Money supply, inflation and exchange rate movement: The case of Cambodia by Bayesian VAR Approach

Monorith Sean[*]**, Pathairat Pastpipatkul**[*]**, Petchaluck Boonyakunakorn**[*]

[*]*Chiang Mai University, Thailand*

JOMEINO
ISSN:
2522-381X (Print)
2521-7054 (Online)
DOI: 10.31039/jomeino

Received 21 November 2018

Revised 28 December 2018

Accepted 31 December 2018

Citation: Monorith Sea, M., Pastpipatku, P., & Boonyakunakorn, P. (2019). Money supply, inflation and exchange rate movement: The case of Cambodia by Bayesian VAR Approach. *Journal of Management, Economics, and Industrial Organization, 3*(1), 63-81. http://doi.org/10.31039/jomeino.2019.3.1.5

Corresponding author:
monorithsean007@gmail.com

Abstract

This research paper aims to investigate the relationship among money supply, inflation and exchange rate in Cambodia by using Bayesian Vector Autoregressive (B-VAR) approach. This study employs the monthly data in the period of October-2009 and April-2018. This research paper applies the Money-in-Utility Function (MIU) that describes the relationship between money growth and price level. Moreover, this paper also employs the Purchasing Power Parity (PPP) which shows the relationship between exchange rate and inflation. The empirical results reveal that money supply in Cambodia, depends on its previous variable. Moreover, money supply also induces the depreciation of exchange rate of Khmer Riel against US Dollar and leads to increase in inflation. Money supply induces 8% of shock to exchange rate and 0.13% to inflation based on variance decomposition while exchange rate can cause 0.024% to inflation in Cambodia. The relative low shocks from money supply to inflation and exchange rate results in supplying money with cautious manner from National Bank of Cambodia. The empirical results are found to be consistent with the theories and some empirical studied of this related fields.

Keywords: *Money-in-Utility(MIU), Bayesian VAR, Purchasing Power Parity(PPP), Money Supply, Inflation, Exchange Rate, Cambodia.*

1. Introduction

Stability of exchange rate and inflation rate are beheld as the objective of monetary policy which is necessary to achieve of every country. To ensure the price stability, central bank, takes an essential role in conducting monetary policy through monetary tools namely discount rate, reserve requirement ratio and operation market. These three important tools are effectively implemented to manage the money supply in the circulation to enhance the stability of price. Based on theoretical framework, an injecting too much money into the circulation leads to an increase in inflation. The inflation could also influence on exchange rate as the depreciation of value of domestic currency against other currencies.

National Bank of Cambodia (NBC) conducts monetary policy with care in the context of high dollarized economy to ensure price stability and to promote economic growth. Precisely, the broad money (M2) grew by 24% as in 2017 higher than 2016 which was 18%. Inflation rate was maintained relatively low for the last few years at nearly 2.9% (NBC, 2017). The exchange rate of Riel against US Dollar was maintained broadly stable at an average 4,050 Riel per USD. NBC has maintained a stable exchange rate through the intervention in foreign exchange market in very cautious manner to supply Riel in accordance with prevailing market mechanism and economic conditions.

Therefore, this study aims to investigate the movement of money supply, inflation and exchange rate in Cambodia by employing Bayesian Vector Autoregressive (B-VAR). This research could capture the relationship among variables and show the impulse response functions due to the endogenous shocks. Moreover, it also illustrates the variance decomposition which could present the effects among variables.

2. Literature review

2.1.Theoretical framework

The theory of money is initially explained by the Quantity Theory of Money (QTM). The concept of QTM is explained by the equation of exchange which states that the movement of price level results solely from changes in the quantity of money. However, this theory does not capture clearly about money supply and price level mathematically. In order to insert mathematical theoretical framework, this paper shows the micro-macroeconomic foundation of the Money-in-Utility function which illustrates the super-neutrality of money. Money growth only induces inflation in the steady states. In other words, inflation will increase with the same proportion as money growth (Lewis and Mizen, 2000).

The model of money utility function is developed by Sidrauski (1967) who introduced money into the classical growth model.

Suppose that utility function of representative household is given by:

$$W = E_t \sum_{t=0}^{\infty} \beta^t u(c_t, m_t), \quad 0 < \beta < 1$$

Where

- c_t is per capita consumption at time *t.*
- m_t is real money balance, $m_t = \frac{M_t}{P_t N_t}$, M_t normal money balance and N_t is population.
- β is discount factor

The utility function is assumed to be increasing in both arguments and its function form is:

$$u(c_t, m_t) = \left(\frac{c_t m_t^{\sigma}}{1-\varphi}\right)^{1-\varphi}, \sigma \text{ } and \text{ } \varphi > 0$$

And household has budget constraint

$$y_t + \tau_t + (1-\delta)k_{t-1} + \frac{m_{t-1}}{1+\pi_t} = c_t + k_t + m_t$$

Where

- y_t is output per capita
- τ_t is government transfer
- k_{t-1} is capital per capita at time *t-1*
- m_{t-1} is real money balance at time *t-1*
- $1 + \pi_t$ is inflation

Let suppose that $y_t = f(k_{t-1}) = k_{t-1}^{\alpha}$ is production function represents output per capita. Hence, household maximize her utility subject to budget constraint through Lagrangian function:

$$\mathcal{L} = E_t \left[\sum_{t=0}^{\infty} \beta^t \left(\frac{(c_t m_t^{\sigma})^{1-\varphi}}{1-\varphi} \right) + \sum_{t=0}^{\infty} \beta^t \lambda_t \left(k_{t-1}^{\alpha} + \tau_t + (1-\delta)k_{t-1} + \frac{m_{t-1}}{1+\pi_t} - c_t - k_t - m_t \right) \right]$$

