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Forecasting Inflation Rate in Ghana using Seasonal Autoregressive Integrated Moving Average Model with Monthly Consumer Price Index, 2012 -2022

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Abstract

This study aimed at modeling and forecasting the inflation rate in Ghana using a seasonal autoregressive integrated moving average model with monthly consumer price index data from January 2012 to December 2022. Using the Philip-Parron unit root test, the result showed that the time series data was stationary in its first difference, showing that the consumer price index was integrated with the first order. Also, from the seasonal graph, seasonality was observed in the data. The correlogram of ACF and PACF helped to select the appropriate lag for p and q. Box-Jenkins procedure was applied to identify the appropriate model that fit the data. From the Box-Jenkins procedure, the SARIMA(1,1, 1)(1,1,1)12 model was identified as the best model to forecast the inflation rate. From the forecast graph, inflation will begin to rise in the second quarter of 2023. However, the forecast from January to March,, 2023 inflation rates were 54.9, 56.5 and 50.2, respectively. Therefore, it is highly likely that Ghanaian inflation will be rising in the subsequent months based on the 2012 to 2022 Consumer Price Index. The appropriate authorities should put monetary and fiscal policy measures in place to moderate the envisaged rise in inflation.

Keywords: SARIMA, Modeling, forecasting, inflation, CPI

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Introduction

Inflation is the increase in the general price level usually over a year. For macroeconomic stability and policy formulation, there is the need to maintain a stable price level. The rising inflation is characterized by a decrease in the value of the domestic currency and the corresponding rise in the exchange rate, in this case Ghana Cedis (GHC) to US Dollar ($). According to Enu and Havi (2014), inflation is one of the key macroeconomic factors in Ghana. It is important that policymakers need accurate forecasts of inflation to enable them to adjust their monetary policy to achieve a stable economy which leads to economic growth. In most countries, the maintenance of price stability is the key objective of monetary policy. In conduct of monetary policy, stable prices are very key to promote sustainable growth and strengthening the purchasing power of the local currency. In Ghana, the Bank of Ghana employs monetary instruments in the conduct of its monetary policy with the assumption that a stable and predictable relationship between money supply and inflation can help achieve most targets. Therefore, understanding of the dynamics of inflation and predicting its future path is imperative to achieving success in monetary policy.

Despite the importance of forecasting inflation, the question which still keeps recurring is 'How can we best model and forecast the inflation rate in Ghana?' Few studies tried forecasting inflation in Ghana, among them were Alnaa and Ahiakpor (2011), Aidoo, E. (2010), and Nortey, et al. (2015). However, these studies do not consider the seasonal effect which may be imperative to the consumer price index data. Therefore, this paper aims at modeling and forecasting the inflation rate in Ghana using the appropriate SARIMA model with monthly consumer price index data from January 2012 to December 2022. This study will help the policymakers have a clear picture of the trajectory of inflation in Ghana for the conduct of monetary policy.
The rest of the paper is arranged as follows. The literature review and methodology is covered in section two and three, respectively. The modeling and forecast are also covered in section four. Finally, the conclusion and recommendation for monetary authority will be in section five.

Literature Review

Most major goals of economic policies include reducing the high unemployment rate, stable and increasing economic growth, and other macroeconomic goals. Though there is no mutual concession that all these goals are compatible, there is an agreement on the roles various instruments can and should play in aiding the realization of these goals (Friedman, 1968). It is almost unnecessary to point out that in most economies both monetary and fiscal policies complement each other in trying to attain the desired economic goals. While various theories of inflation, basically do not agree on

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their views on inflation, it is vital to note that both monetary and fiscal policies play a pivotal role in the economy. The overview of the two most famous and widely used theories of inflation currently is summarized below.

The Keynesian theory of inflation was advanced by the great economist, John Maynard Keynes. The theory claims that an increase in savings will not lead to lower interest rates, as long as the economy suffers under unemployment. The theory states that an increase in the general price level (inflation) is caused by an increase in aggregate demand (exceeding aggregate supply). Keynesians believe that if the economy is at full employment output level, an increase in government expenditure, a rise in private consumption, and a rise in private investment would result in a rise in aggregate demand thereby causing inflation. Keynes himself proposed that government should play an active role in the economy; he advocated for government intervention to stabilize the economy.

The Monetarist theory of inflation was postulated by the great economist, Milton Friedman, a Classical Economist by origin. The theory challenged the Keynesian theory by arguing that government intervention would destabilize the economy. Monetarists strongly challenged Keynesian's view that government spending stimulates national output. Monetarists assume a crowding-out effect of government spending on private investment, especially if that later is deficit financed. The monetarist school of thought believes that the major cause of inflation is monetary mismanagement. In fact, Friedman (1967) is well known for his popular argument that inflation is and everywhere a monetary phenomenon. The monetarists advocate for the use of fixed money growth rate rules to ensure monetary stability in an economy.

Below are the summaries of some empirical literature on modeling and forecasting of inflation. Aminu, et al. (2021) used monthly data from the Central Bank of Nigeria to model the seasonal autoregressive integrated moving average (SARIMA) model in the Box-Jenkins methodology. From the estimated models, SARIMA (1, 1, 0)(1, 1, 0)12 was found to be the best model which was selected based on AIC and BIC values. The estimated model is found to be adequate in making forecasts.

Also, Adelekan, et al. (2020) used the monthly inflation rate from January 2003 to October 2020 to model and forecast inflation for Nigeria using ARMA, ARIMA, SARMA and SARIMA. It was found that SARMA (3, 3)(1, 2)$_{12}$ is the best model for forecasting monthly inflation rates in Nigeria based on the AIC and Root Mean Square Error (RMSE) and Mean Absolute Error (MAE). As a result, a three-month forecast was made which showed that the inflation rate in Nigeria would continue to decrease but it will maintain two digits for the next two years. However, it is likely to rise again in 2023.

