings revealed that in both the short and long run, money demand exhibited a positive association with real *GDP* and a negative association with the interest rate (Muhammad & Khudija, 2014). Moses

(2014) conducted a re-estimation of the money demand function for the period from 2000 to 2013. The results of the study indicated that the income elasticity of *M2* was relatively lower compared to *M3* and *M1*, with values of 0.50, 0.77, and 1.04, respectively. Additionally, the study suggested that the depreciation of the exchange rate, interest rate elasticity, inflation, and Treasury bills had a negative impact on money demand, except for interest on deposits, which positively influenced money demand (Moses K. C., 2014). Sambulo (2015) reported that a structural break in 1994 played a crucial role in stabilizing the money demand function in South Africa. Data from the World Bank and the National Reserve Bank for the period from 1970 to 2013 were utilized to examine the demand model for narrow and broad money in South Africa. Through a comparison of the post and prior periods of the breaks, the Gregory-Hansen cointegration test determined that these breaks did not affect the broad money demand function. The study also advocated for the necessity of liberalizing monetary policies and implementing a floating exchange rate policy in South Africa (Sambulo, 2015).

Umbreen, Dawood, and Muhammad (2016) conducted an examination of the relationships between money demand and various macroeconomic variables in Pakistan. These variables included the official exchange rate, interest rate, gross domestic product, the ratio of fiscal deficit to gross domestic product, and the populations in rural and urban areas. The study utilized the *ARDL* approach to cointegration and analyzed time series data from 1972 to 2013. The findings revealed that the rural population and the exchange rate had a significant negative impact on money demand in Pakistan. Furthermore, the empirical results demonstrated that interest rates negatively affected money demand in both the short and long run (Umbreen, Dawood, & Muhammad, 2016). In another study, the *ARDL* method was employed to enhance the effectiveness of monetary policy in Nigeria between 1998:Q1 and 2014:Q4. The research assumed that the Nigerian Central Bank believed that changes in the interest rate were the primary cause of changes in money demand. The monetary policy variables followed a similar trend, with inflation decreasing and productivity increasing (Ikechukwu, Faith, & Roseline Ike-Anikwe, 2016). Essa (2016) developed money demand functions for Yemen, focusing on narrow (*M1*) and broad (*M2*) money. The study utilized the *ARDL* bounds testing approach to cointegration and error correction modeling, analyzing data from 2001:Q1 to 2013:Q4. The short- and long-term models included three key explanatory variables: real income, inflation rate, and nominal exchange rate. The findings indicated that *M1* and *M2* were influenced positively and negatively by real income and the inflation rate. Additionally, these two determinant variables explained the behavior of monetary aggregates in the long term (Essa, 2016).

A study conducted by Oguz (2017) in Turkey found that the demand for real money was influenced by real domestic output and the interest rate. This study utilized the dynamic *OLS* technique on two models: log-log money and interest rate, and log-log real money with real income and interest rate. The data used in the study covered the period from 1970 to 2013. To account for any structural breaks in the time-series data, the *ADF* test for unit root and the Zivot and Andrews tests were employed. Instead of using the bounds test, the Johansen trace test was used to examine the long-run relationships between the variables. The empirical findings indicated that the logarithm of the real money balance equation performed better than the logarithm of money demand specifications, assuming unitary income elasticities (Oguz, 2017). In another study by Moses, Usman, Patricks, & Nurodeen (2018), a money demand function for Nigeria was constructed using *GDP*, inflation rate, foreign exchange, and domestic interest rate as independent variables. To further investigate the demand for broad money (*M2*), the foreign interest rate and stock market index were included in the *ARDL* approach to cointegration model. The quarterly time series data used in this study

spanned from 1985:Q1 to 2016:Q4. The bounds test revealed that money demand in Nigeria was cointegrated with its explanatory variables, indicating a long-run relationship. Notably, the stock index had a positive impact on real money stock in Nigeria (Moses, Usman, Patricks, & Nurodeen, 2018).

