International Journal of Economics and Financial Issues

ISSN: 2146-4138

available at http: www.econjournals.com

International Journal of Economics and Financial Issues, 2024, 14(5), 156-166.

Analyzing the Effectiveness of a System of Equation Model in Comparison to Single Equation Models for Predicting General Price Level in Cambodia

Siphat Lim*, Edman Flores, Casey Barnett

CamEd Business School, Phnom Penh, Cambodia. *Email: lsiphat@cam-ed.com

Received: 05 March 2024 **Accepted:** 16 July 2024 **DOI:** https://doi.org/10.32479/ijefi.16311

ABSTRACT

The primary aim of this study is to evaluate the effectiveness of two different models in predicting Cambodia's inflation rate: the SARIMAX model, a single equation model, and the VAR model, a system of equation model. The findings from both models indicate that foreign exchange and monetary aggregate are crucial variables in forecasting changes in the inflation rate. During the projected timeframe spanning from November 2023 to April 2024, the SARIMAX model predicted a mean monthly inflation of 0.005452%, while the VAR model forecasted a higher mean of 0.196017% for the previous 7 months. Notably, the SARIMAX model exhibited better accuracy in forecasting inflation rates compared to the VAR model, showcasing a lower RMSE of 1.06903 for SARIMAX, compared to 1.15166 for VAR. This suggests that the SARIMAX model provides more reliable and precise inflation rate predictions than the VAR model during the study period. The superior performance of the SARIMAX model in forecasting inflation rates highlights its effectiveness in capturing the complex dynamics between inflation, exchange rates, and monetary aggregates in the Cambodian economy. This finding has important implications for policymakers in developing appropriate monetary and exchange rate policies to maintain price stability and promote sustainable economic growth.

Keywords: Consumer Price Index, Foreign Exchange, Monetary Aggregate, SARIMAX Model, VAR Model
JEL Classifications: C32, C52, C53, E31, E37, E47

1. INTRODUCTION

The importance of accurately forecasting price levels has become increasingly paramount in recent years, particularly due to the volatile and uncertain nature of commodity prices. Conventional forecasting methods, which rely on historical data extrapolation, have exhibited limitations in effectively predicting future price levels, especially during periods of transition and ambiguity. Accurate prediction of price levels is of paramount importance in the realms of monetary policy and economic planning, as it plays a pivotal role in stabilizing the economy and influencing investment decisions.

The Cambodian economy presents a compelling case for investigation, given its shift from a centrally controlled system to a market-driven one. This significant change has led to substantial alterations in the country's monetary system, impacting inflation, foreign exchange rates, and money supply. The National Bank of Cambodia (NBC), as the central monetary authority, is instrumental in managing these changes and maintaining economic stability.

Cambodia's financial market system has undergone remarkable advancements in the last decade, with the country's economic progress improving the lives of its citizens and leading to its classification as a lower middle-income nation. This economic transformation has been significantly influenced by the historical evolution, organization, and effectiveness of the financial market system, which has been crucial in shaping the country's development trajectory (Clark and Clark, 2020).

From 2012 to 2018, an examination of Cambodia's macroeconomic performance reveals a steady yearly increase in GDP of over 7%, positioning it as one of the rapidly growing nations in Asia. During this period, Cambodia has managed to maintain a low unemployment rate, stable inflation, and a rising trade deficit. Furthermore, the country has experienced a consistent increase in foreign direct investment inflows and an expanding foreign exchange reserve, indicating robust growth prospects (Tang and Li, 2021). In 2024, Cambodia is projected to have a population of 17.1 million[1], with an anticipated GDP growth rate of 5.8% and an inflation rate of 2.0% during the same period.[2]

Despite the considerable research exploring the connections between monetary factors and economic markers in Cambodia, a gap exists in the specific field of price level prediction. This current study seeks to fill this void by conducting an in-depth analysis that concentrates on forecasting the fluctuations of the general price level in Cambodia. The research will employ two distinct models: the Seasonal ARIMA with exogenous variables (SARIMAX) model, a single equation model, and the Vector Autoregression (VAR) model, a system of equation model, to produce forecasts for the general price level.

The comparison between the single equation SARIMAX model and the system of equation VAR model will provide valuable insights into the relative effectiveness of these approaches in predicting the general price level in Cambodia. This analysis will contribute to the existing body of knowledge and inform policymakers and economic planners in their efforts to maintain price stability and promote sustainable economic growth.

Conducting this study is crucial, as it will deepen our understanding of the complex dynamics influencing price levels in Cambodia's evolving economic landscape. The findings can inform the development of more robust forecasting frameworks and guide the formulation of appropriate monetary and fiscal policies to address inflationary pressures and support the country's continued economic progress.

2. LITERATURE REVIEW

2.1. Single Equation Models

The Seasonal Autoregressive Integrated Moving Average (SARIMA) model and its extension with exogenous variables (SARIMAX) are powerful statistical techniques used for time series forecasting. These models are particularly useful for data with strong seasonal patterns, as they can effectively capture both the seasonal and non-seasonal components of the time series (Flores et al., 2019; Farsi et al., 2021; Arumugam and Natarajan, 2023).

The SARIMAX model extends the SARIMA framework by including exogenous variables (X) that can influence the time series being modeled. The inclusion of these external factors allows the model to account for additional information, potentially improving the accuracy of forecasts (Elamin and Fukushige, 2018; Sameh and Elshabrawy, 2023).

Several studies have explored the application of SARIMA and SARIMAX models in the context of inflation forecasting. A study focused on emerging economies such as Mexico, Colombia, and Peru combined SARIMA and Long Short Term Memory (LSTM) models, finding that the hybrid SARIMA-LSTM approach provided higher accuracy in inflation forecasts compared to using SARIMA or LSTM alone. The Mean Square Error (MSE) and Model Confidence Set (MCS) were used to evaluate the models' performance (Peirano et al., 2021).

Research on Indonesian inflation data from 2008 to 2014 utilized the SARIMA model to predict future inflation rates. The study identified that the presence of outliers in residual data could affect the accuracy of the SARIMA model, and the best-performing model was SARIMA (0,1,1) (0,1,1) 12. The findings highlighted the importance of outlier detection in improving the model's accuracy (Fadliani et al., 2021).

In the Philippines, a study aimed to predict the inflation rate using the SARIMA model based on historical data from January 2012 to March 2023. The best-performing model was identified as SARIMA (1,1,1) (0,0,1) 12, which exhibited a Mean Absolute Percentage Error (MAPE) of 8.17%, suggesting acceptable forecasting accuracy. The model forecasted a gradual decline in the inflation rate from April 2023 to March 2024, providing valuable insights for monetary policy decisions (Corpin et al., 2023).

2.2. VAR Models

VAR models are widely used in economic forecasting due to their ability to model the dynamic relationships between multiple economic indicators. These models allow for the simultaneous forecasting of a group of variables, leveraging the correlations among them. This is particularly useful when dealing with highly correlated economic indicators, as demonstrated by a study comparing VAR and ARIMA models for economic variables in Bangladesh (Khan and Khan, 2020).