In addition, Fannoh, R. (2018) used monthly inflation data from January 2012 to December 2013. Using the Box-Jenkins methodology, the seasonal

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autoregressive integrated moving average model was used to capture seasonality. Using the Hyndman-Kbandakar algorithm, ARIMA(0,1,0)(2,1,0)12 was selected as the best model for the Liberia inflation series. Further residual analysis such as the Autoregressive Conditional Heteroscedasticity (ARCH) Lagrange Multiplier test and Li-Jung Box test showed no evidence of ARCH effect and serial correlation, respectively. Hence, this model was used to predict a 12-month forecast for the year 2013 with the model revealing that Liberia is likely to experience single-digit inflation rates.

Pintilescu, et al. (2015) estimated a stochastic model for the inflation rate in Romania which integrated economic characteristics specific to this country; and the high importance of the occupied population in the agricultural sector. Due to the dependence of this sector on the weather conditions, estimated stochastic models included a seasonal component which belongs to the seasonal autoregressive integrated moving average (SARIMA) model. Based on this model the inflation rate for the next two quarters was forecasted. It has been observed that the inflation target for the year 2015 set by the National Bank of Romania, which was equal to 2.5%±1 percentage point, will not be reached since there is a risk that the deflationist phenomenon may occur.

According to Zhang, L.L. & Li, J.J. (2012), inflation forecasting plays a significant role in monetary policy. The study focused on developing an inflation support vector regression model to forecast the consumer price index. The money gap and consumer price index data were used to conduct the forecasts. Also, the grid search method was applied to select the parameters of the support vector regression. In addition, the study examined the feasibility of applying support vector regression in inflation forecasting by comparing it to back-propagation neural networks and linear regression. The results showed that support vector regression provided a promising alternative to inflation forecasting.

Suleman, N and Sarpong (2012) employed an empirical approach to modeling monthly inflation data in Ghana using the Box-Jenkins approach. The result showed that the ARIMA(3,1,3)$(2,1,1)_{12}$ model was best for modeling the inflation rates. This model has a Maximum log-likelihood of 242.9, the least AIC of -465.8 and RMSE of 0.08. The diagnostic test of the residuals with the ARCH LM-test and Durbin-Watson tests indicated that there were no ARCH effect and autocorrelation in the residuals, respectively. Finally, the 11-month forecast for the year 2012 with the model revealed that Ghana is likely to experience single-digit inflation values.

Finally, Kapur, M. (2012) focused on modeling and forecasting inflation in India using an augmented Philips curve framework. Both demand and supply factors were seen as drivers of inflation. Demand conditions were

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found to have a stronger impact on non-food manufactured products inflation vis-à-vis headline WPI inflation. Moreover, non-food manufactured products inflation was found to be more persistent than headline inflation. Inflation in non-fuel commodities is seen as a more important driver of domestic inflation rather than fuel inflation. The exchange rate pass-through coefficient was found to be modest but sharp depreciation which in a short period can add to inflationary pressures. The estimated equations showed a satisfactory in-sample as well as out-of-sample performance based on dynamic simulations.
In sum, inflation series exhibit trends or seasonality which makes it difficult to analyze the inflationary pressures for monetary policy decision-making. It is imperative to note that few empirical studies have tilted towards addressing the seasonality issues to track the sources responsible for these fluctuations. It is against this background that this study aims at developing a model of inflation with higher data points taking into cognizance its periodic seasonal component and using the estimated model to make the forecast. ARIMA adds a seasonality component to each factor of the ARIMA equation to produce the forecast.

Methodology

The data used for this study consists of monthly consumer price index (CPI) data from January 2012 to December 2022 from Ghana Statistical Service's various issues. In this study Autoregressive Integrated Moving Average, ARIMA, or Seasonal Autoregressive Integrated Moving Average, SARIMA will be used to model an appropriate one selected to forecast the monthly inflation using the Box-Jenkins approach.

The classic ARIMA model has three parts; that is, Autoregressive, Integrated (differencing) and Moving Average terms. Linearly, these terms are combined to form the model as:

$$y_t^{'} = c + \sum_{n=1}^{p} \phi_n y_{t-n}^{'} + \sum_{n=1}^{q} \theta_n \varepsilon_{t-n} + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots [1]$$

Where:

- y' - differencing time series, the number of differences applied is noted as ***d,***
- ϕ -coefficients of the autoregressive terms (lag),
- p – number of autoregressive terms,
- ε - forecast error terms, the moving average terms,
- θ -coefficients of the lagged forecast errors,
- q - number of lagged error terms.

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The above model is usually written as *ARIMA(p, d, q),* where p. d and q refer to the order of autoregressive, differencing and moving average terms, respectively.

The SARIMA adds a seasonality term to each factor of the ARIMA equation to produce *SARIMA(p, d, q)(P, D, Q)m.* Linearly, the *ARIMA* terms combined with seasonality terms to form the model as:

$$y_t^{'} = c + \sum_{n=1}^{p} \phi_n y_{t-n}^{'} + \sum_{n=1}^{q} \theta_n \varepsilon_{t-n} + \sum_{n=1}^{P} \eta_n y_{t-mn}^{'} + \sum_{n=1}^{Q} \omega_n \varepsilon_{t-mn} + \varepsilon_t \quad [2]$$

Where:

- y' - differenced time series, through both regular, d, and seasonal, D, differencing,
- P – number of seasonal auto-regressors terms,
- ω -coefficients of the seasonal autoregressive terms,
- Q - number of seasonal moving average terms
- η - coefficients of the seasonal forecast errors
- m – length of season.

To model and forecast time series, the ARIMA or SARIMA model must have stationary data. The stationary time series does not exhibit any long-term trend or clear seasonality, its mean and variance are constant over time. To achieve a stationary time series the mean need to be stabilized through differencing and the number of differencing applied is d or D in the case of seasonal differencing. The variance also can be stabilized through logarithmic transformation. Finally, the corresponding coefficients for these orders are computed using the most popular method, the Maximum Likelihood Estimation (MLE).

Diagnostics Checks: The model with the lowest Akaike Information Criteria (AIC) and with the corresponding Root Mean Squared Error will be the preferred model. Also, the forecast accuracy will be checked with Root Mean Squared Error (RMSE), Mean Absolute Percentage Error (MAPE), and Mean Absolute Error (MAE). The residuals from the estimated model will be checked for unit root and serial correlation.