In order to ascertain the monetary aggregate in Turkey, a mathematical framework referred to as the Vector Error Correction Model (*VECM*) was employed for the period spanning from 1990 to 2016. The empirical findings of this study suggest that the monetary base may not be the most effective instrument for regulating the price level (Incekara & Amanov, 2017). Furthermore, in order to examine the impact of inflation rate and exchange rate on money supply in Indonesia, a threshold VAR (*TVAR*) model with one threshold and two regimes at one lag was utilized, in addition to the *VAR* model. The *TVAR* model exhibited superior performance in predicting money supply compared to the VAR model (Yuhan & Sohibien, 2018). To ascertain the money supply in Indonesia amidst the global financial crisis, a Vector Autoregressive (*VAR*) model was employed, utilizing monthly data spanning from January 2006 to July 2016. The findings of this research unveiled a sustained association between money supply, interest rate, exchange rate, government revenues, and interest rate. Furthermore, it was observed that interest rate exerted a positive influence on M2 (Rachman, 2019).

Between 1970 and 2018, Muhammad and Jauhari (2019) conducted an analysis of the money demand function in Malaysia using the *ARDL* approach to cointegration. Their findings revealed that financial innovation and real *GDP* had a significant positive and negative impact on real money demand, respectively. Notably, a one-unit depreciation of the exchange rate resulted in a long-term increase in real money demand by 0.97, while a 1% increase in real *GDP* led to a decrease in real money demand by 0.6395. However, the estimated model was deemed unstable based on the results of the *CUSUMSQ* test (Muhammad & Jauhari, 2019). In Indonesia, the demand for real monetary aggregates (*M1* and *M2*) was found to have a long-run relationship with factors such as real income, price level, domestic interest rate, and foreign interest rate, according to the results of the bound test. The inflation rate, real income, and exchange rate positively explained the short and long-term real demand for *M1* and *M2*. Additionally, domestic and foreign interest rates significantly affected *M2* but had no influence on *M1*. The *CUSUM* and *CUSUMSQ* test results indicated that Indonesia's real money demand was unstable between 2000:Q1 and 2019:Q4. The instability was attributed to two factors: the flexibility of inflation targeting, which Bank Indonesia has always implemented, and macroeconomic stability, which negatively impacted money demand due to the exchange rate (Mahrus, 2020).

In 2021, Raouf, Mohammed, and Mohamed conducted a classification of Algeria's monetary aggregates into three distinct categories: *Cash*, *M1*, and *M2*. The long-term equation for each type of real money demand was analyzed in relation to real *GDP*, Treasury bill rate, inflation rate, and exchange rate. The study period spanned from 1979 to 2019. The estimated elasticity of the scale variables for *M2*, *M1*, and *Cash* were 1.019, 1.040, and 1.006, respectively, with each parameter being statistically significant. Additionally, the inflation rate's elasticity significantly explained the real money demand for all three aggregates, with Cash generating the highest elasticity. The empirical findings of this study further indicated that the real money demand for *M1* and *M2* remained stable, while the demand for fiat money was unstable (Raouf, Mohammed, & Mohamed, 2021).

The assessment of monetary aggregates in various countries, as observed in the literature review, primarily relied on the utilization of a single equation model. However, this approach proved inadequate in capturing the interconnectedness between monetary aggregates and other variables

under examination. Consequently, to address this research gap, the present study employs a system of equation model known as the Vector Autoregressive (VAR) model to explore the interrelationship among four variables in Cambodia, namely monetary aggregate, consumer price index, nominal exchange rate, and interest rate.

3. METHODOLOGY

Sims (1980) developed a renowned system of equation models, namely the Vector Autoregressive (*VAR*) model, which is commonly utilized to examine the interdependence among macroeconomic variables. In order to achieve the primary objective of the study, four time series variables, namely monetary aggregate (*M2*), consumer price index (*CPI*), foreign exchange (*FX*), and interest rate (*R*), have been integrated into the VAR model. The model specification is presented herewith.

$$lnM2_t = \beta_{10} + \sum_{i=1}^{p} \beta_{11i} lnM2_{t-i} + \sum_{i=1}^{p} \beta_{12i} lnCPI_{t-i} + \sum_{i=1}^{p} \beta_{13i} lnFX_{t-i} + \sum_{i=1}^{p} \beta_{14i} lnR_{t-i} + \varepsilon_{1t}$$

$$lnCPI_t = \beta_{20} + \sum_{i=1}^{p} \beta_{21i} lnM2_{t-i} + \sum_{i=1}^{p} \beta_{22i} lnCPI_{t-i} + \sum_{i=1}^{p} \beta_{23i} lnFX_{t-i} + \sum_{i=1}^{p} \beta_{24i} lnR_{t-i} + \varepsilon_{2t}$$

$$lnFX_t = \beta_{30} + \sum_{i=1}^{p} \beta_{31i} lnM2_{t-i} + \sum_{i=1}^{p} \beta_{32i} lnCPI_{t-i} + \sum_{i=1}^{p} \beta_{33i} lnFX_{t-i} + \sum_{i=1}^{p} \beta_{34i} lnR_{t-i} + \varepsilon_{3t}$$

$$lnR_t = \beta_{40} + \sum_{i=1}^{p} \beta_{41i} lnM2_{t-i} + \sum_{i=1}^{p} \beta_{42i} lnCPI_{t-i} + \sum_{i=1}^{p} \beta_{43i} lnFX_{t-i} + \sum_{i=1}^{p} \beta_{44i} lnR_{t-i} + \varepsilon_{4t}$$