VAR models can be further enhanced by incorporating additional features. For instance, Bayesian VAR (BVAR) models have been shown to outperform traditional models, such as the Bank of England's DSGE model, in forecasting GDP growth and CPI inflation in the UK (Domit et al., 2019). In scenarios involving a large number of variables, such as forecasting inflation rates in the eurozone, Bayesian panel VAR models with time-varying parameters and stochastic volatility have demonstrated superior performance (Koop and Korobilis, 2019).

VAR models are also applied in financial markets for forecasting exchange rates. A study found that a large-dimensional VAR model with time-varying parameters performed well in predicting major forex pairs like EUR-USD and GBP-USD (Taveeapiradeecharoen and Aunsri, 2020).

Structural VAR models, which incorporate external instruments for identification, are used to analyze the impact of monetary policy

1 This information is taken from the UNFPA's World Population Dashboard – Cambodia.

2 These data are taken from ADB's flagship economic report (2024).

shocks. For example, augmenting a standard small-scale Proxy VAR with factors from a large set of financial variables provided more theoretically consistent price responses (Bruns, 2019). In environments where interest rates are at or near their effective lower bound, shadow-rate VAR models have been developed to account for this constraint, providing more accurate forecasts for interest rates and other macroeconomic variables (Carriero et al., 2021).

VAR models can also be extended to account for time-varying dynamics. Time-varying VAR models allow the coefficients and covariance matrix of the error innovations to change smoothly over time, providing a more accurate representation of the evolving relationships between economic variables. This approach is particularly useful for analyzing the transmission mechanism of monetary policy (Yan et al., 2021).

To further improve the performance of VAR models, researchers have explored combining them with other techniques. For example, the Bayesian Proxy Factor-Augmented VAR (BP-FAVAR) model combines a large information set with an identification scheme based on an external instrument, enhancing the model dynamics and delivering more theoretically consistent price responses to monetary policy shocks (Bruns, 2019). Another approach, the Bayesian additive vector autoregressive tree model, combines VAR with Bayesian additive regression tree models, allowing for the capture of arbitrary non-linear relations between variables and improved forecasting accuracy (Huber and Rossini, 2022).

High-dimensional VAR models augmented with common factors can also accommodate the interconnectedness and temporal co-variability present in large dimensional systems. These models use advanced estimation techniques like the 1-nuclear-norm regularized estimator to handle the complexity of high-dimensional data, improving estimation precision and capturing the dynamic connectedness in financial markets (Miao et al., 2023).

The effectiveness of VAR models in forecasting economic variables has been examined in various contexts. A study comparing multivariate models for forecasting inflation in BRICS and OPEC countries found that the inclusion of long-run information via cointegrated equations generally improved forecasting performance, with the nature of the economy and inflation history significantly influencing the model's effectiveness (Ajayi, 2019). Similarly, a study in the context of Pakistan found that BVAR models provided relatively better forecasts for GDP growth, interest rates, and inflation compared to other models, with the DSGE model's forecasting performance improving over longer horizons (Ahmad and Haider, 2019).

While not exclusively focused on developing economies, a study on high-dimensional panel VARs with time-varying parameters and stochastic volatility demonstrated superior forecasting performance for inflation rates in the eurozone, offering potential improvements in forecast accuracy through flexible model specifications that could be adapted for use in developing economies (Koop and Korobilis, 2019). Additionally, a study on the G7 economies found that a hierarchical shrinkage approach for multi-country VAR models, particularly with the Horseshoe prior, was highly effective in forecasting inflation, which could also benefit developing economies by incorporating foreign information to enhance forecast accuracy (Bai et al., 2022).

Finally, a study on macroeconomic forecasting for China compared various models, including autoregressive (AR), autoregressive moving average (ARMA), VAR, and Bayesian VAR models, and found that these models provided superior short-term forecasts for the producer price index compared to simple benchmarks. This suggests that similar models could be effective for short-term inflation forecasting in other developing economies (Heaton et al., 2020).

2.3. The Interconnectedness of Money Supply, Inflation, and Foreign Exchange Rates

The existing literature has extensively investigated the complex relationships between inflation, foreign exchange rates, and money supply in various economic contexts. Studies have uncovered a range of findings, including positive, negative, and sequential causal relationships among these macroeconomic variables.

Several studies have highlighted the impact of money supply on foreign exchange rate dynamics. Syamad and Rossanto (2023) emphasized that an increase in money supply can lead to a depreciation of the foreign exchange rate in both the short and long term. Daoud and Al-Ezzi (2023) also argued that foreign exchange rate dynamics are directly influenced by the money supply in the long term.

Furthermore, the relationship between money supply, inflation, and foreign exchange rates is influenced by a range of other macroeconomic factors. Agustina and Permadi (2023) contended that inflation is positively influenced by the money supply, foreign exchange rates, and fuel prices, suggesting that increases in these variables can contribute to higher inflation rates. Elshafei and Abdallah (2023) stressed that broad money and foreign exchange rates can stimulate inflation by increasing purchasing power and aggregate demand.

However, the impact of money supply on inflation and foreign exchange rates can vary depending on the state of the economy. Buthelezi (2023) highlighted that different effects are observed during periods of low and high inflation or economic growth. Similarly, Elshafei and Abdallah (2023) found that money supply can have both positive and negative impacts on inflation in different states of economic growth.

Numerous studies have delved into the specific relationships between these macroeconomic variables in various country contexts. Wang (2021) examined the relationship between money supply, inflation, and unemployment in the US, while Joshi (2021), Nguyen et al. (2022), and Dekkiche (2022) focused on the long-term and short-term relationships between money supply and inflation in Nepal, Vietnam, and Egypt, respectively.

In the case of Cambodia, several studies have utilized different econometric models to explore the interconnectedness of money supply, inflation, and foreign exchange rates. Sean et al. (2019) employed a Bayesian VAR approach and found that money supply in Cambodia induced depreciation of the foreign exchange rate, leading to an increase in inflation. In contrast, Song and Lim (2023) established a money demand function in Cambodia using the ARDL approach and found that real income had a positive impact on real money demand in the long run, while the general price level and interest rate had a negative impact.

Additionally, Ky and Lim (2023) used a VAR model to analyze the movement of monetary aggregates in Cambodia, revealing that inflation rate positively impacted the movement of monetary aggregates, while foreign exchange rate depreciation had a negative impact. Vorlak et al. (2019) also assessed the impact of foreign exchange rates on Cambodia's economic growth, finding a positive correlation between foreign exchange rates and GDP.

By focusing on price level forecasting in Cambodia, this study aims to contribute to the existing knowledge on the economic dynamics within the country. The utilization of SARIMAX and VAR models allows for a comprehensive analysis of the factors influencing price levels, providing valuable insights for policymakers, researchers, and stakeholders in Cambodia's economy.