Results and Discussion

This section shows the results of the time series properties of the data, model selection and the forecasted result. Time series plots of CPI data from Jan-2012 to Dec-2022 which was used to model and forecast the monthly

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inflation in Ghana are shown below. Figure 1(A and B) shows the plots of the CPI in level data and its first difference. From the figure, the plot of CPI data showed that the series in level is not stationary over the period under consideration. However, the first difference is stationary. This is confirmed by the Philip-Parron unit root test for CPI in Table 1. The correlogram also showed that CPI in level decay slowly while that of the first difference decay rapidly as shown in Table 2A and 2B.

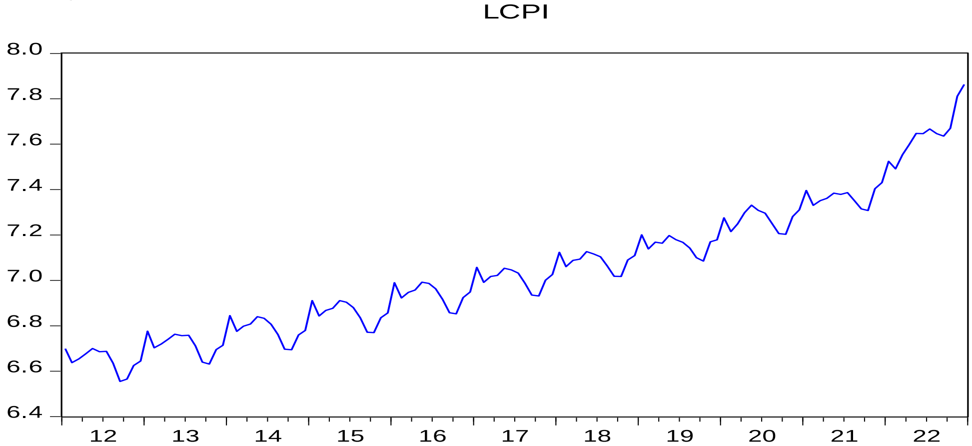

Figure 1A. The Plots of Level Data and the First Difference of CPI

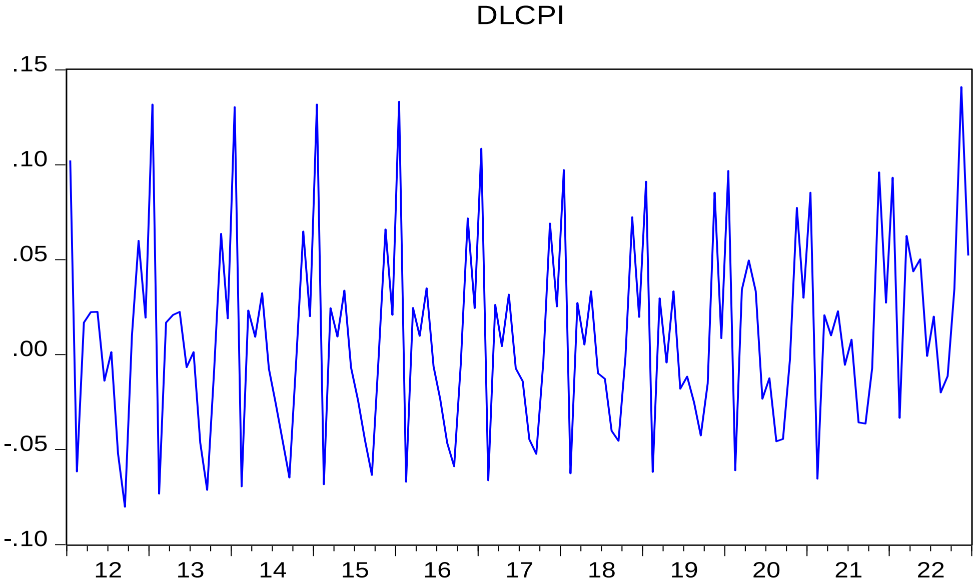

Figure 1B. The Plots of Level Data and the First Difference of CPI

For identification of the SARIMA model, the seasonal graph was plotted for the CPI in level and the first difference. Figure 2 A and B below show the seasonality plots of CPI in level data and the first difference. From

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the figure, there is a seasonality of twelve months in the consumer price index data. From the unit root test for CPI in Table 1, the series is integrated of the first order, I(1). Therefore, the SARIMA model is preferred to the ARIMA model as a result SARIMA will be estimated; that is, SARIMA(p,1,q)(P,1,Q)$_{12}$. This model is based on the autocorrelation function (ACF) and partial autocorrelation function (PACF) of the first difference of correlogram decay fast or decay exponentially indicating that the lag p and q for the model lies between 1 and 3 while P and Q should be one (1). The SARIMA(p,1,q)(P,1,Q)$_{12}$ with the lowest AIC will be selected for estimation, evaluation and forecast.