The First-Order Conditions (FOCs) are:

$$\frac{\partial \mathcal{L}}{\partial c_t} = c_t^{-\varphi} \left(m_t^{\sigma}\right)^{1-\varphi} - \lambda_t = 0$$

$$\lambda_t = c_t^{-\varphi} (m_t^{\sigma})^{1-\varphi} \tag{1}$$

$$\frac{\partial \mathcal{L}}{\partial m_t} = \sigma c_t^{1-\varphi} (m_t^{\sigma})^{\sigma(1-\varphi)-1} + \beta \frac{\lambda_{t+1}}{1+\pi_{t+1}} - \lambda_t = 0$$

$$\lambda_t = \sigma c_t^{1-\varphi}(m_t^{\sigma})^{1-\varphi} + \beta \frac{\lambda_{t+1}}{1+\pi_{t+1}} \quad (2)$$

$$\frac{\partial \mathcal{L}}{\partial k_t} = \alpha\beta^{t+1}\lambda_{t+1}k_t^{\alpha-1} + \beta^{t+1}\lambda_{t+1}(1-\delta) - \lambda_t\beta^t = 0$$

$$\lambda_t = \beta E_t[\lambda_{t+1}\,(\alpha k_t^{\alpha-1} + (1-\delta))] \quad (3)$$

If we substitute (1) into (2), we get

$$c_t^{-\varphi}\,(m_t^{\sigma})^{1-\varphi} = \sigma c_t^{1-\varphi}(m_t^{\sigma})^{\sigma(1-\varphi)-1} + \beta \frac{c_{t+1}^{-\varphi}\,(m_{t+1}^{\sigma})^{1-\varphi}}{1+\pi_{t+1}} \quad (4)$$

(4) states that the marginal benefit of adding to money holding at time *t* must equal to the marginal utility of consumption.

If we plug (1) into (3) we get,

$$c_t^{-\varphi}\,(m_t^{\sigma})^{1-\varphi} = \beta\ c_{t+1}^{-\varphi}\,(m_{t+1}^{\sigma})^{1-\varphi}[\alpha k_t^{\alpha-1} + (1-\delta)] \quad (5)$$

(5) states that the marginal return for holding additional capital must equal marginal utility of consumption.

If we recall the real money balance for household holding,

$$\frac{M_t}{P_tN_t} = \frac{M_{t-1}}{P_tN_t} + \tau_t \quad (6)$$

The above equation illustrates that money that household holds is the previous money at time *t-1* and the transfer from government.

(6) could be written as:

$$\frac{M_t}{P_tN_t} = \frac{M_{t-1}}{P_{t-1}P_tN_t}P_{t-1} + \tau_t \quad (7)$$

Moreover,

$$\tau_t = \frac{\Delta M_t}{P_tN_t} = \frac{M_t}{P_tN_t} - \frac{M_{t-1}}{P_tN_t} \quad (8)$$

Or

$$\tau_t = \frac{\Delta M_t}{P_tN_t} = \frac{M_t}{P_tN_t} - \frac{M_{t-1}}{P_{t-1}P_tN_t}P_{t-1} \quad (9)$$

But

$M_t = (1 + g_t)M_{t-1}$ is money growth rate

The (9) could be written as:

$$\tau_t = \frac{(1+g_t)M_{t-1}}{P_{t-1}P_tN_t}P_{t-1} - \frac{M_{t-1}}{P_{t-1}P_tN_t}P_{t-1} \quad (10)$$

Then,

$$\tau_t = \frac{(1+g_t)m_{t-1}P_{t-1}}{P_t} - \frac{m_{t-1}P_{t-1}}{P_t}$$

Hence,

$$\tau_t = \frac{g_t m_{t-1}}{1+\pi_t} \quad (11)$$

Where

- $m_{t-1} = \frac{M_{t-1}}{P_{t-1}N_t}$ and $\frac{P_{t-1}}{P_t} = \frac{1}{1+\pi_t}$ is inflation
- $N_t = N_{t-1} = \ldots\ldots\ldots\ldots\ldots\ldots$ Labor at all times is assumed to be fixed.

If we substitute (11) into (7) we get,

$$\frac{M_t}{P_tN_t} = \frac{M_{t-1}}{P_{t-1}P_tN_t}P_{t-1} + \frac{g_t m_{t-1}}{1+\pi_t} \quad (12)$$

Then,

$$m_t = \frac{m_{t-1}}{1+\pi_t} + \frac{g_t m_{t-1}}{1+\pi_t}$$

Or

$$m_t = \frac{(1+g_t)m_{t-1}}{1+\pi_t} \quad (13)$$

In steady state, there is no time subscript. Hence (13) could be written as:

$$m = \frac{(1+g)m}{1+\pi}$$

Hence

$$g = \pi \quad (14)$$

(14) implies that money growth rate equal to the price level or inflation. Hence this confirms the increase in money growth induces the inflation.