3. METHODOLOGY

3.1. VAR Model

In this study, the VAR model is utilized to analyze the connections between all variables within the system. The model includes three endogenous variables, with three equations outlined as follows:

$$DlnCPI_t = \partial_{10} + \sum_{i=1}^{p}\varphi_{11i} DlnCPI_{t-i} + \sum_{i=1}^{p}\varphi_{12i} DlnFX_{t-i} + \sum_{i=1}^{p}\varphi_{13i} DlnM_{t-i} + \varepsilon_{1t} \quad (1)$$

$$DlnFX_t = \partial_{20} + \sum_{i=1}^{p}\omega_{21i} DlnCPI_{t-i} + \sum_{i=1}^{p}\omega_{22i} DlnFX_{t-i} + \sum_{i=1}^{p}\omega_{23i} DlnM_{t-i} + \varepsilon_{2t} \quad (2)$$

$$DlnM_t = \partial_{30} + \sum_{i=1}^{p}\delta_{31i} DlnCPI_{t-i} + \sum_{i=1}^{p}\delta_{32i} DlnFX_{t-i} + \sum_{i=1}^{p}\delta_{33i} DlnM_{t-i} + \varepsilon_{3t} \quad (3)$$

The VAR model includes three endogenous variables: the consumer price index (CPI), the foreign exchange rate (FX) measured in Khmer Riel (KHR) per US dollar, and the broad money supply (M). In order to maintain uniformity, all variables are converted using the natural logarithm (ln). The model is comprised of constant terms ∂_{j0} and white-noise disturbance terms ε_{jt}, where j takes on the values of 1, 2, or 3. The optimal number of lags p is established for the model, with i ranging from 1 to N and time t ranging from 1 to T. Furthermore, the parameters ϕ, ω and δ must be estimated as a component of the model.

In order to prevent inaccurate regression outcomes, a unit root analysis is conducted on all time series data in this research using the Augmented Dickey-Fuller (ADF) test. The primary purpose of this examination is to ascertain the presence of a unit root in the time series data. If the null hypothesis is rejected, it indicates that the series is non-stationary. In instances like these, the series undergoes a transformation into its initial difference, followed by a repetition of the test. It is important to highlight that a series displaying this particular pattern is categorized as integrated of order one, represented as I(1).

The criteria for selecting the order in the VAR model are subsequently employed utilizing the Akaike Information Criteria (AIC). A decreased value of the criterion signifies a more precise estimation of the model. After conducting a stability test, the examination and explanation of the forecast error variance decomposition and impulse response function are carried out according to the estimated VAR model.

It should be emphasized that the initial deviation (D) assigned to each dataset signifies the rate of growth. As an example, the inflation rate is reflected by the growth rate of the consumer price index, whereas the appreciation or depreciation of the Riel is signified by the positive or negative growth rate of the foreign exchange rate, respectively.

3.2. SARIMAX Model

The following equations represent the structural equation of the consumer price index, which is labeled as equation (4), and the equation for the autoregressive integrated moving average, SARIMAX(p,d,q), which is labeled as equation (5).

$$DlnCPI_t = \beta_1 DlnFX_t + \beta_2 DlnM_t + \mu_t \quad (4)$$

$$\mu_t = \sum_{i=1}^{p}\rho_i \mu_{t-i} + \sum_{i=1}^{q}\theta_j \epsilon_{t-i} + \phi SMA(12)_t + \epsilon_t \quad (5)$$

The foreign exchange rate's slope coefficient is represented by β_1, while the money supply's slope coefficient is denoted by β_2. The unconditional residual terms of the structural equation and ARMA equation are symbolized by μ and ϵ, respectively. The error term ϵ_t is considered to follow a white-noise pattern with a mean of zero and a consistent variance, or to be independently and identically distributed as $\epsilon_t \sim$ i. i d. N $(0, \sigma^2)$. The symbols ρ and ϵ represent the autocorrelation and moving-average parameters, respectively. Furthermore, ϕ signifies the parameter for a seasonal twelve-month moving average (SMA(12)). This model incorporates two exogenous variables, namely exchange rate and money supply, along with a seasonal component, transforming the ARIMA model into a SARIMAX model. The model requires estimation of the parameters β, ρ, θ, ϕ, and σ^2, and the method employed for estimation is Maximum Likelihood (ML). The likelihood function, assuming Gaussian innovation of the ARMA model, is provided by:

$$\log\ L\left(\beta,\rho,\theta,\phi,\sigma^2\right)=-\frac{T}{2}log\left(2\pi\right)-\frac{1}{2}log\left|\Omega\right|-\frac{1}{2}\mu^{'}\Omega^{-1}\mu \quad (6)$$

$$=-\frac{T}{2}log\left(2\pi\right)-\frac{1}{2}log\left|\Omega\right|-S\left(\beta,\rho,\theta,\phi\right)$$

The variance-covariance matrix Ω, which is symmetric Toeplitz, is obtained from the unconditional residual of the ARMAX model as outlined by Doornik and Ooms (2003). The AIC is utilized to determine the most suitable values for the lag lengths p and q in the model.

This investigation makes use of monthly data, specifically from January 2014 to April 2024. The data has been sourced exclusively from the International Monetary Fund's International Financial Statistics database. The parameters of SARIMAX and VAR models are estimated using a sample size from January 2014 to December 2023. The last four observations, between January 2024 and April 2024, are reserved for assessing the performance of the models. The model that generates the lowest root mean square error (RMSE) will be selected. It is important to note that a lower RMSE indicates a better forecasting model. The RMSE can be calculated using the following formula.

$$RMSE=\sqrt{\frac{\left(\hat{Y}_t-Y_t\right)^2}{n}}$$

The forecasted inflation rate at time t using the SARIMAX/VAR model is denoted as $\hat{Y}_t$, whereas the observed inflation rate at time t is represented by Y_t. It is important to highlight that the gap between the predicted and observed values is referred to as error or residual terms. Moreover, n signifies the sample size across the forecasting period.

4. EMPIRICAL RESULTS

Throughout the duration of the study, the consumer price index, foreign exchange rate, and money supply experienced average monthly growth rates of 0.21%, 0.012%, and 1.429% respectively. The inflation rate fluctuated between a minimum of −2.51% and a maximum of 1.60%/month. Regarding the foreign exchange rate, the lowest appreciation and highest depreciation were recorded at −1.07% and 1.11%, respectively. The money supply growth rate fluctuated between −5.50% and 8.85%/month. The summary statistics for the variables being studied are displayed in Table 1. According to the Jarque-Bera test results, it is indicated that, with a significance level of 5%, only the fluctuations in foreign exchange rates adhere to a normal distribution.