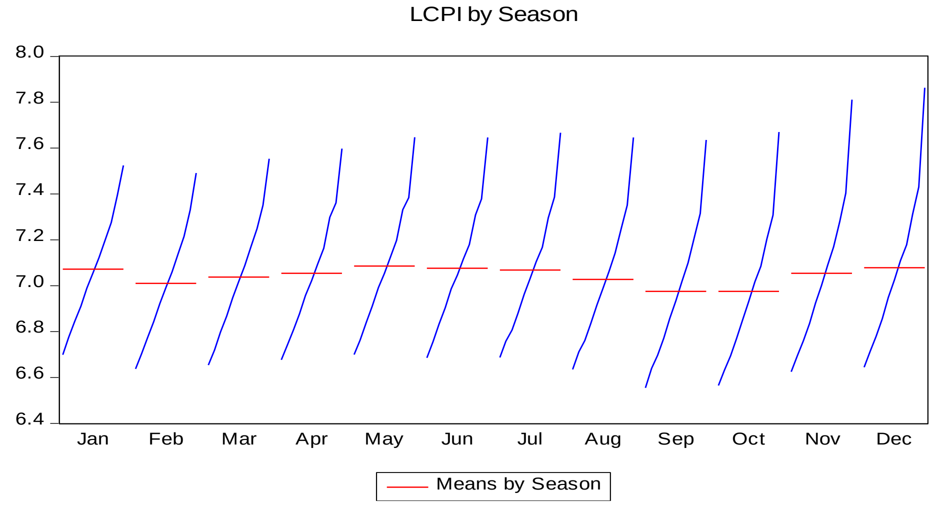

Figure 2A. The Seasonality Plots of CPI in Level

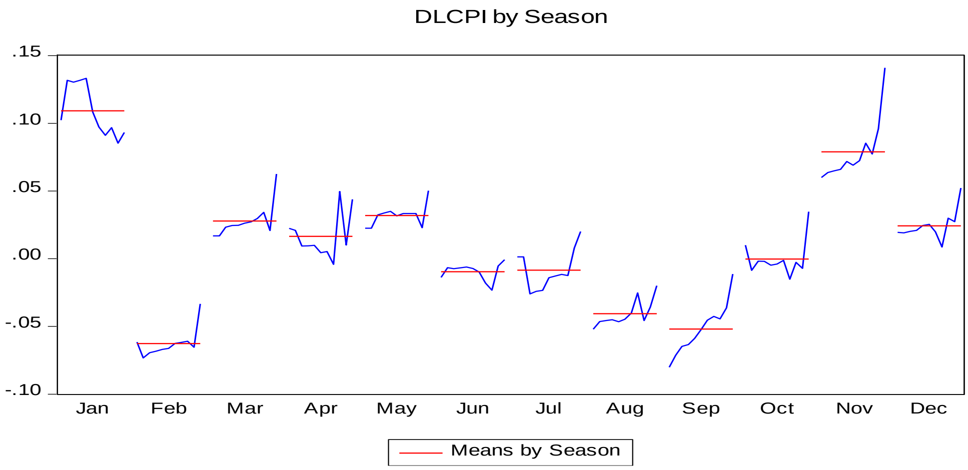

Figure 2B. The Seasonality Plots of CPI in First Difference

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Table 1. Phillips-Perron (PP) the Unit Root Test for CPI

	Level						First Difference					
	None		Constant		Const and Trend		None		Constant		Const and Trend	
	t-Stat	Prob	t- Stat	Prob	t- Stat	Prob	t- Stat	Prob	t- Stat	Prob	t- Stat	Prob
PP	3.925	1	2.008	0.9999	-1.760	0.718	-11.67	0	-13.13	0	-14.08	0

Table 2A. Correlelogram of Consumer Price Index (CPI) in Level

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>.|*******</td><td>.|*******</td><td>1</td><td>0.969</td><td>0.969</td><td>194.41</td><td>0.000</td></tr>
<tr><td>.|*******</td><td>.|. |</td><td>2</td><td>0.940</td><td>0.017</td><td>378.30</td><td>0.000</td></tr>
<tr><td>.|*******</td><td>.|. |</td><td>3</td><td>0.914</td><td>0.031</td><td>552.95</td><td>0.000</td></tr>
<tr><td>.|******|</td><td>.|. |</td><td>4</td><td>0.892</td><td>0.063</td><td>720.24</td><td>0.000</td></tr>
<tr><td>.|******|</td><td>.|. |</td><td>5</td><td>0.872</td><td>0.017</td><td>880.76</td><td>0.000</td></tr>
<tr><td>.|******|</td><td>.|. |</td><td>6</td><td>0.852</td><td>0.004</td><td>1034.8</td><td>0.000</td></tr>
<tr><td>.|******|</td><td>.|. |</td><td>7</td><td>0.831</td><td>-0.014</td><td>1182.2</td><td>0.000</td></tr>
<tr><td>.|******|</td><td>.|. |</td><td>8</td><td>0.811</td><td>0.003</td><td>1323.2</td><td>0.000</td></tr>
<tr><td>.|******|</td><td>.|. |</td><td>9</td><td>0.794</td><td>0.033</td><td>1458.9</td><td>0.000</td></tr>
<tr><td>.|******|</td><td>.|. |</td><td>10</td><td>0.780</td><td>0.063</td><td>1590.8</td><td>0.000</td></tr>
<tr><td>.|******|</td><td>.|. |</td><td>11</td><td>0.766</td><td>-0.006</td><td>1718.6</td><td>0.000</td></tr>
<tr><td>.|***** |</td><td>.|. |</td><td>12</td><td>0.751</td><td>-0.013</td><td>1842.2</td><td>0.000</td></tr>
<tr><td>.|***** |</td><td>*|. |</td><td>13</td><td>0.729</td><td>-0.119</td><td>1959.1</td><td>0.000</td></tr>
<tr><td>.|***** |</td><td>.|. |</td><td>14</td><td>0.708</td><td>0.009</td><td>2070.0</td><td>0.000</td></tr>
<tr><td>.|***** |</td><td>.|. |</td><td>15</td><td>0.689</td><td>0.011</td><td>2175.7</td><td>0.000</td></tr>
<tr><td>.|***** |</td><td>.|. |</td><td>16</td><td>0.674</td><td>0.033</td><td>2277.3</td><td>0.000</td></tr>
<tr><td>.|***** |</td><td>.|. |</td><td>17</td><td>0.659</td><td>0.009</td><td>2374.9</td><td>0.000</td></tr>
<tr><td>.|***** |</td><td>.|. |</td><td>18</td><td>0.644</td><td>0.003</td><td>2468.8</td><td>0.000</td></tr>
<tr><td>.|***** |</td><td>.|. |</td><td>19</td><td>0.629</td><td>-0.006</td><td>2558.6</td><td>0.000</td></tr>
<tr><td>.|**** |</td><td>.|. |</td><td>20</td><td>0.614</td><td>0.001</td><td>2644.7</td><td>0.000</td></tr>
<tr><td>.|**** |</td><td>.|. |</td><td>21</td><td>0.601</td><td>0.012</td><td>2727.6</td><td>0.000</td></tr>
<tr><td>.|**** |</td><td>.|. |</td><td>22</td><td>0.591</td><td>0.034</td><td>2808.2</td><td>0.000</td></tr>
<tr><td>.|**** |</td><td>.|. |</td><td>23</td><td>0.579</td><td>-0.022</td><td>2886.0</td><td>0.000</td></tr>
<tr><td>.|**** |</td><td>.|. |</td><td>24</td><td>0.565</td><td>-0.026</td><td>2960.5</td><td>0.000</td></tr>
<tr><td>.|**** |</td><td>*|. |</td><td>25</td><td>0.544</td><td>-0.101</td><td>3030.0</td><td>0.000</td></tr>
<tr><td>.|**** |</td><td>.|. |</td><td>26</td><td>0.525</td><td>0.005</td><td>3095.2</td><td>0.000</td></tr>
<tr><td>.|**** |</td><td>.|. |</td><td>27</td><td>0.509</td><td>0.007</td><td>3156.6</td><td>0.000</td></tr>
<tr><td>.|**** |</td><td>.|. |</td><td>28</td><td>0.495</td><td>0.030</td><td>3215.2</td><td>0.000</td></tr>
<tr><td>.|*** |</td><td>.|. |</td><td>29</td><td>0.483</td><td>0.016</td><td>3271.2</td><td>0.000</td></tr>
<tr><td>.|*** |</td><td>.|. |</td><td>30</td><td>0.471</td><td>0.005</td><td>3324.8</td><td>0.000</td></tr>
<tr><td>.|*** |</td><td>.|. |</td><td>31</td><td>0.457</td><td>-0.016</td><td>3375.5</td><td>0.000</td></tr>
<tr><td>.|*** |</td><td>.|. |</td><td>32</td><td>0.443</td><td>-0.015</td><td>3423.5</td><td>0.000</td></tr>
<tr><td>.|*** |</td><td>.|. |</td><td>33</td><td>0.431</td><td>0.006</td><td>3469.2</td><td>0.000</td></tr>
<tr><td>.|*** |</td><td>.|. |</td><td>34</td><td>0.423</td><td>0.038</td><td>3513.4</td><td>0.000</td></tr>
<tr><td>.|*** |</td><td>.|. |</td><td>35</td><td>0.413</td><td>-0.006</td><td>3555.8</td><td>0.000</td></tr>
<tr><td>.|*** |</td><td>.|. |</td><td>36</td><td>0.402</td><td>-0.013</td><td>3596.2</td><td>0.000</td></tr>
</table>