The parameters β_{ij} are to be estimated, and the vector ε_{it} represents the error terms, which are assumed to be independent and identically distributed (*i.i.d*). All variables in the system are logarithmically transformed, except for the interest rate, in order to ensure continuity. The growth rate is interpreted as the first difference of each data series. Prior to analyzing the model, a unit root test is conducted using the Augmented Dickey-Fuller (*ADF*) test (Dickey & Fuller, 1979) on all data series in the system to determine whether they are stationary or non-stationary. If the test results indicate non-stationarity or the presence of a unit root, the series is transformed into its first difference and the test is repeated. The *VAR* model, which encompasses all indicators and is represented by equation (1), will be converted into first differences (*D*) as outlined in equation (2). This transformation is necessary to prevent spurious regression outcomes, particularly when the majority of variables within the system are integrated of order one, denoted as *I(1)*.

$$DlnM2_t = \beta_{10} + \sum_{i=1}^{p} \beta_{11i} DlnM2_{t-i} + \sum_{i=1}^{p} \beta_{12i} DlnCPI_{t-i} + \sum_{i=1}^{p} \beta_{13i} DlnFX_{t-i} + \sum_{i=1}^{p} \beta_{14i} DlnR_{t-i} + \varepsilon_{1t}$$

$$DlnCPI_t = \beta_{20} + \sum_{i=1}^{p} \beta_{21i} DlnM2_{t-i} + \sum_{i=1}^{p} \beta_{22i} DlnCPI_{t-i} + \sum_{i=1}^{p} \beta_{23i} DlnFX_{t-i} + \sum_{i=1}^{p} \beta_{24i} DlnR_{t-i} + \varepsilon_{2t}$$

$$DlnFX_t = \beta_{30} + \sum_{i=1}^{p} \beta_{31i} DlnM2_{t-i} + \sum_{i=1}^{p} \beta_{32i} DlnCPI_{t-i} + \sum_{i=1}^{p} \beta_{33i} DlnFX_{t-i} + \sum_{i=1}^{p} \beta_{34i} DlnR_{t-i} + \varepsilon_{3t}$$

$$DlnR_t = \beta_{40} + \sum_{i=1}^{p} \beta_{41i} DlnM2_{t-i} + \sum_{i=1}^{p} \beta_{42i} DlnCPI_{t-i} + \sum_{i=1}^{p} \beta_{43i} DlnFX_{t-i} + \sum_{i=1}^{p} \beta_{44i} DlnR_{t-i} + \varepsilon_{4t}$$

After resolving the matter of unit root, the subsequent stage entails ascertaining the optimal lag length of the model through the utilization of Schwarz Information Criterion (*SIC*). A lower *SIC* value signifies a superior model. Once the estimated outcomes of the model are produced, it is unnecessary to conduct diagnostic tests of the *VAR* model, such as stability test, serial correlation Lagrange Multiplier (*LM*) test, and residual Heteroskedasticity tests, with no cross terms (solely levels and squares).

All data utilized in this research has been sourced from the International Financial Statistics of the International Monetary Fund. The time frame of monthly data spans from January 2002 to March 2023. The monetary aggregate, *M2*, is quantified in billions of Khmer Riel (*KHR*), while the consumer price index, *CPI*, serves as a gauge for the movement of the general price level. Foreign exchange, *FX*, denotes the value of Riel per US Dollar, with an increase in *FX* indicating depreciation of the Riel and vice versa. The interest rate, *R*, in this study is measured by the deposit rate. The examination of the interaction among Consumer Price Index (*CPI*), Foreign Exchange (*FX*), Interest Rate (*R*), and Money Supply (*M2*) is conducted through the analysis of the impulse response function (*IRF*) and the forecast error variance decomposition (*FEVD*) of the Vector Autoregressive (*VAR*) model.