If we recall the budget constraint,

$$k_{t-1}^{\alpha} + \tau_t + (1-\delta)k_{t-1} + \frac{m_{t-1}}{1+\pi_t} - c_t - k_t - m_t \quad (15)$$

Where $\tau_t = \frac{g_t m_{t-1}}{1+\pi_t}$ and $m_t = \frac{(1+g_t)m_{t-1}}{1+\pi_t}$

Then (15) could be written as:

$$k_{t-1}^{\alpha} + \frac{g_t m_{t-1}}{1+\pi_t} + (1-\delta)k_{t-1} + \frac{m_{t-1}}{1+\pi_t} = c_t + k_t + \frac{(1+g_t)m_{t-1}}{1+\pi_t}$$

Then,

$$k_{t-1}^{\alpha} + (1-\delta)k_{t-1} = c_t + k_t \quad (16)$$

If we recall (5)

$$c_t^{-\varphi}\,(m_t^{\sigma})^{1-\varphi} = \beta\ c_{t+1}^{-\varphi}\,(m_{t+1}^{\sigma})^{1-\varphi}[\alpha k_t^{\alpha-1} + (1-\delta)]$$

In steady state,

$$c^{-\varphi}(m)^{\sigma(1-\varphi)} = \beta c^{-\varphi}(m)^{\sigma(1-\varphi)}[\alpha k^{\alpha-1} + (1-\delta)]$$

Then,

$$\alpha k^{\alpha-1} + (1-\delta) = \frac{1}{\beta}$$

Hence,

$$k^* = \left[\frac{\frac{1}{\beta}-1+\delta}{\alpha}\right]^{1/\alpha-1} \quad (17)$$

Then (16) in steady state

$$k^{\alpha} + (1-\delta)k = c + k$$

Then

$$c^* = \left[\frac{\frac{1}{\beta}-1+\delta}{\alpha}\right]^{\alpha/\alpha-1} - \delta\left[\frac{\frac{1}{\beta}-1+\delta}{\alpha}\right]^{1/\alpha-1} \quad (18)$$

Hence,

$$y^* = f(k) = \left[\frac{\frac{1}{\beta}-1+\delta}{\alpha}\right]^{\alpha/\alpha-1} \tag{19}$$

Based on Money in Utility Function, money is super-neutrality and neutrality since (17)-(19) illustrate that real variables are independent from policy variable. Moreover, an increase in money growth rate proportionally leads to increase in price level which known as inflation. Hence, this theory aims to explain a positive correlation between inflation and money supply growth.

The theory of money supply and exchange rate is explained through the monetary approach. This theory states that exchange rate is expressed through the balance of payment since it is the price of one currency in terms of another currency. The model starts with the reasonable statement that as the exchange rate is the relative price of foreign and domestic money, it should be determined by the relative supply and demand for this money (Frankel and Rose, 1994). With monetary approach therefore, it is important to emphasize the role of demand and supply of money in determining the exchange rates.

The theory of exchange rate and inflation is captured through Purchasing Power Parity (PPP). This theory attempts to quantify inflation and exchange rate relationship by insisting that change in exchange rate is caused by inflation rate differentials (Ndung'u, 1997). He indicated that exchange rate must change to adapt the change in the prices of goods in the two countries. The PPP in simplest form echoed that in the long run, change in exchange rate among countries will tend to reflect change in relative price.

2.2. Empirical studies

Many empirical analyses have studied in this related topic. Precisely, (Vogel, 1974) investigated the impact of change of money growth on the general price in Latin America. He pointed out that an increase in money growth rate leads to increase in inflation as the same rate. (Abdullah & Yusop, 1996) employed quarterly data in the period of 1970-1992 to analyze the causality between money growth and inflation in Malaysia. He indicates that there is a unidirectional causality from money supply to inflation. (Bengali, Khan and Sadaqat, 1999) showed that an increase in money supply induces inflation rate in Pakistan. (Bafekr, 1998) investigated the most significant factors that possibly influence on inflation in Iran. He indicates that 10% increases in liquidity in the long run causes inflation to increase by 2.7% as in retail sales and 3.2% as in whole sales. Moreover, (Dawoodi, 1997) also stated that 1% increase in liquidity which is 95% as confident level could induce 1% increase in exchange rate and cause inflation to increase by 0.301%. (Levin, 1997) showed that money growth causes domestic currency to depreciate. (Kazerooni and Asghari, 2002) examined the relationship between money supply and inflation in Iran. He indicates that money supply and inflation has a positive correlation. (İsfahani, 2003) concluded that an increase in money supply causes exchange rate to jump up and inflation expectation to increase where inflation is treated as normal variables in the VAR 1971-2001 of his model. (Okhiria, & Saliu, 2008) pointed that money supply and exchange rate has a great impact on inflation in Nigeria. (Simwaka, et al. 2012) indicates that money supply growth drives inflation with lags of 3 to 6 months. Moreover, he also confirmed that exchange rate is relatively more significant to induce inflation in Malawi. (Madesha et al., 2013) illustrated that there is a long run relationship between inflation rate and exchange rate in Zimbabwe. (Adeniji, 2013) demonstrated that there is a positive significant correlation among exchange rate, inflation and money supply in Nigeria by employing VECM model in the period of 1986-2012.

3. Data description

This empirical study is conducted through monthly data in the period of October 2009-April 2018. All variables such as money supply (MS), inflation (INF) and exchange rate (ER) are mainly extracted from Economic and Monetary Statistic of National Bank of Cambodia (NBC).