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Table 2B. Correlelogram of Consumer Price Index (CPI) in First Difference

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>.|. |</td><td>.|. |</td><td>1</td><td>-0.026</td><td>-0.026</td><td>0.1394</td><td>0.709</td></tr>
<tr><td>.|* |</td><td>.|* |</td><td>2</td><td>0.150</td><td>0.149</td><td>4.7984</td><td>0.091</td></tr>
<tr><td>**|. |</td><td>**|. |</td><td>3</td><td>-0.310</td><td>-0.310</td><td>24.784</td><td>0.000</td></tr>
<tr><td>*|. |</td><td>*|. |</td><td>4</td><td>-0.151</td><td>-0.196</td><td>29.556</td><td>0.000</td></tr>
<tr><td>*|. |</td><td>.|. |</td><td>5</td><td>-0.105</td><td>-0.020</td><td>31.884</td><td>0.000</td></tr>
<tr><td>.|* |</td><td>.|. |</td><td>6</td><td>0.106</td><td>0.073</td><td>34.268</td><td>0.000</td></tr>
<tr><td>*|. |</td><td>**|. |</td><td>7</td><td>-0.096</td><td>-0.207</td><td>36.213</td><td>0.000</td></tr>
<tr><td>*|. |</td><td>**|. |</td><td>8</td><td>-0.140</td><td>-0.302</td><td>40.403</td><td>0.000</td></tr>
<tr><td>**|. |</td><td>**|. |</td><td>9</td><td>-0.301</td><td>-0.338</td><td>59.796</td><td>0.000</td></tr>
<tr><td>.|* |</td><td>.|* |</td><td>10</td><td>0.184</td><td>0.206</td><td>67.124</td><td>0.000</td></tr>
<tr><td>.|. |</td><td>*|. |</td><td>11</td><td>-0.018</td><td>-0.093</td><td>67.198</td><td>0.000</td></tr>
<tr><td>.|******|</td><td>.|******|</td><td>12</td><td>0.898</td><td>0.837</td><td>242.83</td><td>0.000</td></tr>
<tr><td>.|. |</td><td>*|. |</td><td>13</td><td>-0.064</td><td>-0.174</td><td>243.73</td><td>0.000</td></tr>
<tr><td>.|* |</td><td>*|. |</td><td>14</td><td>0.102</td><td>-0.075</td><td>246.00</td><td>0.000</td></tr>
<tr><td>**|. |</td><td>.|. |</td><td>15</td><td>-0.315</td><td>0.019</td><td>268.03</td><td>0.000</td></tr>
<tr><td>*|. |</td><td>.|. |</td><td>16</td><td>-0.152</td><td>0.002</td><td>273.16</td><td>0.000</td></tr>
<tr><td>*|. |</td><td>.|. |</td><td>17</td><td>-0.104</td><td>-0.011</td><td>275.56</td><td>0.000</td></tr>
<tr><td>.|* |</td><td>*|. |</td><td>18</td><td>0.081</td><td>-0.169</td><td>277.04</td><td>0.000</td></tr>
<tr><td>*|. |</td><td>.|. |</td><td>19</td><td>-0.104</td><td>-0.063</td><td>279.47</td><td>0.000</td></tr>
<tr><td>*|. |</td><td>*|. |</td><td>20</td><td>-0.154</td><td>-0.130</td><td>284.83</td><td>0.000</td></tr>
<tr><td>**|. |</td><td>.|. |</td><td>21</td><td>-0.300</td><td>-0.062</td><td>305.36</td><td>0.000</td></tr>
<tr><td>.|* |</td><td>*|. |</td><td>22</td><td>0.197</td><td>-0.100</td><td>314.31</td><td>0.000</td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>23</td><td>-0.001</td><td>0.041</td><td>314.31</td><td>0.000</td></tr>
<tr><td>.|******|</td><td>.|* |</td><td>24</td><td>0.835</td><td>0.136</td><td>476.45</td><td>0.000</td></tr>
<tr><td>*|. |</td><td>.|* |</td><td>25</td><td>-0.067</td><td>0.087</td><td>477.51</td><td>0.000</td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>26</td><td>0.073</td><td>0.021</td><td>478.74</td><td>0.000</td></tr>
<tr><td>**|. |</td><td>.|. |</td><td>27</td><td>-0.312</td><td>0.012</td><td>501.74</td><td>0.000</td></tr>
<tr><td>*|. |</td><td>.|. |</td><td>28</td><td>-0.152</td><td>0.026</td><td>507.24</td><td>0.000</td></tr>
<tr><td>*|. |</td><td>.|. |</td><td>29</td><td>-0.095</td><td>0.024</td><td>509.40</td><td>0.000</td></tr>
<tr><td>.|* |</td><td>.|* |</td><td>30</td><td>0.084</td><td>0.097</td><td>511.11</td><td>0.000</td></tr>
<tr><td>*|. |</td><td>.|. |</td><td>31</td><td>-0.090</td><td>0.015</td><td>513.10</td><td>0.000</td></tr>
<tr><td>*|. |</td><td>.|. |</td><td>32</td><td>-0.134</td><td>0.068</td><td>517.43</td><td>0.000</td></tr>
<tr><td>**|. |</td><td>.|. |</td><td>33</td><td>-0.272</td><td>0.033</td><td>535.55</td><td>0.000</td></tr>
<tr><td>.|* |</td><td>*|. |</td><td>34</td><td>0.210</td><td>-0.075</td><td>546.38</td><td>0.000</td></tr>
<tr><td>.|. |</td><td>*|. |</td><td>35</td><td>0.004</td><td>-0.093</td><td>546.39</td><td>0.000</td></tr>
<tr><td>.|***** |</td><td>*|. |</td><td>36</td><td>0.753</td><td>-0.147</td><td>687.58</td><td>0.000</td></tr>
</table>