4. EMPIRICAL RESULTS

The present section has been partitioned into three distinct segments, namely descriptive statistics, *ADF* unit root tests, and an analysis of the empirical outcomes of the *VAR* model, encompassing impulse response function and forecast error variance decomposition.

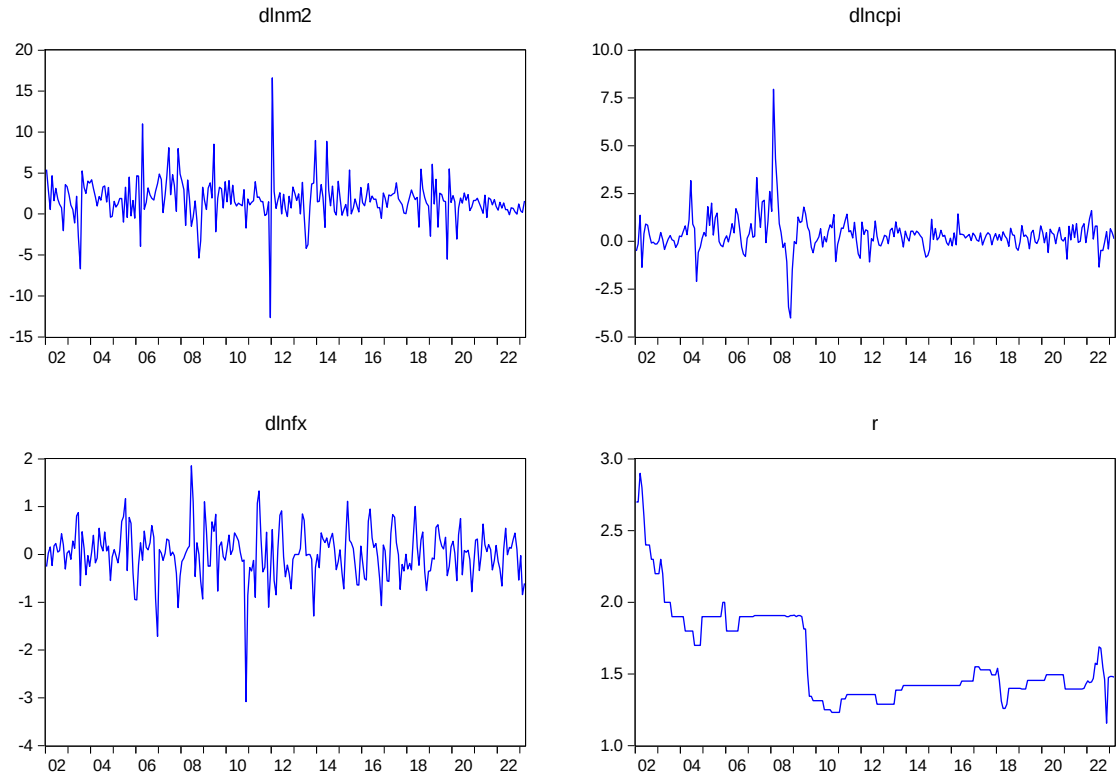

Figure 1. Broad Money, Foreign Exchange, Inflation Rate, and Interest Rate

Given that the focal point of this research is the monetary aggregate, the impulse response function (*IRF*) will concentrate on the response of *M2* to the shock of *CPI*, *FX*, and *R*. Furthermore, the forecast error variance decomposition (*FEVD*) analysis will elucidate the variations in the money supply that are caused by fluctuations in other variables within the system.

According to Figure 1, the growth rate of the money supply, the fluctuations in the domestic foreign exchange rate, and the inflation rate, observed from January 2002 to March 2023, demonstrate a mean-reverting process. This implies that each series oscillates around its average value. However, the behavior of the interest rate series differs from the aforementioned three data series. From January 2002 to November 2004, the interest rate experienced a significant monthly decrease. Subsequently, between January 2005 and May 2009, the rates remained relatively stable, fluctuating within the range of 1.8% to 2%. Starting from June 2009, the rates once again began to decline until January 2011, after which they exhibited minor fluctuations until March 2023.

The study reveals that the average monthly growth rate of the money supply over a period of 255 months is 1.72%. The inflation rate, measured by the growth rate of the consumer price index, stands at 0.35% on a monthly basis. Furthermore, the growth rate of foreign exchange is 0.015%, while the interest rate is 1.61%. It is worth noting that the Jarque-Bera test indicates that each individual time series under investigation does not follow a normal distribution, as the probability of this occurrence is lower than the significance level of 1%.