The study utilizes the ADF test to evaluate the stationarity characteristics of the time series. It examines three distinct model specifications: one with a constant, another with a constant and trend, and a third without a constant and trend. The null hypothesis of the ADF test suggests the presence of a unit root, indicating non-stationarity within the data. The findings, as shown in Table 2, suggest that the consumer price index demonstrates unit root or non-stationarity in all three ADF test models. Conversely, the foreign exchange rate series is determined to be stationary in the models with constant and constant with trend, but non-stationary in the model without constant and trend. The analysis reveals that the money supply series demonstrates stationarity in models that include a constant term, but exhibits non-stationarity in models that include both a constant and trend term, as well as in models without either constant or trend. Upon taking the first difference, all data series and models tested using the ADF tests

Table 1: Summary statistics

Statistics	*DlnCPI*	*DlnFX*	*DlnM*
Mean	0.210050	0.011800	1.429053
Median	0.265561	0.071878	1.396071
Maximum	1.604258	1.109342	8.853960
Minimum	−2.508474	−1.072852	−5.504916
Std. Dev.	0.520505	0.428070	1.688551
Skewness	−1.228956	0.072547	0.299889
Kurtosis	8.588498	2.866025	7.960459
Jarque-Bera	192.5753	0.201509	128.9904
Probability	0.000000	0.904155	0.000000
Sum	26.04625	1.463169	177.2026
Sum Sq. Dev.	33.32387	22.53900	350.6983
Observations	124	124	124

Table 2: Unit root tests

At Level			
Models			
With Constant	LNCPI	LNFX	LNM
t-Statistic	−0.4179	−0.9261	−3.1015
Prob.	0.9015	0.7767	0.0290
	n0	n0	**
With constant and trend			
t-Statistic	−2.5575	−6.3358	−1.2079
Prob.	0.3005	0.0000	0.9040
	n0	***	n0
Without constant and trend			
t-Statistic	4.4466	0.7533	8.4464
Prob.	1.0000	0.8754	1.0000
	n0	n0	n0
At First Difference			
	d (LNCPI)	**d (LNFX)**	**d (LNM)**
With constant			
t-Statistic	−9.7781	−4.2838	−13.5697
Prob.	0.0000	0.0008	0.0000
	***	***	***
With constant and trend			
t-Statistic	−9.7369	−4.2580	−14.3147
Prob.	0.0000	0.0052	0.0000
	***	***	***
Without Constant and trend			
t-Statistic	−5.4221	−4.2695	−2.0041
Prob.	0.0000	0.0000	0.0436
	***	***	**

The statistical significance of the findings is denoted using the following notation: (*) Significant at the 10% level, (**) Significant at the 5% level, (***) Significant at the 1% level, and (n0) Not Significant
The lag length selection was based on the Schwarz Information Criterion (SIC)
The probability values reported are derived from the one-sided P values proposed by MacKinnon (1996)

show stationarity, except for the model that lacks constant and trend components in the money supply, which is considered to be statistically insignificant. Since all data series are integrated of order one, denoted as I(1), the analysis that follows will utilize a VAR model with the first different data series.

4.1. Empirical Results of VAR Model

The subsequent stage involves determining the lag length for the VAR model. Table 3 shows a range of selection order criteria, such as the likelihood ratio (LR) test, final prediction error (FPE), AIC, Schwarz information criterion (SIC), and Hannan-Quinn information criterion (HIC). The findings suggest that the ideal lag length varies depending on the criteria used. The LR, FPE, and AIC recommend incorporating two lags, whereas the SIC and HIC indicate zero and one lag should be utilized.

To ensure the proper degree of freedom, the VAR model estimation involves the use of two lags. This decision is based on the recommendations of the LR, FPE, and AIC criteria, which are widely used and considered reliable in determining the optimal lag length for VAR models. By incorporating two lags, the model can better capture the dynamic relationships between the variables and provide more accurate estimates.

Once the parameters of the VAR model have been estimated, it becomes necessary to conduct a stability test by analyzing the inverse roots of the AR characteristic polynomial. This test plays a critical role in confirming the stability of the model before proceeding to generate the forecast error variance decomposition and impulse response function.

The system's stability can be inferred from Figure 1, where it is shown that all characteristic roots lie within the unit circle. This crucial observation plays a key role in evaluating the model's behavior and performance, as the placement of the roots inside the unit circle indicates that the system will remain stable and not exhibit any unstable behavior in the long run.

The stability of the VAR model is an essential requirement for the subsequent analysis, as it ensures the reliability and validity of the forecast error variance decomposition and impulse response function. By confirming the stability of the model, the researcher can have confidence in the interpretations and conclusions drawn from these analytical techniques.

The analysis displayed in Table 4, which decomposes the forecast error variance, indicates that over a time span of ten periods, fluctuations in the inflation rate are primarily influenced by fluctuations in the foreign exchange rate. The impact of fluctuations in foreign exchange rates on inflationary pressures within the economy becomes more pronounced over time, with the contribution increasing significantly from 10.85% in the second period to a peak of 22.01% in the tenth period. This highlights the crucial role that exchange rate changes play in influencing inflation dynamics. Changes in the money supply growth rate play a significant role in the fluctuation of price levels, with an initial impact of around 2.45% in the second period and peaking at 9.81% in the seventh period before gradually decreasing in the following periods. The shift from the second to the third period sees a slight acceleration in the rate of price changes, which can be linked to the interaction between fluctuations in foreign exchange rates and the growth rate of the money supply. It is crucial to emphasize that prices demonstrate a degree of inflexibility over the medium and long run, suggesting that inflation trends are not solely influenced by short-term changes in exchange rates and money supply expansion. This underscores the necessity for a more thorough comprehension of the fundamental elements that fuel enduring inflationary forces, including structural, institutional, and policy-related aspects.

Additionally, the examination uncovers that variations in the currency exchange rate are mainly affected by slight adjustments in the inflation rate, varying from 0.05% to 0.6% throughout the initial to tenth projected time frames. This relatively minimal effect indicates that currency exchange rate shifts are not significantly propelled by inflationary pressures within the economy. Simultaneously, the increase in money circulation has a greater impact on influencing the fluctuations of foreign exchange rates, usually falling within the range of 0.4%-1.41% over the same timeframe. This discovery indicates that the movements of foreign exchange rates are more strongly connected to the expansion of the money supply rather than to inflationary forces. Policymakers must take into account the significant implications of this relationship, as it underscores the necessity of factoring in the interconnectedness of monetary policy decisions and fluctuations in exchange rates when devising plans to uphold exchange rate stability and address potential ripple effects on the overall economy.

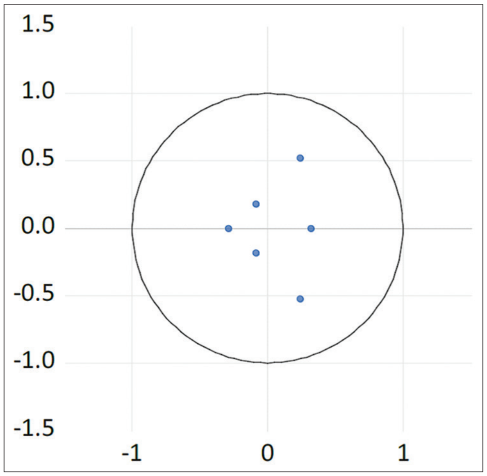
In the beginning, the changes in money supply growth were linked to a 1.78% effect from inflation rate changes and a 0.24% effect from foreign exchange rate fluctuations. Nevertheless, as the analysis advances from the second period to the tenth period, the fluctuations in money supply growth rate are mainly driven by variations in the foreign exchange rate, ranging from 7.89% to 12.59%. Conversely, the fluctuation in money supply growth due to changes in inflation rates ranges from 2.83% to 5.57% during the identical timeframe. This discovery implies that external factors, like fluctuations in exchange rates, may constrain the central bank's

Table 3: Selection order criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	−361.0229	NA	0.112726	6.330833	6.402440*	6.359898
1	−346.9810	27.10694	0.103271	6.243148	6.529576	6.359408*
2	−337.1924	18.38563*	0.101902*	6.229433*	6.730681	6.432887
3	−333.9852	5.856610	0.112801	6.330177	7.046246	6.620826
4	−331.4765	4.450237	0.126483	6.443069	7.373959	6.820913
5	−323.1992	14.25128	0.128408	6.455639	7.601349	6.920677

*Indicates the lag order selected by the criterion

Figure 1: Inverse roots of AR characteristic polynomial



capacity to regulate the growth rate of money supply. Policymakers should take into account the interconnectedness of money supply, exchange rates, and inflation when developing monetary policy strategies, as the intricate relationships among these factors can greatly impact the attainment of macroeconomic goals.