Table 3 below shows the SARIMA$(p,1,q)(P,1,Q)_{12}$ model estimated with various lag between 1 and 3, with AIC. The SARIMA$(p,1,q)(P,1,Q)_{12}$ model with the lowest Akaike Information Criteria (AIC) will be the preferred model. From the table, SARIMA$(1,1,1)(1,1,1)_{12}$ model estimated is the model with the lowest AIC being -5.7336 with Root Mean Square Error (RMSE) of 0.0151. Therefore, the SARIMA model of AR term of lag 1, MA term of lag

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

1, SAR(12) and SMA(12) will be estimated for forecasting the consumer price index and hence the inflation.

Table 3. Fitted SARIMA(p,1,q)(P,1,Q)$_{12}$ Model for Consumer Price Index (CPI) Data

AR	d	MA	SAR	D	SMA	AIC	MAPE
1	1	0	1	1	1	-5.6671	0.0153
0	1	1	1	1	1	-5.6240	0.0154
1	1	1	1	1	1	-5.7336	0.0151
2	1	0	1	1	1	-5.6003	0.0154
2	1	1	1	1	1	-5.6650	0.0153
2	1	2	1	1	1	-5.6339	0.0155
0	1	2	1	1	1	-5.6003	0.0151
1	1	2	1	1	1	-5.6745	0.0150
3	1	3	1	1	1	-5.6027	0.0154

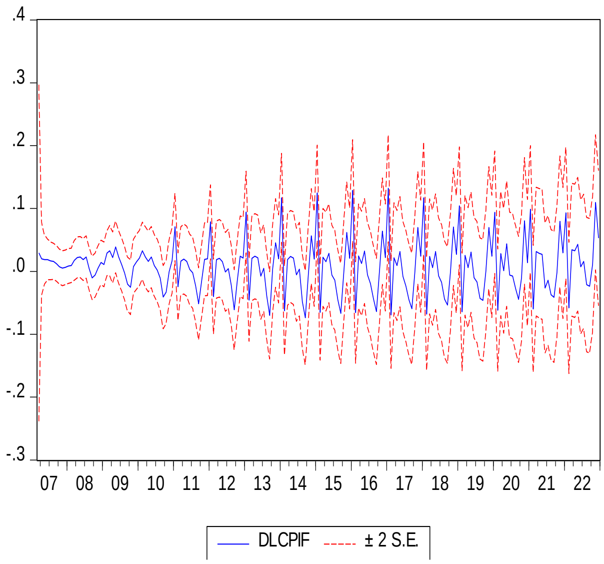
Parameter Estimation

Table 4 below shows the parameter estimated for the SARIMA((1,1,1)(1,1,1)$_{12}$ model with the forecast evaluation in Figure 3. The forecast evaluation showed a Root Mean Square Error (RMSE) of 0.0151. Diagnostic checks on the residuals are shown in Table 5 and Figure 4 below. The Philip-Parron unit root tests of the residuals and the residual plot showed stationarity of the SARIMA((1,1,1)(1,1,1)$_{12}$ model estimated. The Box-Pierce G and Ljung-Box (LB) statistic (Q- statistic) in Table 6 showed that none of the ACF and PACF are statistically significant. Therefore, the residuals of the estimated model are white noise. The best model for forecasting consumer price index and inflation is the SARIMA((1,1,1)(1,1,1)$_{12}$ model. The inflation rate was forecasted from January to March, 2023 as 54.9, 56.5 and 50.2, respectively. These forecasts were close to the actuals for the period which was reported by the Ghana Statistical Service as 53.6, 52.8 and 45.0. The forecasted values deviated from the actuals by -2.4, -7.7.1 and -11.6, respectively.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Table 4. Estimated Result of SARIMA((1,1,1)(1,1,1)$_{12}$ for Consumer Price Index Data