Table 1. Descriptive Statistics

	DLNM2	*DLNCPI*	*DLNFX*	*R*
Mean	1.716830	0.348457	0.014920	1.608250
Median	1.646521	0.280633	0.047237	1.455000
Maximum	16.62435	7.949397	1.856259	2.900000
Minimum	-12.63986	-4.009501	-3.077166	1.155455
Std. Dev.	2.570181	0.954166	0.523668	0.314453
Skewness	0.159648	1.938861	-0.746818	1.322410
Kurtosis	11.72888	21.59023	7.821525	4.903069
Jarque-Bera	810.6381	3831.729	270.7043	112.8029
Probability	0.000000	0.000000	0.000000	0.000000
Sum	437.7918	88.85650	3.804685	410.1039
Sum Sq. Dev.	1677.881	231.2498	69.65400	25.11577
Observations	255	255	255	255

The *ADF* test was utilized to scrutinize each time series data under investigation, employing three regression models: a model with a constant, a model with a constant and trend, and a model without a constant and trend, as presented in Table 2. At the level, both the money supply and consumer price index were found to possess a unit root or non-stationary, as the null hypothesis failed to be rejected. However, under the *ADF* model without constant and trend, the foreign exchange variable exhibited a unit root, whereas the series was stationary under the model with a constant and the model with a constant and trend. Based on the three models, it was determined that the interest rate did not possess a unit root. Of particular interest, it is noteworthy that all data series exhibit stationarity across all models of the *ADF* test subsequent to their transformation into first differences.

Table 2. *ADF* Unit Root Tests

		At Level			
		LNM2	*LNCPI*	*LNFX*	*R*
With Constant	t-Statistic	-1.7884	-1.3990	-3.7169	-3.5870
	Prob.	*0.3858*	*0.5827*	*0.0044*	*0.0067*
		n0	n0	***	***
With Constant & Trend	t-Statistic	-0.9026	-1.6684	-3.6355	-3.1822
	Prob.	*0.9530*	*0.7625*	*0.0289*	*0.0904*
		n0	n0	**	*
Without Constant & Trend	t-Statistic	10.1294	3.0540	0.4639	-2.0049
	Prob.	*1.0000*	*0.9995*	*0.8141*	*0.0433*
		n0	n0	n0	**
		At First Difference			
		DLNM2	*DLNCPI*	*DLNFX*	*DR*
With Constant	t-Statistic	-17.9116	-9.0410	-3.6146	-14.8176
	Prob.	*0.0000*	*0.0000*	*0.0061*	*0.0000*

		***	***	***	***
With Constant & Trend	t-Statistic	-18.1046	-9.0934	-3.6875	-14.9822
	Prob.	*0.0000*	*0.0000*	*0.0250*	*0.0000*
		***	***	**	***
Without Constant & Trend	t-Statistic	-4.9030	-8.3269	-3.5940	-14.7475
	Prob.	*0.0000*	*0.0000*	*0.0004*	*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.

Due to the presence of a combination of variables in the *VAR* system being examined, which are integrated of order zero (*I(0)*) and one (*I(1)*), it is imperative to convert all variables in the model into first differences. This is done to prevent the occurrence of spurious regression outcomes. The subsequent phase involves ascertaining the most suitable lag length for the *VAR* model. The determination of the lag length will be based on the information criteria outlined in Table 3. The information criteria encompass the sequential modified likelihood ratio (*LR*) test statistic, Final Prediction Error (*FPE*), Akaike Information Criterion (*AIC*), Schwarz Information Criterion (*SIC*), and Hannan-Quinn Information Criterion (*HQIC*). However, the *SIC* is employed in the selection process for determining the lag length of the model. It is observed that the *VAR* model with a single lag yields the lowest *SIC*.

The aim of this research is to analyze the impulse response function and forecast error variable decomposition of the monetary aggregate, specifically examining its relationship with the consumer price index, foreign exchange, and interest rate. However, it is important to note that this analysis can only be conducted if the *VAR* model is stable. Therefore, a stability test is necessary. Figure 2 demonstrates that all the characteristic roots are situated within the unit circle, indicating that the estimated model is indeed stable.