The impulse response functions, as depicted in Figure 2, provide further insights. The first row of the figure shows that the inflation rate initially reacts favorably to an increase in the growth rate of the money supply, but the impact of this shock weakens over time. Specifically, the response is reduced from the third to the sixth period, followed by a resurgence between the seventh and eighth periods. This suggests that monetary policy tools aimed at controlling the money supply growth rate may have a limited and temporary effect on inflation. The inflation rate also exhibits a cyclical pattern in its response to changes in the foreign exchange rate. During the initial two periods, there is a negative response, indicating a decrease in the inflation rate, followed by a positive reflection from the third to the fifth period, suggesting an increase in the inflation rate. As time progresses, the response to the shock starts to diminish between the sixth and seventh period, only to rebound and stabilize until the tenth period. This highlights the complex and dynamic relationship between exchange rate movements and inflationary pressures.

Furthermore, the inflation rate demonstrates a downward reaction to its own shock during the initial period until the middle of the fourth period, before a change in dynamics leads to a reversal in the situation. This suggests that inflation exhibits some degree of persistence, and policymakers may need to consider a range of policy tools, including monetary, fiscal, and structural policies, to effectively manage inflationary pressures.

The second row of Figure 3 illustrates the response of foreign exchange rate changes to various shocks. The foreign exchange rate change shows a relatively weaker response to the shock of the inflation rate, indicating that exchange rate policy may not be the most effective tool for addressing inflationary pressures. However, during the initial three periods, the response of the foreign exchange rate change to the money supply growth rate highlights

Table 4: Forecast error variance decomposition

Variance Decomposition of *DlnCPI*				
Period	**S.E.**	***DlnCPI***	***DlnFX***	***DlnM***
1	0.466512	100.0000	0.000000	0.000000
		(0.00000)	(0.00000)	(0.00000)
2	0.471860	98.93666	0.163991	0.899352
		(2.68725)	(1.49998)	(2.09518)
3	0.475131	98.44806	0.492770	1.059169
		(3.06224)	(1.92959)	(2.00341)
4	0.475428	98.36262	0.565224	1.072157
		(3.29810)	(2.20116)	(2.07959)
5	0.475444	98.36027	0.566972	1.072753
		(3.35194)	(2.24077)	(2.08618)
6	0.475460	98.35394	0.573343	1.072719
		(3.38553)	(2.26348)	(2.09827)
7	0.475465	98.35203	0.575266	1.072703
		(3.39262)	(2.27228)	(2.10088)
8	0.475465	98.35201	0.575288	1.072702
		(3.39799)	(2.27648)	(2.10181)
9	0.475466	98.35171	0.575594	1.072699
		(3.39996)	(2.27836)	(2.10234)
10	0.475466	98.35166	0.575639	1.072698
		(3.40042)	(2.27875)	(2.10254)
Variance Decomposition of *DlnFX*				
Period	**S.E.**	***DlnCPI***	***DlnFX***	***DlnM***
1	0.385187	0.496031	99.50397	0.000000
		(1.65189)	(1.65189)	(0.00000)
2	0.426525	0.405274	99.53420	0.060524
		(1.68725)	(2.19051)	(1.30204)
3	0.431887	1.511449	98.41995	0.068606
		(2.41431)	(3.06056)	(1.98315)
4	0.440608	1.817712	98.11418	0.068105
		(2.63751)	(3.22692)	(1.97671)
5	0.441299	1.814375	98.11768	0.067941
		(2.67678)	(3.31123)	(2.05674)
6	0.441637	1.838358	98.09380	0.067843
		(2.68806)	(3.32230)	(2.07163)
7	0.441924	1.842922	98.08932	0.067762
		(2.68855)	(3.32853)	(2.08090)
8	0.441930	1.843106	98.08913	0.067761
		(2.69143)	(3.33144)	(2.08354)
9	0.441951	1.844210	98.08803	0.067755
		(2.69174)	(3.33240)	(2.08502)
10	0.441960	1.844289	98.08796	0.067752
		(2.69181)	(3.33283)	(2.08586)
Variance Decomposition of *DlnM*				
Period	**S.E.**	***DlnCPI***	***DlnFX***	***DlnM***
1	1.732694	2.696690	9.777424	87.52589
		(3.11703)	(5.79802)	(6.31884)
2	1.775115	2.681033	9.440565	87.87840
		(3.37232)	(5.85012)	(6.51594)
3	1.775707	2.718047	9.439241	87.84271
		(3.55979)	(5.72256)	(6.52941)
4	1.775900	2.723930	9.452159	87.82391
		(3.55102)	(5.73790)	(6.54339)
5	1.775908	2.724770	9.452129	87.82310
		(3.55018)	(5.73988)	(6.57046)
6	1.775919	2.724886	9.453119	87.82199
		(3.54931)	(5.74031)	(6.57098)
7	1.775924	2.724901	9.453518	87.82158
		(3.55099)	(5.73907)	(6.57381)
8	1.775924	2.724906	9.453521	87.82157
		(3.55076)	(5.73869)	(6.57374)
9	1.775924	2.724910	9.453571	87.82152
		(3.55115)	(5.73893)	(6.57465)

(Contd...)

Table 4: ***(Continued)***

Variance Decomposition of *DlnM*				
Period	**S.E.**	***DlnCPI***	***DlnFX***	***DlnM***
10	1.775924	2.724909 (3.55116)	9.453579 (5.73879)	87.82151 (6.57455)
Cholesky One S.D. (d.f. adjusted) Innovations				
Cholesky ordering: *DlnCPI DlnFX DlnM*				

Standard errors: Monte Carlo (100 repetitions) standard deviations in parentheses

Table 5: SARIMAX (2,1,2) Model

Variables	Coefficient
DlnFX	0.020017*** (3.649823)
DlnM	0.069827*** (2.858145)
AR (1)	1.480079*** (32.82047)
AR (2)	−0.978855*** (−19.10649)
MA (1)	−1.444509*** (−3.889866)
MA (2)	0.994547*** (2.003966)
SMA (12)	0.160044** (2.131184)
SIGMASQ	0.199621** (2.099822)

t-Statistics are in brackets. ***, **, * indicates significant at 1%, 5%, and 10%, respectively, Source: Authors' calculation.