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.029405	0.133384	0.220456	0.8259
AR(1)	0.962290	0.061724	15.59029	0.0000
SAR(12)	0.990741	0.005491	180.4310	0.0000
MA(1)	-0.759457	0.129120	-5.881784	0.0000
SMA(12)	-0.364578	0.090856	-4.012700	0.0001
SIGMASQ	0.000127	1.16E-05	10.96369	0.0000
R-squared	0.949989	Mean dependent var		0.009596
Adjusted R-squared	0.948004	S.D. dependent var		0.050521
S.E. of regression	0.011520	Akaike info criterion		-5.733617
Sum squared resid	0.016722	Schwarz criterion		-5.602580
Log likelihood	384.4187	Hannan-Quinn criter.		-5.680369
F-statistic	478.6846	Durbin-Watson stat		1.895766
Prob(F-statistic)	0.000000			
Inverted AR Roots	1.00	.96	.87-.50i	.87+.50i
	.50+.87i	.50-.87i	.00+1.00i	-.00-1.00i
	-.50+.87i	-.50-.87i	-.87-.50i	-.87+.50i
	-1.00			
Inverted MA Roots	.92	.80+.46i	.80-.46i	.76
	.46+.80i	.46-.80i	.00+.92i	-.00-.92i
	-.46-.80i	-.46+.80i	-.80+.46i	-.80-.46i
	-.92			



Forecast: DLCPIF	
Actual: DLCPI	
Forecast sample: 2006M01 2022M12	
Adjusted sample: 2007M03 2022M12	
Included observations: 190	
Root Mean Squared Error	0.015144
Mean Absolute Error	0.009758
Mean Abs. Percent Error	64.75703
Theil Inequality Coefficient	0.172389
Bias Proportion	0.000752
Variance Proportion	0.054025
Covariance Proportion	0.945223
Theil U2 Coefficient	0.306912
Symmetric MAPE	49.68433

Figure 3. Forecast evaluation of the estimated model

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Table 5. Phillips-Perron (PP) Unit Root Tests of the Residuals of the Estimated Model

	None		Constant		Constant, Linear Trend	
	t-Statistic	Prob.*	t-Statistic	Prob.*	t-Statistic	Prob.*
PP	-13.47	0	-13.62	0	-13.28	0

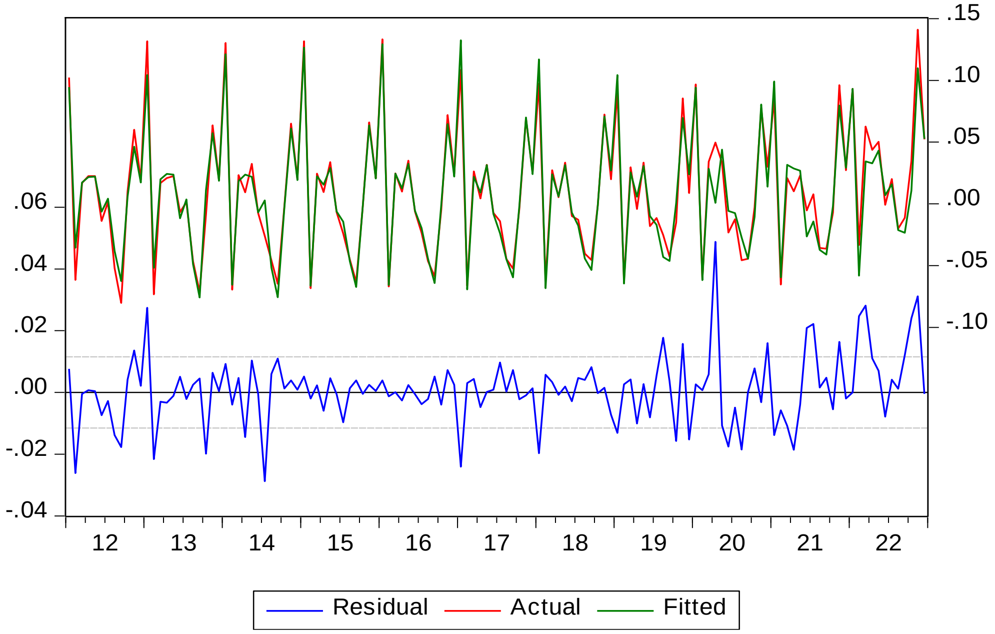

Figure 4. The Residuals of the SARIMA((1,1,1)(1,1,1)$_{12}$ Model

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Table 6. Corelogram of the Residual of the SARIMA((1,1,1)(1,1,1)$_{12}$ Model

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|. |	.|. |	1	0.059	0.059	0.4697	0.493
.|. |	.|. |	2	0.011	0.007	0.4850	0.785
.|. |	.|. |	3	-0.057	-0.058	0.9325	0.818
.|* |	.|* |	4	0.083	0.091	1.8940	0.755
.|. |	.|. |	5	-0.028	-0.038	2.0058	0.848
.|. |	.|. |	6	0.015	0.014	2.0375	0.916
.|. |	.|. |	7	0.009	0.019	2.0497	0.957
.|* |	.|* |	8	0.207	0.197	8.1846	0.416
.|* |	.|. |	9	0.083	0.068	9.1820	0.421
.|. |	.|. |	10	-0.044	-0.061	9.4581	0.489
.|. |	.|. |	11	0.033	0.064	9.6127	0.566
.|* |	.|* |	12	0.109	0.087	11.356	0.499
*|. |	*|. |	13	-0.066	-0.090	11.996	0.528
.|. |	.|* |	14	0.055	0.080	12.457	0.570
.|* |	.|* |	15	0.119	0.123	14.612	0.480
.|. |	*|. |	16	-0.008	-0.096	14.622	0.552
.|. |	.|. |	17	-0.010	-0.016	14.636	0.622
.|. |	.|. |	18	0.014	0.045	14.666	0.685
.|. |	.|. |	19	0.069	0.040	15.412	0.696
.|. |	.|. |	20	0.005	-0.055	15.415	0.752
.|. |	.|. |	21	-0.039	-0.015	15.652	0.789
.|* |	.|* |	22	0.119	0.150	17.923	0.711
.|* |	.|. |	23	0.153	0.053	21.704	0.538
.|. |	*|. |	24	-0.056	-0.095	22.219	0.566
*|. |	.|. |	25	-0.081	-0.008	23.299	0.560
.|. |	*|. |	26	-0.046	-0.075	23.647	0.596
.|* |	.|. |	27	0.078	0.023	24.681	0.592
.|. |	.|. |	28	-0.048	-0.026	25.072	0.624
.|. |	.|* |	29	0.057	0.074	25.625	0.645
.|* |	.|* |	30	0.125	0.087	28.321	0.553
.|* |	.|* |	31	0.206	0.121	35.765	0.254
*|. |	*|. |	32	-0.087	-0.072	37.115	0.245
.|. |	.|. |	33	-0.015	0.023	37.157	0.283
.|. |	.|. |	34	-0.032	-0.044	37.346	0.318
.|. |	.|. |	35	-0.003	-0.044	37.348	0.362
.|. |	.|. |	36	-0.020	0.032	37.422	0.404