4. Research methodology

4.1. Vector Autoregressive Model (VAR)

Vector Autoregressive Model (VAR) model is developed by Christopher Sims (1980) with the aim of analyzing multivariate time series data (Christiano, 2012). The VAR(q) model can be written as:

$$y_t = c + \sum_{j=1}^{q} B_j \, y_{t-j} + \varepsilon_t \quad (20)$$

In this study, there are three necessary variables to be observed, namely money supply (MS), exchange rate (EX), and inflation rate (INF).

Where

- MS: is money supply Broad Money (M2) In Million Riel
- EX: is exchange rate of Khmer Riel against US Dollar
- INF: is inflation Consumer Price Index (CPI)

Hence, the VAR(q) could be written:

$$MS_{1,t} = \alpha_1 + \sum_{j=1}^{q} \beta_{1,j}\, MS_{1,t-j} + \sum_{j=1}^{q} \theta_{1,j}\, EX_{1,t-j} + \sum_{j=1}^{q} \delta_{1,j}\, INF_{1,t-j} + \mu_{1t} \qquad (21)$$

$$EX_{1,t} = \alpha_2 + \sum_{j=1}^{q} \beta_{2,j}\, MS_{1,t-j} + \sum_{j=1}^{q} \theta_{2,j}\, EX_{1,t-j} + \sum_{j=1}^{q} \delta_{2,j}\, INF_{1,t-j}\, \mu_{2t} \qquad (22)$$

$$INF_{1,t} = \alpha_3 + \sum_{j=1}^{q} \beta_{3,j}\, MS_{1,t-j} + \sum_{j=1}^{q} \theta_{3,j}\, EX_{1,t-j} + \sum_{j=1}^{q} \delta_{3j}\, INF_{1,t-j} + \mu_{3t} \qquad (23)$$

4.2. Bayesian VAR (B-VAR)

BVAR is suggested by Litterman (1985) for econometric models and other time series techniques. According to Sims and Zha (1995), they have shown how to compute Bayesian error bands for impulse response estimated from reduced from VAR (Sims and Zha, 1998).

So, VAR equation namely, (21)-(23) could be written in a matrix form below:

$$Y = XB + E \qquad (24)$$

Where

Y is an1×1 matrix of exogenous variables,

X is an1×1 matrix of endogenous variables,

B is an 3×1matrix of coefficients

E is an1×1 matric-variate normal distribution matrix.

Canova (2007) and Geweke (2005) note a useful, alternative vectorized form of (24)

$$y = (\mathbb{I}_m \otimes X)A + \epsilon \qquad (25)$$

Where $A = vec(B)$, vec is the Column-stacking operator , $y_{((T\times m)\times 1)} = vec(Y)$ is the stacked matrix of observations, $\epsilon_{((T\times m)\times 1)} \sim (0, \Sigma \otimes \mathbb{I}_T)$ is stacked vector of disturbance terms, $\mathbb{I}_T$ is an identity matrix of size $T \times T$, and $\otimes$ is the kronecker product.

The first B-VAR model is considered as the normal-inverse-Wishart model, where the kernel of the joint posterior distribution could be written as:

$$p(A, \Sigma | L, y) \propto p(y | L, A, \Sigma) p(A, \Sigma) \qquad (26)$$

Where

$p(A, \Sigma | L, y)$ is the posterior distribution

$p(y | L, A, \Sigma)$ is the likelihood function which is already derived from the data set

$p(A, \Sigma)$ is the prior distribution

The parameters in the joint prior $p(A, \Sigma)$ are assumed to be independent. So, it could be written as:

$$p(A) = N(\bar{A}, \Xi_A)$$
$$= \left(\frac{1}{2\pi}\right)^{(m\times p+1)/2} |\Xi_A|^{-\frac{1}{2}} \exp\left[-\frac{1}{2}(A-\bar{A})'\Xi_A{}^{-1}(A-\bar{A})\right] \quad (27)$$

And

$$p(\Sigma) = IW(\Xi_\Sigma, \gamma)$$
$$= \left(\frac{1}{2}\right)^{\frac{\gamma m}{2}} \pi^{-\frac{m(m-1)}{4}} |\Xi_\Sigma|^{\frac{\gamma}{2}} \left\{\prod_{i=1}^{m} \frac{\Gamma(\gamma+1-i)}{2}\right\}^{-1}$$
$$\cdot \left(\frac{1}{|\Sigma|}\right)^{(\gamma-m-1)} \exp\left(-\frac{1}{2} trace(\Xi_\Sigma \frac{1}{\Sigma})\right) \quad (28)$$

Where $\Gamma(.)$ is gamma function

Finally, the conditional Kernel of A could be written as:

$$p(A, \Sigma | L, y) \propto \exp\left(-\frac{1}{2}(A-\widetilde{A})' \widetilde{\Sigma_A}^{-1}(A-\widetilde{A}) + C\right) \quad (29)$$

Where

$$\widetilde{\Sigma_A}^{-1} = \Xi_A{}^{-1} + L'(\Sigma^{-1} \otimes \mathbb{I}_T)L$$

$$\tilde{A} = \widetilde{\Sigma_A}^{-1}(\Xi_A{}^{-1}\overline{A} + L'(\Sigma^{-1} \otimes \mathbb{I}_T)y)$$

$$C = y'(\Sigma^{-1} \otimes \mathbb{I}_T)y + \overline{A}' \Xi_A{}^{-1}\overline{A} - \widetilde{A}'\widetilde{\Sigma_A}^{-1}\widetilde{A}$$