Table 6: Predicted Inflation Rate (%), SARIMAX and VAR Model

Time	Observed	SARIMAX Model	VAR Model
	DlnCPI	***Predicted DlnCPI***	***Predicted DlnCPI***
2023M10	0.07126	0.07126	0.07126
2023M11	−0.65155	0.21347	0.21378
2023M12	−0.38085	−0.15379	0.21315
2024M01	−2.50847	−0.10396	0.21326
2024M02	0.65703	−0.08771	0.21773
2024M03	0.45196	−0.10926	0.22105
2024M04	0.94886	0.20815	0.22188

Source: Authors' calculation.

a negative influence, which gradually becomes positive and continues until the end of the fourth period, after which the shock diminishes from the fifth to the tenth period. This underscores the importance of coordinating monetary and exchange rate policies to ensure macroeconomic stability.

Interestingly, the response of the foreign exchange rate change to its own shock exhibits a cyclical pattern, with significant fluctuations around the mean value from one period to another. This suggests that the foreign exchange market is subject to complex and dynamic forces, and policymakers may need to closely monitor and potentially intervene in the foreign exchange market to maintain exchange rate stability.

The final line in Figure 2 depicts the reaction of money supply growth to both its own shock and the shocks of foreign exchange rate changes and inflation rates. Initially, there is a decrease in the response of money supply to inflation rate shocks during the first three periods, followed by an upward trend from period three to period five, with the shock dissipating from period six onwards. This indicates that the central bank's ability to control the money supply growth rate may be influenced by inflationary pressures, and policymakers should consider the complex interactions between monetary policy, inflation, and exchange rate dynamics.

The response of money supply to foreign exchange rate shocks is negative during the first two periods, before undergoing a reversal from the third to the fourth period, where the response becomes positive but gradually diminishes from the sixth period onwards, with a slight resurgence between the seventh and eighth periods. This further highlights the need for policymakers to coordinate monetary and exchange rate policies to achieve their desired macroeconomic objectives.

4.2. Empirical Results of SARIMAX Model

The study employs several SARIMAX models with varying lag lengths of AR and moving average (MA), while controlling for exchange rate change and the growth rate of money supply, and including a 12-month seasonal moving average. The purpose of this approach is to identify the most suitable model specification that can accurately capture the dynamics of the inflation rate.

Based on the AIC, the most suitable lag length for the model was determined to be SARIMAX(*2,1,2*). This particular model exhibited the lowest AIC value, indicating its superior performance compared to other model specifications. The selection of the SARIMAX(*2,1,2*) model is a crucial step, as it ensures that the subsequent analysis and inferences are based on the most appropriate and well-fitting model.

The SARIMAX(*2,1,2*) model's empirical findings provide several insights. The estimated AR(*1*) and AR(*2*) parameters have a significant positive and negative impact on the inflation rate at the 1% level, respectively. This suggests that the first and second lags of the inflation rate exert opposing influences on the current inflation, highlighting the complex dynamics involved.

Regarding the moving average (MA) components, the MA(*1*) parameter has a significant negative impact, while the MA(*2*) parameter has a significant positive impact on the inflation rate, both at the 1% level. These findings suggest that the short-term and longer-term moving average terms play distinct roles in shaping the inflation rate.

Additionally, the sample coefficient for the seasonal moving average term, SMA(*12*), stands at 0.160044, showing a positive and statistically significant relationship at the 5% level. This indicates the presence of seasonal patterns in the inflation rate, which the SARIMAX model effectively captures.

The estimated parameter for sigma square (SIGMASQ) is positive and significantly explains the inflation rate at a 5% level of significance, suggesting that the model adequately accounts for the underlying volatility in the inflation data.

Notably, the inflation rate is expected to increase with exchange rate depreciation and an increase in money supply growth rate, as

Figure 2: Impulse response function

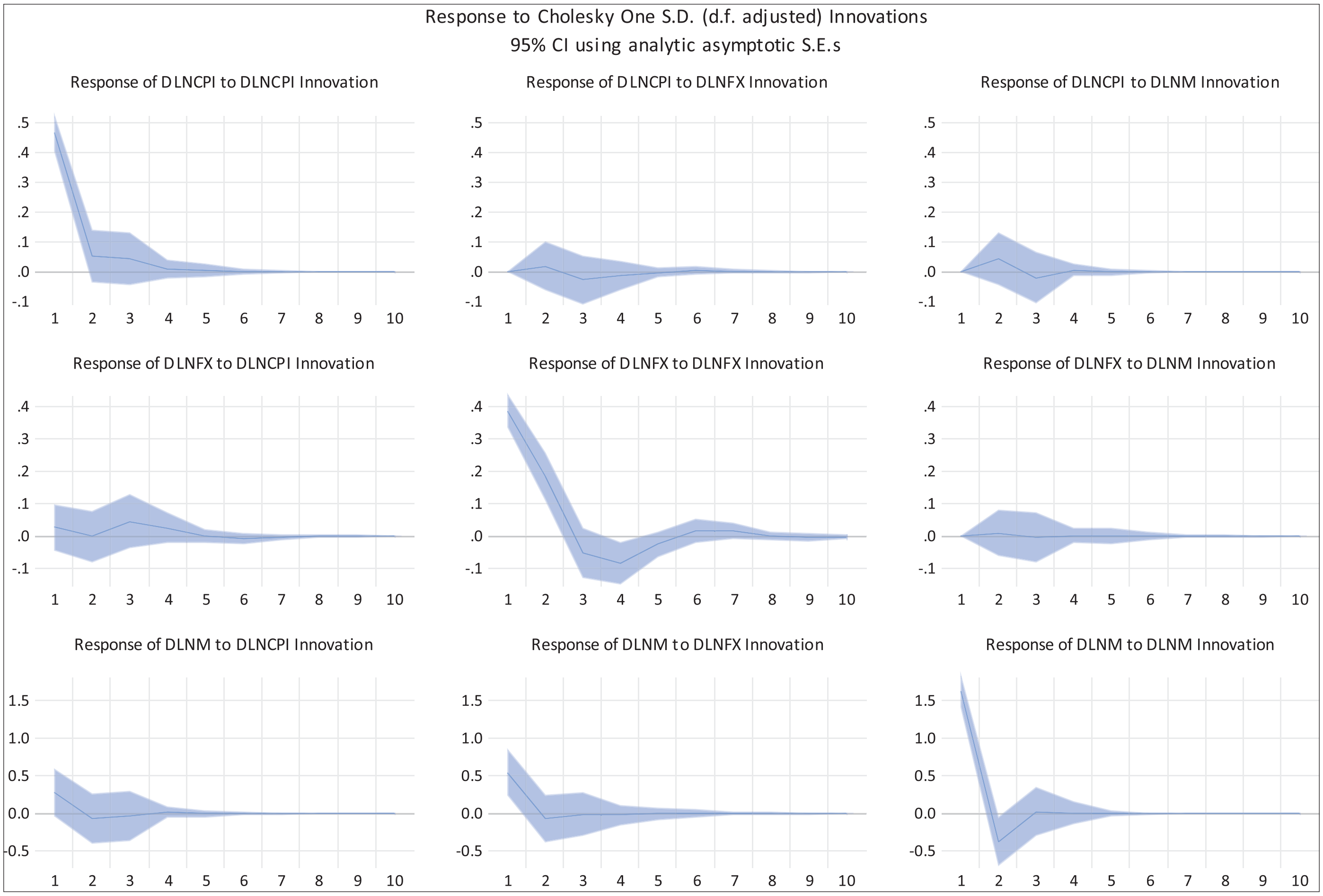
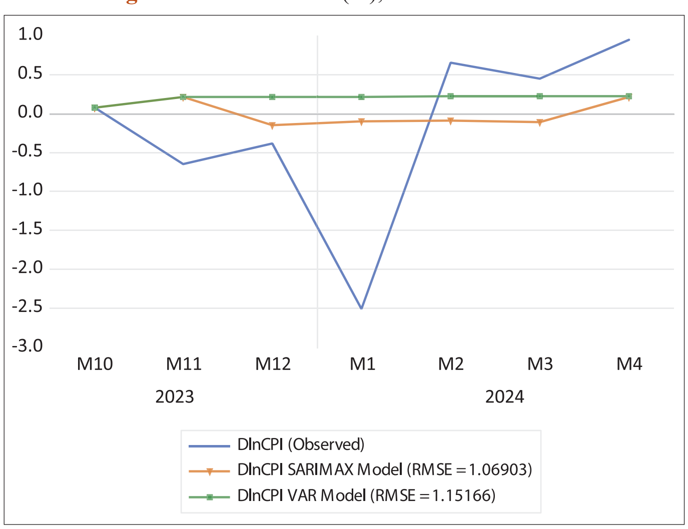