Table 3. Information Criteria

Lag	*LogL*	*LR*	*FPE*	*AIC*	*SIC*	*HQIC*
0	-1144.504	NA	0.114925	9.188033	9.244376	9.210709
1	-671.8112	926.4780	0.002977*	5.534490*	5.816207*	5.647873*
2	-658.7606	25.16155	0.003048	5.558085	6.065175	5.762174
3	-647.5584	21.23948	0.003168	5.596467	6.328931	5.891262
4	-637.9762	17.86117	0.003336	5.647810	6.605647	6.033311
5	-621.6549	29.90070*	0.003330	5.645239	6.828450	6.121447

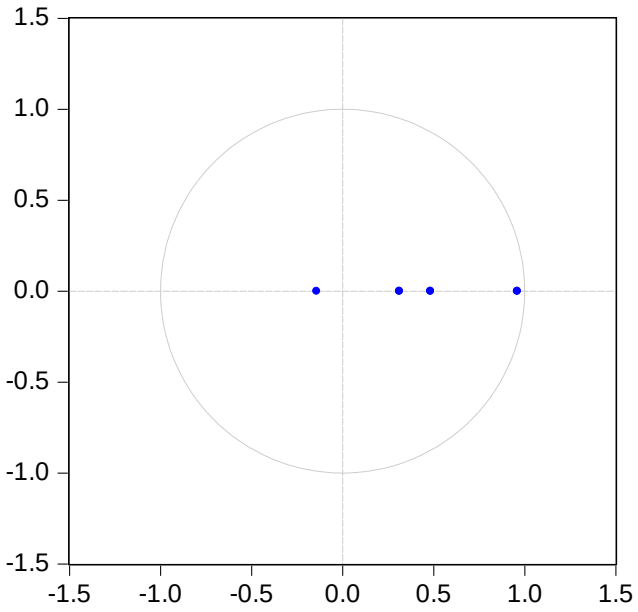

Figure 2. Inverse Roots of AR Characteristic Polynomial

In addition to the stability test, which is considered as one of the diagnostic tests for the *VAR* model, the residual serial correlation *LM* test is also conducted. This test is performed for lags ranging from one to four. The null hypothesis of this test suggests the absence of serial correlation. However, the *LM*-statistics probabilities for lags one through four are found to be greater than the 5% significance level. This indicates that there is no evidence to support the existence of serial correlation in the residual terms of the model.

Table 4. *VAR* Residual Serial Correlation *LM* Test

Lags	LM-Stat	Prob
1	23.71236	0.0960
2	25.43875	0.0625
3	17.15148	0.3759
4	19.10535	0.2632

Probs from chi-square with 16 df.

Although heteroscedasticity has been detected, as shown in Table 5, it will not have an impact on the estimated results of the impulse response function and forecast error variance decomposition of the *VAR* model. Furthermore, it should be noted that the primary objective of the model is not to conduct hypothesis testing to determine the significant relationship between independent and dependent variables. Additionally, the dependent variable in an equation within a system of *VAR* models is also treated as an independent variable in another equation within the same system of equations. This is why the interpretation of the impact of independent variables on the dependent variable in all equations within a system of *VAR* models is not conducted.

Table 5. *VAR* Residual Heteroskedasticity Tests

Dependent	*R-squared*	*F(8,245)*	*Prob.*	*Chi-sq(8)*	*Prob.*
res1*res1	0.226620	8.973907	0.0000	57.56150	0.0000
res2*res2	0.023056	0.722755	0.6714	5.856233	0.6633

res3*res3	0.004528	0.139304	0.9973	1.150136	0.9971
res4*res4	0.062319	2.035365	0.0430	15.82905	0.0449
res2*res1	0.230114	9.153642	0.0000	58.44908	0.0000
res3*res1	0.132527	4.678681	0.0000	33.66179	0.0000
res3*res2	0.047338	1.521753	0.1501	12.02377	0.1501
res4*res1	0.014383	0.446904	0.8919	3.653258	0.8870
res4*res2	0.042634	1.363825	0.2130	10.82914	0.2116
res4*res3	0.040532	1.293738	0.2472	10.29519	0.2449

The response of the growth rate of the money supply to an inflation rate shock exhibits a positive trend during the initial three months, followed by a gradual decline and eventual cessation after reaching its peak in the third month. This outcome suggests that an increase in the inflation rate leads to a corresponding increase in the money supply. Conversely, a depreciation of the Riel against the US Dollar results in a decrease in the money supply. This finding is consistent with the economic conditions prevailing in Cambodia, where the Riel often experiences a significant depreciation against the US Dollar, leading to a notable impact on the general price level. In such instances, the central bank intervenes in the domestic foreign exchange market by conducting US Dollar auctions, a traditional process that involves selling US Dollars to money exchangers. This action serves to absorb Riel circulating in the economy back into the central bank and vice versa. The growth rate of the money supply exhibits a relatively muted response to an interest rate shock.