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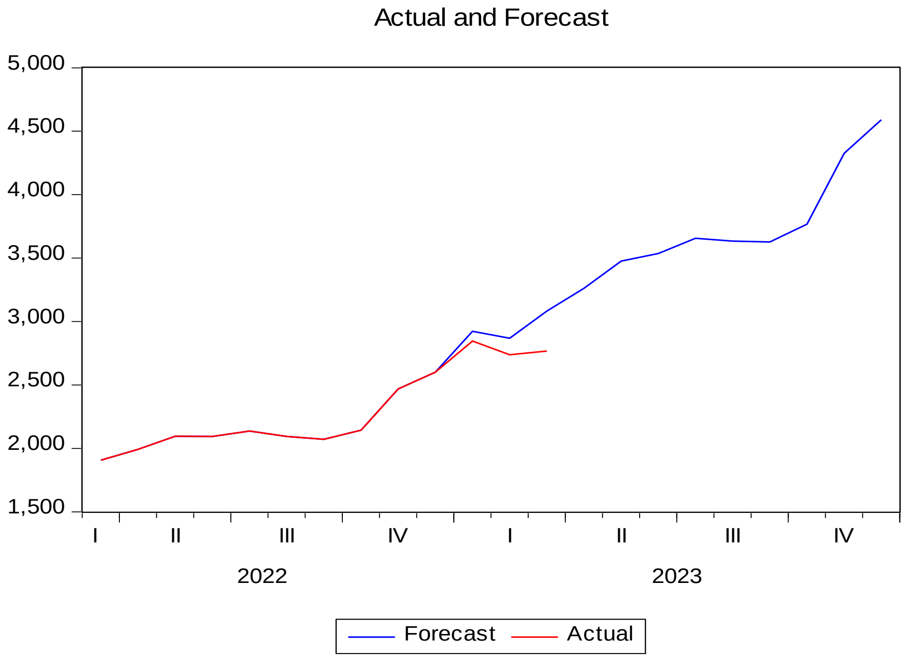

Table 7. The Observed and Predicted Values of the Consumer Price Index, CPI and Inflation

MONTH	CPI	CPI- FORECASTED	INF	INF- FORECASTED	FORECAST-ERROR
2021M01	1629.50	1652.14	12.8	14.7	1.9
2021M02	1526.44	1535.30	12.3	13.0	0.7
2021M03	1558.54	1575.41	10.8	12.7	1.9
2021M04	1574.32	1603.77	6.5	13.9	7.4
2021M05	1610.84	1617.16	5.4	4.7	-0.7
2021M06	1602.19	1569.01	7.3	3.3	-4.0
2021M07	1614.88	1579.49	9.5	6.6	-2.9
2021M08	1558.23	1555.78	10.6	8.4	-2.2
2021M09	1502.65	1495.43	11.5	11.0	-0.5
2021M10	1491.96	1500.12	11	12.5	1.5
2021M11	1642.40	1615.77	13.1	10.9	-2.2
2021M12	1687.84	1691.21	12.8	14.8	2.0
2022M01	1852.75	1852.66	13.7	12.1	-1.6
2022M02	1792.04	1748.24	17.4	13.9	-3.5
2022M03	1907.65	1854.75	22.4	17.7	-4.7
2022M04	1993.09	1971.12	26.6	22.9	-3.7
2022M05	2095.70	2081.00	30.1	28.7	-1.4
2022M06	2094.07	2110.56	30.7	34.5	3.8

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

2022M07	2136.49	2127.58	32.3	34.7	2.4
2022M08	2094.26	2091.67	34.4	34.4	0.0
2022M09	2070.66	2045.83	37.8	36.8	-1.0
2022M10	2143.94	2093.17	43.7	39.5	-4.2
2022M11	2468.53	2392.75	50.3	48.1	-2.2
2022M12	2600.96	2602.09	54.1	53.9	-0.2
2023M01	2845.82	2845.82	53.6	53.6	0.0
2023M02	2738.23	2738.23	52.8	56.6	3.8
2023M03	2766.09	2766.09	45	49.1	4.1

Conclusion and Policy Recommendation

This study aimed at modeling and forecasting the inflation rate in Ghana using the SARIMA model. The time series data was stationary in its first difference using the Philip-Parron unit root test, showing that the consumer price index was integrated with the first order. Also, seasonality was observed in the data. The ACF and PACF helped to select the appropriate lag for p and q. Box-Jenkins procedure was applied to identify the appropriate SARIMA model that fit the data. From the Box-Jenkins procedure SARIMA$((1,1,1)(1,1,1)_{12}$ model with AIC, -5.7336 and RMSE equal to 0.0151 was selected as the best model to forecast the inflation rate. Therefore, this model was used to forecast from January to March, 2023 as 54.9, 56.5 and 50.2, respectively. Therefore, it is highly likely that Ghanaian inflation will be rising in the subsequent months based on the 2012 to 2022 Consumer Price Index. The appropriate authorities should put monetary and fiscal policy measures in place to moderate the envisaged rise in inflation.

Limitation of the study: Inflation is influenced by many macroeconomic and world economic factors, past data is only one factor. However, this study used only past data on inflation to build a univariate Seasonal Autoregressive Integrated Moving Average (SARIMA) model to forecast inflation. Therefore, subsequent studies should use other macroeconomic and world economic factors to model and forecast inflation.

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Data Availability: The data are available in the content of the paper.

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