The conditional kernel of Σ could be written as

$$p(\Sigma | B, X, Y) \propto |\Sigma|^{-\frac{T}{2}} |\Sigma|^{-\frac{(\gamma-m-1)}{2}}$$
$$\times\, exp\left(-\frac{1}{2} trace(\Xi_\Sigma \frac{1}{\Sigma})\right) exp\left(-\frac{1}{2} trace\left[\frac{1}{\Sigma}(Y-XB)'(Y-XB)\right]\right)$$
$$\propto |\Sigma|^{-\frac{(\gamma-m-1)}{2}} \times exp\left(-\frac{1}{2} trace\left[\frac{1}{\Sigma}(\Xi_\Sigma + (Y-XB)'(Y-XB))\right]\right) \quad (30)$$

The kernel posterior of *A* and Σ could be written:

$$p(A, \Sigma | L, y) = N(\tilde{A}, \tilde{\Sigma}_A) \quad (31)$$

$$p(\Sigma | B, X, Y) = IW(\Xi_\Sigma + (Y-XB)'(Y-XB), T+\gamma) \quad (32)$$

Where *N(.)* and *IW(.)* denote normal and inverse-Wishart distribution, respectively.

5. Empirical results

5.1. Unit Root Test

Before estimating B-VAR, there is necessary to access the unit root test. The unit root test confirms the stationary of variables. If the data is non-stationary, it will produce the spurious regression.

Table 1: Unit Root Test Result (ADF Test)

Variables	Level		1st difference	
	Constant	Constant and Trend	Constant	Constant and Trend
MS	3.077	-0.052	-7.005*	-7.980*
INF	-0.457	-3.181***	-8.800*	-8.768*
ER	-3.199**	-3.368***	-6.895*	-6.970*

Source: Author's own calculation
Note: *, **, *** denotes significant level at 1%, 5% and 10%, respectively.

Based on table 1, it can be seen clearly that money supply is non-stationary in level *I (0)*. However, it confirms stationary in first difference *I (1)* with significant level, 1% for both constant as well as constant and trend. Inflation is non-stationary at level for constant. However, it is stationary in level for constant and trend with significant level, 10 %. Moreover, inflation indicates stationary in first difference. Last but not least, exchange rate confirms stationary in level with 5% and 10% for constant and constant and trend, respectively. Moreover, exchange rate is stationary significant level, 1% in the first difference. To ensure the stationary process, all equations are written in first difference since all variables confirm stationary in this level.

5.2. Lag Length Selection Criterion

Table 2: Lag Length Selection Criterion

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1275.487	NA	1.31e+08	27.201	27.283*	27.234*
1	-1262.461	24.942	1.20e+08*	27.116*	27.440	27.247
2	-1259.623	5.253	1.37e+08	27.247	27.815	27.476
3	-1251.562	14.407	1.40e+08	27.267	28.078	27.595

Source: Author's own calculation
*indicates lag order selected by the criterion

It is necessary to choose lag for VAR (q). The lag length selection is chosen based on the minimum value of Akaike Information Criterion (AIC), Schwarz Information Criterion

(SIC) and Hannan-Quinn Information Criterion (HQ) and Final Prediction Error (FPE). Based on table 2, lag 1 is selected due to the minimum value of AIC and FPE.

5.3. Stability of VAR

This is necessary to access the stability of VAR. If VAR confirms the stability, roots are located in the unit circle. Based on figure 1, it is clearly seen that all roots are in the unit circle which confirms the stability of VAR.

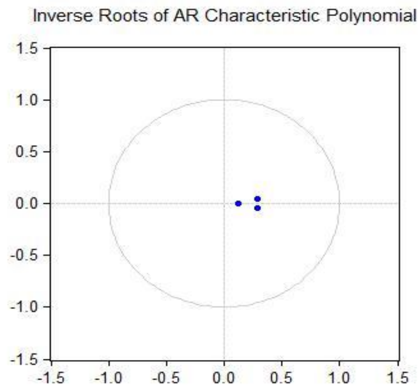


Figure 1: VAR Stability
Source: Author's own calculation

5.4. Estimation of Coefficients

After checking stationary, lag selection and stability of VAR, the estimation of B-VAR with inverse-normal Wishart prior is provided with lag 1 and three necessary equations as follow:

Table 3: B-VAR Coefficients

Variables	$D(MS)$	$D(INF)$	$D(ER)$
$D(MS)$	0.339 [3.528]	0.000348 [0.28763]	0.005 [1.526]
$D(INF)$	-86.127 [-1.019]	0.126 [1.193]	1.747 [0.540]
$D(ER)$	-0.350 [-0.128]	0.000528 [0.154]	0.236 [2.264]
Constant	432.538 [4.738]	0.321 [2.80755]	-4.896 [-1.402]

Source: Author's own calculation
Note: [] denotes standard error
D() represents first difference

There are three necessary equations to be discussed. First, there is a money supply equation. From this equation, it can be seen clearly that the money supply at time *t* only depends on its own lag *t-1* with the mean (0.339) and standard error (3.528). However, inflation and exchange rate at time *t-1* display negatively on money supply at time *t*. Based on money supply equation, it could be said that the amount of money supply at time *t* continuously increases due to its previous amount. Based on statistical point of view, the money supply is continuously increased due to the fact as NBC still injects more money in the circulation.