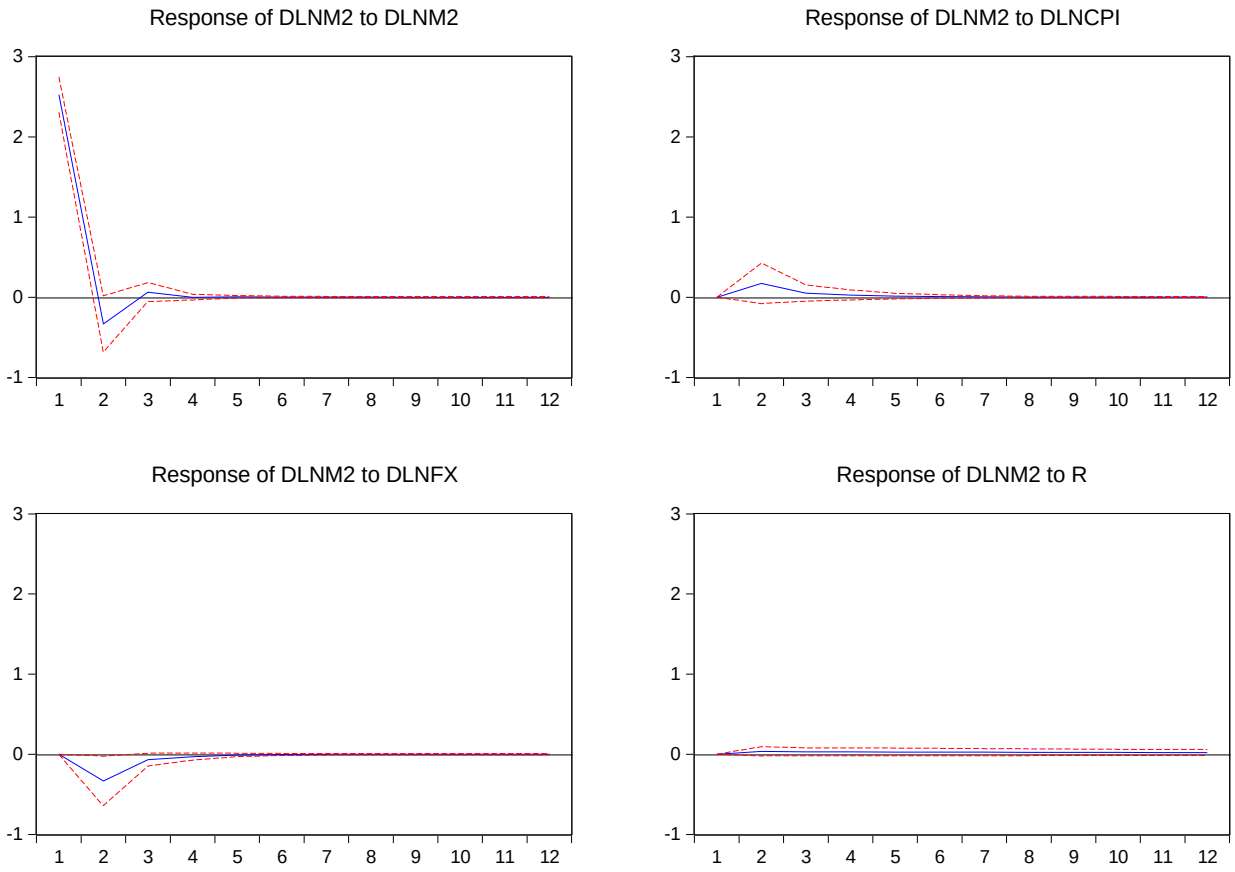

Figure 3. Response to Cholesky One S.D. Innovations ± 2 S.E.

This study employs the Monte Carlo response standard error in the forecast error variance decomposition generated from the *VAR* model. The prediction of the variation of the money supply resulting from changes in the price level, exchange rate, and interest rate is conducted over a twelve-month period into the future. In the first period, the variation of the money supply is entirely caused by its own variation. In subsequent periods, namely from the second to the twelfth period, the variation of the money supply is primarily caused by changes in the exchange rate, ranging from 1.67% to 1.749%, followed by changes in the inflation rate, ranging from 0.4526% to 0.5052%. The least variation is caused by changes in the interest rate, ranging from 0.02% to 0.1168%.