Figure 3: Inflation Rate (%), 2023M10-2024M04



Source: Authors' calculation.

suggested by the estimated parameters of 0.020017 and 0.069827, respectively. This aligns with economic theory, as exchange rate depreciation and money supply growth are commonly associated with inflationary pressures.

Finally, the performance of the SARIMAX model is evaluated by comparing its forecasting accuracy with the VAR model. Between November 2023 and April 2024, the SARIMAX model demonstrated superior performance in predicting the inflation rate, with a lower RMSE of 1.06903 compared to the VAR model's RMSE of 1.15166. Additionally, the average monthly inflation rate forecasts generated by the SARIMAX and VAR models were 0.005452% and 0.196017%, respectively, further highlighting the SARIMAX model's advantage in capturing the inflation dynamics.

5. CONCLUSION

This study aims to conduct a comprehensive analysis that focuses on predicting the dynamics of general price levels in Cambodia. The study employs a rigorous methodological approach, integrating time series analysis techniques, including the ADF test, VAR modeling, and SARIMAX modeling, to uncover the underlying relationships and interdependencies between inflation, exchange rates, and money supply in the Cambodian economy.

The initial descriptive analysis reveals the distinct patterns and characteristics of the key macroeconomic variables under investigation. The ADF test results indicate that the time series for consumer price index, foreign exchange rate, and money supply are integrated of order one, *I(1)*, necessitating the use of first-differenced data in the subsequent VAR and SARIMAX modeling. This finding underscores the importance of considering the non-stationarity properties of the data to avoid potential biases in the model estimates and inferences.

The VAR model analysis provides several notable insights. The forecast error variance decomposition highlights the significant and increasing influence of fluctuations in the foreign exchange rate on inflationary pressures within the economy, with its contribution rising from 10.85% in the second period to a peak of 22.01% in the tenth period. This finding aligns with the theoretical postulation that exchange rate movements can exert a considerable impact on domestic price dynamics, particularly in small, open economies like Cambodia. Additionally, the forecast error variance decomposition reveals the notable role played by changes in the money supply growth rate in driving inflation, with the impact peaking around the seventh period.

The impulse response functions derived from the VAR model further elucidate the complex and dynamic relationships between the variables. The inflation rate exhibits a cyclical pattern in its response to shocks in the foreign exchange rate, indicating the presence of intricate feedback mechanisms between these macroeconomic indicators. Moreover, the analysis suggests that the effectiveness of monetary policy tools aimed at controlling the money supply growth rate may be limited and temporary in their influence on inflation, highlighting the need for policymakers to consider a more comprehensive policy framework.

The SARIMAX modeling approach provides additional insights into the inflation dynamics. The selection of the SARIMAX(*2,1,2*) model, based on the AIC, underscores the importance of identifying the appropriate model specification to capture the underlying complexities. The estimated model parameters reveal the significant and opposing influences of the first and second lags of the inflation rate, as well as the distinct roles played by the short-term and longer-term moving average terms in shaping the inflation rate. The positive and statistically significant seasonal moving average term (SMA(*12*)) indicates the presence of seasonal patterns in the inflation dynamics, which the SARIMAX model successfully accounts for.

Notably, the SARIMAX model outperforms the VAR model in forecasting the inflation rate, as evidenced by its lower RMSE and more accurate average monthly inflation rate projections during the out-of-sample evaluation period. This finding emphasizes the SARIMAX model's superior capability in capturing the complex and evolving nature of inflation in the Cambodian economy.

The study's findings have significant policy implications. Policymakers should carefully consider the substantial influence of exchange rate fluctuations and money supply growth on inflation when formulating monetary and exchange rate policies. The evidence suggests that coordinating these policies may be necessary to effectively manage inflationary pressures and maintain macroeconomic stability. Furthermore, the analysis highlights the complex interactions between inflation, exchange rates, and money supply, underscoring the need for a more comprehensive policy approach that integrates monetary, fiscal, and structural elements to address the underlying drivers of persistent inflationary trends.

This research contributes to the broader academic discourse on inflation dynamics, particularly in the context of small, open economies. The methodological rigor and the incorporation of both VAR and SARIMAX modeling techniques provide a robust analytical framework for understanding the intricate relationships between key macroeconomic variables. The study's findings also offer valuable insights for policymakers in Cambodia and similar developing economies, as they navigate the challenges of maintaining price stability and promoting sustainable economic growth.

Future research avenues may involve expanding the analysis to include additional macroeconomic variables, such as global commodity prices, fiscal policy indicators, and other structural factors, to further enhance the comprehension of the drivers of inflation. Comparative studies across regional economies or with developed countries could also provide valuable benchmarks and shed light on the unique characteristics of the Cambodian inflation dynamics. Moreover, exploring alternative modeling approaches, such as nonlinear time series analysis or structural vector autoregressive models, may uncover additional nuances in the underlying relationships and better capture the potential nonlinearities inherent in the inflation process.

REFERENCES

Agustina, I.A.S., Permadi, I.K.O. (2023), The impact of the money supply, exchange rate and fuel prices on the inflation rate. Ekonomis: Journal of Economics and Business, 7(1), 32-36.

Ahmad, S., Haider, A. (2019), An evaluation of the forecast performance of DSGE and VAR models: The case of a developing country. Business Review, 14(1), 28-52.