Second equation is an inflation equation. Based on this equation, it illustrates that money supply and exchange rate at time *t-1* positively influence inflation at time *t* with the mean (0.0000348) and (0.000528) and standard error (0.287) and (0.114) for money supply and exchange rate at time *t-1*, respectively. According to this statistical result, it is clearly demonstrated that an increase in money supply causes inflation rate to rise. This finding is consistent with the theory of MIU. Moreover, it also supports (Simwaka, et al. 2012) and (Kazerooni and Asghari, 2002) who confirmed a positive correlation between money supply and inflation. Furthermore, a positive correlation between exchange rate and inflation in Cambodia is also statistically confirmed. This result is found to be consistent with the theory of PPP. Moreover, this finding also supports some empirical studies (Madesha et al., 2013) and (Adeniji, 2013). In accordance with this statistical result, it indicates that the depreciation of Khmer Riel against US Dollar leads to increase in inflation due to the depreciation of Khmer Riel.

Last but not least, there is an exchange rate equation. Based on this equation, the exchange rate at time *t* depends on money supply at time *t-1* with the mean (0.005) and standard error (1.52652). Inflation and exchange rate at time *t-1*, moreover, positively influence on exchange rate at time *t* with the mean (1.747) and (0.005) and standard error (0.540) and (1.526) for inflation and exchange rate at time *t-1* respectively. Based on this statistical finding, an increase in money supply causes exchange rate of Khmer Riel depreciates against US Dollar.

5.5. Impulse Response Function

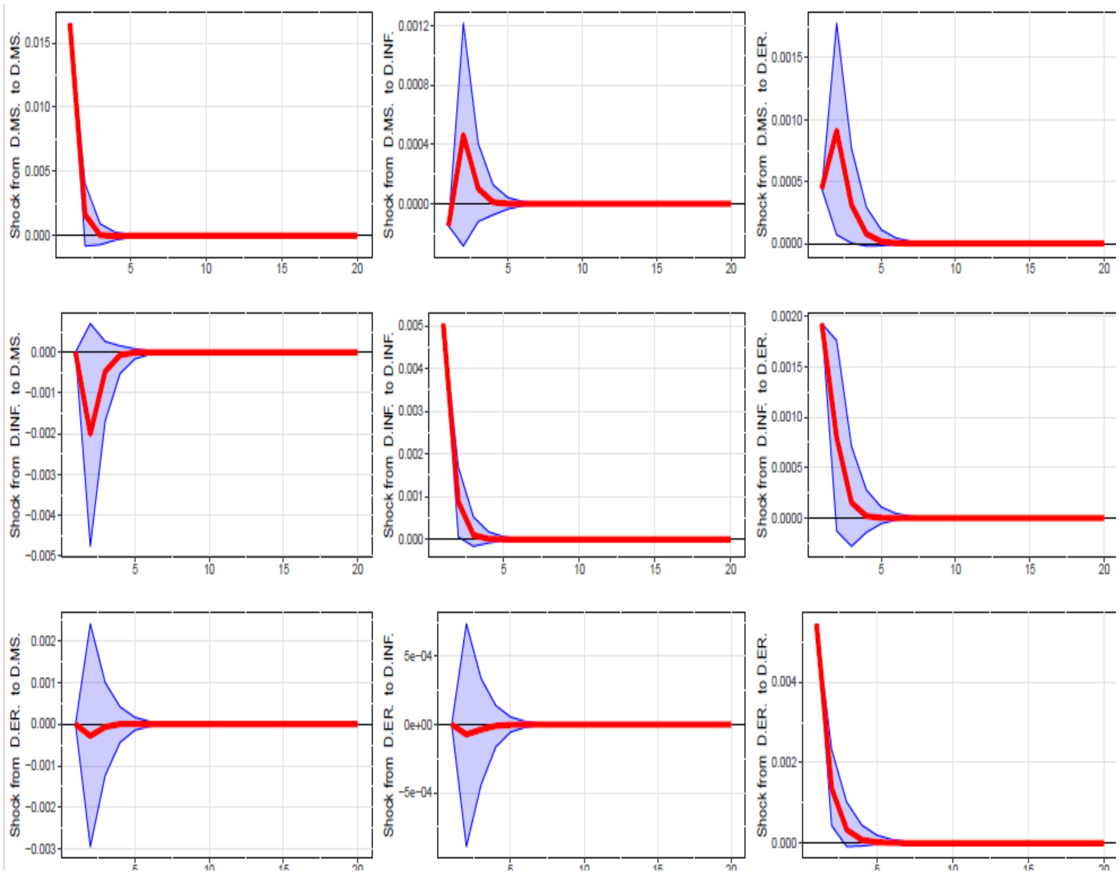
The impulse responses to the related variables presented are estimated over a period of twenty monthly horizons. The shocks increase by a value of one standard deviation and then a shock changes on variable itself and other variables.

Based on Figure 1, it is clearly seen that the shock from money supply on itself displays a decrease trend. However, response from the shock is in the positive side. The response of shock becomes stable after the fifth period.

Moreover, the shock from money supply to inflation illustrates an upward trend. The response slightly increases for the first two period and decreases after the third period. The response becomes stable after the fifth period. This shock indicates that an increase in inflation results in increasing money supply. However, due to the money supply is done with care by NBC; the inflation rate slightly decreases to in stable value as it is shown in the impulse response.