Table 6. Variance Decomposition of *DLNM2*

Period	S.E.	*DLNM2*	*DLNCPI*	*DLNFX*	*R*
1	2.527289	100.0000	0.000000	0.000000	0.000000
		(0.00000)	(0.00000)	(0.00000)	(0.00000)
2	2.576861	97.85613	0.452621	1.670516	0.020734
		(1.81894)	(0.79740)	(1.68706)	(0.03394)
3	2.579157	97.74124	0.491072	1.734085	0.033605
		(1.90624)	(0.87616)	(1.74350)	(0.05559)
4	2.579648	97.70402	0.502125	1.747729	0.046125
		(1.93315)	(0.90905)	(1.75180)	(0.07685)
5	2.579851	97.68890	0.504447	1.749051	0.057604
		(1.93899)	(0.91670)	(1.75180)	(0.09649)
6	2.580000	97.67765	0.505032	1.749086	0.068234
		(1.94136)	(0.91892)	(1.75131)	(0.11473)
7	2.580129	97.66783	0.505176	1.748939	0.078053
		(1.94277)	(0.91940)	(1.75079)	(0.13159)
8	2.580247	97.65890	0.505204	1.748782	0.087117
		(1.94401)	(0.91942)	(1.75028)	(0.14716)
9	2.580356	97.65069	0.505197	1.748635	0.095480
		(1.94528)	(0.91931)	(1.74979)	(0.16155)
10	2.580456	97.64313	0.505179	1.748500	0.103193
		(1.94661)	(0.91918)	(1.74934)	(0.17485)
11	2.580548	97.63616	0.505158	1.748376	0.110307
		(1.94800)	(0.91905)	(1.74891)	(0.18715)
12	2.580633	97.62973	0.505137	1.748263	0.116866
		(1.94943)	(0.91893)	(1.74851)	(0.19853)

The empirical findings of this study have revealed that, among the three variables under consideration, namely, the consumer price index, nominal exchange rate, and interest rate, the variation in exchange rate is the primary factor responsible for the variation in monetary aggregate. Additionally, this outcome offers a conclusive response to the research inquiry, indicating that the exchange rate between the Khmer Riel and the US Dollar remains a reliable indicator for the central bank in regulating the monetary aggregate.

5. CONCLUSION

A study on the monetary aggregate in Cambodia is typically conducted using a single equation model, specifically the autoregressive distributed lags model. However, this model fails to capture the interrelationship between variables in the study, unlike a system of equations such as the *VAR* model. In order to investigate the movement of the monetary aggregate in Cambodia, the VAR model, a system of equations, was employed. This model incorporated four endogenous variables, namely broad money, inflation rate, exchange rate, and interest rate. The study period encompassed from January 2002 to March 2023. The empirical findings of this research, based on 255 data points, offer valuable insights into the economic landscape of Cambodia. The fluctuations in the exchange rate were found to be the primary driver of variation in the monetary aggregate, followed by the inflation rate, while the interest rate exhibited the least impact. Additionally, the response of money supply to the inflation rate was observed to be positive, whereas it was negative in relation to the exchange rate. The limited explanatory power of the interest rate in relation to the variation of the monetary aggregate truly reflects the current economic situation of Cambodia, where the interest rate is not a policy variable under the control of the central bank.

The VAR model comprising four variables, which has been developed in the course of this research, may be utilized by the central bank and policymakers to undertake scenario analysis with a view to evaluating the response of the monetary aggregate to inflation rate, interest rate, and exchange rate shocks. Specifically, the model enables the determination of the changes in the monetary aggregate that would result from alterations in each variable by a given number of points. Prior to the formulation of specific economic policies, it is imperative to conduct an analysis of the interrelationships between the variables in the model.

An inquiry into the correlation between money supply, inflation rate, exchange rate, and interest rate was carried out utilizing a reduced-form VAR model. However, this model did not account for the impact of one variable on the other variables in the system during the same time period. The reaction of monetary aggregate in the current period was explicated by the shock of inflation rate, exchange rate, and interest rate in the previous period. Therefore, it is deemed a compelling subject for further exploration concerning the determination of monetary aggregate in Cambodia by adopting a structural VAR model that can capture the simultaneous shock among the variables in the system.

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