Ajayi, O.V. (2019), Comparing multivariate models' forecasts of inflation for brics and opec countries. Business, Management and Education, 17(2), 152-172.

Arumugam, V., Natarajan, V. (2023), Time series modeling and forecasting using autoregressive integrated moving average and seasonal autoregressive integrated moving average models. Instrumentation, Mesures, Métrologies, 22(4), 161.

Bai, Y., Carriero, A., Clark, T.E., Marcellino, M. (2022), Macroeconomic forecasting in a multi-country context. Journal of Applied Econometrics, 37(6), 1230-1255.

Bruns, Martin, Proxy VAR Models in a Data-Rich Environment (November 2019). DIW Berlin Discussion Paper No. 1831, Available at SSRN: https://ssrn.com/abstract=3494233 or http://dx.doi.org/10.2139/ssrn.3494233

Buthelezi, E.M. (2023), Impact of money supply in different states of inflation and economic growth in South Africa. Economies, 11(2), 64.

Carriero, A., Clark, T.E., Marcellino, M., Mertens, E. (2021), Forecasting with Shadow-rate VARs. United States: Federal Reserve Bank of Cleveland.

Clark, H.A., Clark, H.A. (2020), Cambodia's financial market system (2004-2019): History, structure, and performance. In: Beyond Borders, Beyond Banking: The ACLEDA Bank Story, 2005-2019. Germany: Springer Nature. p29-65.

Corpin, S.J.T., Marbella, J.N.P., Kua, S.J.J., Mabborang, R.C., Lamprea, C.T. (2023), Forecasting Inflation rate in the Philippines using seasonal autoregressive integrated moving average (SARIMA) model. European Journal of Computer Science and Information Technology, 11(2), 13-36.

Daoud, H.E.D., Al-Ezzi, R. (2023), The cointegration relationship between money supply, exchange rate and economic growth in Iraq (2004-2020). Business Series, 2(1), 9-35.

Dekkiche, D. (2022), Impact of money supply on inflation rate in Egypt: A VECM approach. Economics and Business, 36(1), 134-148.

Domit, S., Monti, F., Sokol, A. (2019), Forecasting the UK economy with a medium-scale Bayesian VAR. International Journal of Forecasting, 35(4), 1669-1678.

Doornik, A.J., Ooms, M. (2003), Computational aspects of maximum likelihood estimation of autoregressive fractionally integrated moving average models. Computational Statistics and Data Analysis, 2003, 333-348.

Elamin, N., Fukushige, M. (2018), Modeling and forecasting hourly electricity demand by SARIMAX with interactions. Energy, 165, 257-268.

Elshafei, A.S., Abdallah, R.M.A. (2023), The impact of broad money, exchange rate and interest rate on inflation In Egypt, Nigeria, South Africa for the period of 1982-2020. Journal of Politics and Economics, 21(20), 495-471.

Fadliani, I., Purnamasari, I., Wasono, W. (2021), Peramalan dengan metode sarima pada data inflasi dan identifikasi tipe outlier (Studi Kasus: Data Inflasi Indonesia Tahun 2008-2014). Jurnal Statistika Universitas Muhammadiyah Semarang, 9(2), 109-116.

Farsi, M., Hosahalli, D., Manjunatha, B.R., Gad, I., Atlam, E.S., Ahmed, A., Elmarhomy, G., Elmarhoumy, M., Ghoneim, O.A. (2021), Parallel genetic algorithms for optimizing the SARIMA model for better forecasting of the NCDC weather data. Alexandria Engineering Journal, 60(1), 1299-1316.

Flores, J.J., González, J.D., Cortés, B., Reyes, C., Calderón, F. (2019), Evolving SARIMA Models Using cGA for Time Series Forecasting. In: 2019 IEEE International Autumn Meeting on Power, Electronics and Computing (ROPEC). United States: IEEE. p1-6.

Heaton, C., Ponomareva, N., Zhang, Q. (2020), Forecasting models for the Chinese macroeconomy: The simpler the better? Empirical Economics, 58(1), 139-167.

Huber, F., Rossini, L. (2022), Inference in bayesian additive vector autoregressive tree models. The Annals of Applied Statistics, 16(1), 104-123.

Joshi, U.L. (2021), Effect of money supply on inflation in Nepal: Empirical evidence from ARDL bounds test. International Research Journal of MMC, 2(1), 84-98.

Khan, M.S., Khan, U. (2020), Comparison of forecasting performance with VAR vs. ARIMA models using economic variables of Bangladesh. Asian Journal of Probability and Statistics, 10(2), 33-47.

Koop, G., Korobilis, D. (2019), Forecasting with high-dimensional panel VARs. Oxford Bulletin of Economics and Statistics, 81(5), 937-959.

Ky, S., Lim, S. (2023), An examination of monetary aggregates in Cambodia: A vector autoregressive model. International Journal of Social Science, Management and Economics Research, 1(3), 22-35.

MacKinnon, J.G. (1996), Numerical distribution functions for unit root and cointegration tests. Journal of Applied Econometrics, 11, 601-618.

Miao, K., Phillips, P.C.B., Su, L. (2023), High-dimensional VARs with common factors. Journal of Econometrics, 233(1), 155-183.

Nguyen, V.A.T., Hoang, T.T., Le, D.A. (2022), A study on the relationship between money supply and inflation in Vietnam from 2005 to 2021. Accounting, 8(4), 395-402.

Peirano, R., Kristjanpoller, W., Minutolo, M.C. (2021), Forecasting inflation in Latin American countries using a SARIMA-LSTM combination. Soft Computing, 25(16), 10851-10862.

Sameh, B., Elshabrawy, M. (2023), Seasonal autoregressive integrated moving average for climate change time series forecasting. American Journal of Business and Operations Research, 8(2), 25-35.

Sean, M., Pastpipatkul, 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.

Song, K., Lim, S. (2023), A comprehensive investigation into the money demand function in Cambodia: An empirical analysis. Asian Journal of Economics, Business and Accounting, 23(22), 358-371.

Syamad, Handoyo R.D. (2023), The effects of money supply on exchange rate: Evidence of Dornbusch overshooting model in Indonesia (2000-2021). JIET (Jurnal Ilmu Ekonomi Terapan), 8(1), 144–156.

Tang, Q., Li, M. (2021), Analysis of Cambodia's macroeconomic development. E3S Web of Conferences, 235, 01015.

Taveeapiradeecharoen, P., & Aunsri, N. (2020). A large dimensional var model with time-varying parameters for daily forex forecasting. Wireless Personal Communications, 115(4), 3051-3072.

Vorlak, L., Abasimi, I., & Fan, Y. (2019). The impacts of exchange rate on economic growth in Cambodia. International Journal of Applied Economics, Finance and Accounting, 5(2), 78-83.

Wang, G. (2021), Dynamic Analysis of Money Supply, Unemployment and Inflation Rate in the US. Available from: https://ink.library.smu.edu.sg/etd_coll/369

Yan, Y., Gao, J., Peng, B. (2021), On time-varying VAR models: Estimation, testing and impulse response analysis. arXiv preprint.