Furthermore, the shock from money supply causes exchange rate increases due to the depreciation of Khmer Riel. Based on Figure 2, it indicates that exchange rate jumps up for the first two period and reaches to the stable path after the fifth period. This confirms that the depreciation of Khmer Riel is controlled by the policy tools from NBC through stabilizing the exchange rate stability.

Figure 2: Impulse Responses Function



5.6. Variance Decomposition

In order to find the share of variation in a given variable caused by different shocks, the variance decomposition in B-VAR is applied. Variance decomposition, based on Table 4, takes 10 periods that help to visual the effect of related variables.

Based on the variance decomposition, money supply can cause its own shock approximately 98% both as in shot run and a long run trend. However, inflation and exchange rate display a very low percentage of shock on money supply.

Furthermore, inflation which is given in variance decomposition causes 99% to its own shocks. Money supply, moreover, causes approximately 0.13% to inflation for both short run and a long run trend. Furthermore, exchange rate causes only 0.024% to inflation. This low shocks could be explained due to the fact as NBC has achieve its goal through ensuring the price stability in terms of inflation rate and exchange rate.

Exchange rate, furthermore, responds 80% to its own shocks while money supply can cause approximately 8% to exchange rate. The related lower shock from money supply to exchange rate could be explained due to the cautious manner in supply money in a high dollarized economic context in Cambodia by NBC.

Table 4: Variance Decomposition

Per	1	2	3	4	5	6	7	8	9	10
Variance Decomposition of MS										
MS	100	98.89	98.65	96.61	98.61	98.61	98.61	98.61	98.61	98.61
INF	0.00	1.090	1.327	1.360	1.364	1.365	1.365	1.365	1.365	1.365
ER	0.00	0.013	0.019	0.021	0.021	0.021	0.021	0.021	0.021	0.021
Variance Decomposition of INF										
MS	0.000	0.097	0.124	0.128	0.129	0.129	0.129	0.129	0.129	0.129
INF	99.99	99.88	99.85	99.84	99.84	99.84	99.84	99.84	99.84	99.84
ER	0.00	0.022	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
Variance Decomposition of ER										
MS	3.930	6.964	7.729	7.858	7.876	7.878	7.879	7.879	7.879	7.879
INF	11.40	12.01	11.92	11.91	11.90	11.90	11.90	11.90	11.90	11.90
ER	84.66	81.02	80.34	80.23	80.21	80.21	80.21	80.21	80.21	80.21

Source: Author’s own calculation

6. Conclusion

By employing Bayesian VAR with the monthly data in the period of October-2009 and April-2018, the statistical results reveal that money supply in Cambodia positively depends on its previous period which indicates that money supply has continuously increased for the last several years. The increase in money supply causes inflation to jump up which illustrate that the aggregate price of all items increases. At the same time, exchange rate illustrates a positive correlation with inflation as well. This positive relationship statistically reveals that the depreciation of Khmer Riel against US Dollar results in rising inflation in Cambodia. Money supply induces 8% of shock to exchange rate and 0.13% to inflation based on variance decomposition while exchange rate can cause 0.024% to inflation in Cambodia. This statistical result echoes and supports the money in utility function which states that in steady state; money growth equal to the inflation. In other words, an increase in money growth rate causes inflation to jump up. The correlation between inflation and exchange rate also support the theory of PPP which states that the adjustment of exchange rate reflects to inflation. Furthermore, this finding also strongly supports with many empirical studies on this related fields. Based on this statistical results, there is a conclusion that an increase in money supply in Cambodia causes exchange rate of Riel against US Dollar to depreciate and hence to increase in inflation. Since Cambodia is still characterized as dollarized economy, money supply has been done cautiously by NBC in order to maintain price stability by making the stable exchange rate and inflation rate.

References

Abdullah, A. Z., & Yusop, Z. (1996). Money, Inflation and Causality: The Case of Malaysia (1970-92). *Asian Economic Review*, *38*(1), 44-51.

Adeniji, S. O. (2013). Exchange rate volatility and inflation upturn in Nigeria: testing for Vector Error Correction Model. *MPRA Paper No. 52062*.

Bafekr, A. (1998). Investigation about causes of inflation in Iran with cointegration method. *Economic Department of Shahid Beheshti University. Tehran. Iran*.

Bengali, K., Khan, A. H., & Sadaqat, M. (1999). Money, income, prices, and causality: The Pakistani experience. *The Journal of Developing Areas*, 503-514.

Christiano, L. J. (2012). Christopher A. Sims and vector autoregressions. *The Scandinavian Journal of Economics*, *114*(4), 1082-1104. https://doi.org/10.1111/j.1467-9442.2012.01737.x

Dawoodi, P. (1997). Economic stabilization policy and estimating dynamic inflation model in Iran. *Research publication and economic policy. Tehran, Iran*.

Frankel, J. A., & Rose, A. K. (1994). *A survey of empirical research on nominal exchange rates* (No. w4865). National Bureau of Economic Research.

İsfahani, R. v. (2003). Refahiyete İran dar tavarrom: VAR. *Feslnameye Pejuheşhaye İktisati*, 69-99.

Kazerooni, A., And Asghari, B., (2002), The study of classical model of inflation in Iran, cointegration test, *Iranian Journal of Trade Studies*, 23, 97-138.

Levin, J. H. (1997). Money supply growth and exchange rate dynamics. *Journal of Economic Integration*, 344-358.

Litterman, R. B. (1985). *A Bayesian procedure for forecasting with vector autoregressions and forecasting with Bayesian Vector Autoregressions-four years of experience*. Federal Reserve Bank of Minneapolis.

Lewis, M. K., & Mizen, P. D. (2000). *Monetary economics*. OUP Catalogue.

Madesha, W., Chidoko, C., & Zivanomoyo, J. (2013). Empirical test of the relationship between exchange rate and inflation in Zimbabwe. *Journal of Economics and Sustainable Development*, *4*(1), 52-58.

NBC. (2017). *National Bank of Cambodia Annual Report*. Phnom Penh, NBC.

Ndung'u, N. S. (1997). Price and exchange rate dynamics in Kenya: an empirical investigation (1970-1993). *Research Paper/African Economic Research Consortium, No.58*.

Okhiria, O., & Saliu, T. (2008). E*xchange rate variation and inflation in Nigeria (1970-2007)*. Master Degree Project. University of Skovde.

Sidrauski, M. (1967). Rational choice and patterns of growth in a monetary economy. *The American Economic Review*, *57*(2), 534-544. https://doi.org/10.1086/259552

Sims, C. A. (1980). Macroeconomics and reality. *Econometrica: Journal of the Econometric Society*, 1-48. https://doi.org/10.2307/1912017

Sims, C. A., & Zha, T. (1998). Bayesian methods for dynamic multivariate models. *International Economic Review*, 949-968. https://doi.org/10.2307/2527347

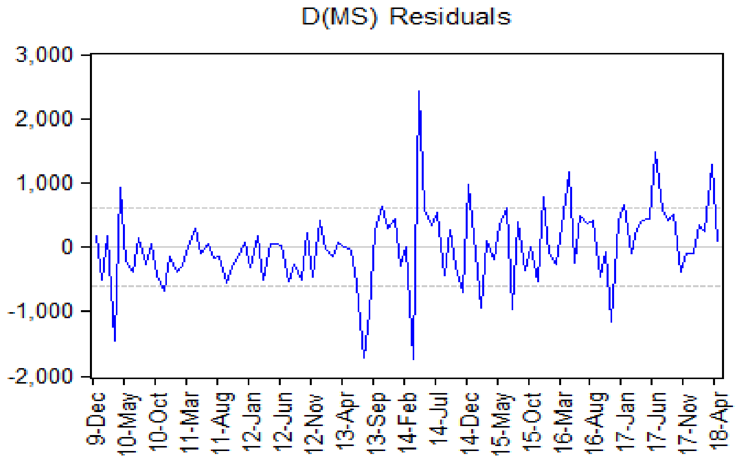
Sims, C. A., & Zha, T. (1995). *Error bands for impulse responses* (No. 95-6). Working Paper, Federal Reserve Bank of Atlanta.

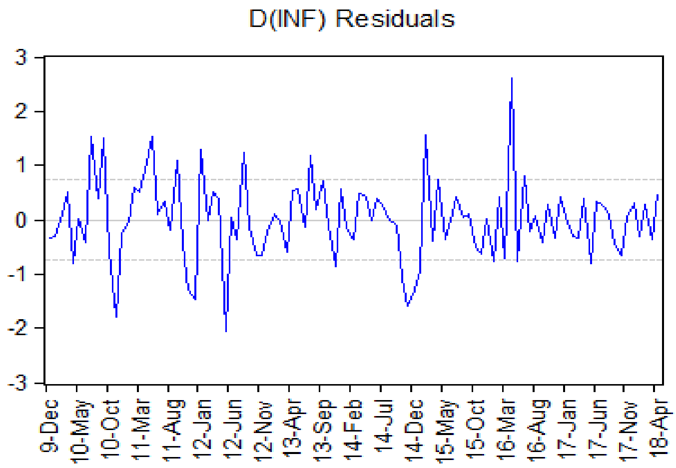
Simwaka, K., Ligoya, P., Kabango, G., & Chikonda, M. (2012). Money supply and inflation in Malawi: An econometric investigation. *Journal of Economics and International Finance*, *4*(2), 36-48. https://doi.org/10.5897/JEIF11.138

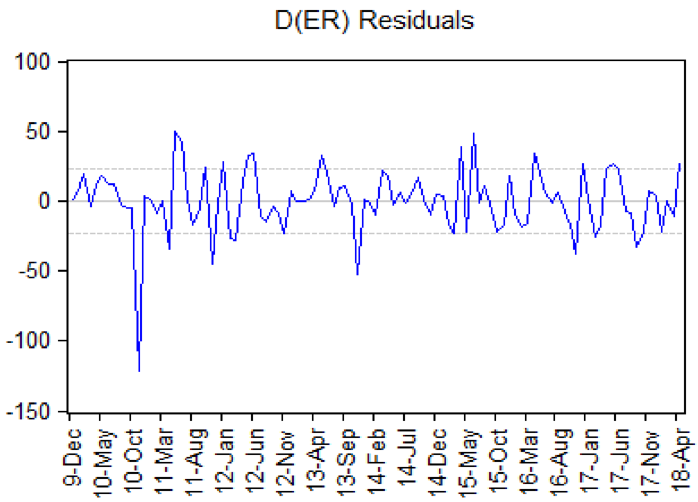
Walsh, C. E. (2017). *Monetary theory and policy*. MIT press.

Vogel, R. C. (1974). The dynamics of inflation in Latin America, 1950-1969. *The American Economic Review*, *64*(1), 102-114.

Appendix 1: Residual Plots







Appendix 2: Statistical Data