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Modelling Consumer Price Index Inflation in Ghana

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Abstract

This paper aims to develop a model for CPI inflation of Ghana using data on CPI inflation obtain from the Bank of Ghana database within the period 2000 to 2011. Based on the method of maximum likelihood and the lower lags of the ACF and PACF, ARIMA (0, 1, 1) X $(0, 1, 1)_{12}$ was identified as the tentative model for the CPI inflation data in Ghana. The diagnostic check revealed that the residuals of the fitted model have zero mean, constant variance, and free from higher-order serial correlation. The Ljung-Box statistics and the time series plot of the model residuals clearly indicated no significant departure from white noise. The model was found to be free from conditional heteroscedasticity following the ARCH-LM test.

Keywords: SARIMA, macroeconomic variables, Ghana, modeling, ARCH-LM, ARIMA

INTRODUCTION

Inflation is one of the most macroeconomic variables of great concern in recent years (Alnaa & Ahiakpor, 2011). It is mostly used as one of the indicators of the performance of a country's economy. The Bank of Ghana, in recent years, had been charged with monetary policy management for an economy. Given that monetary policy is just one of many other Government policies designed to help it achieve its responsibilities to the people, the manner in which monetary policy is administered in line with other macroeconomic policies has implication for the real sector of the economy.

Many researchers focus their attention on forecasting (Mckay & Sowah, 2004; Riaz, 2012; Aggarwal, Mohanty, & Song, 1995; Carlson, 1977; Najeeb, Khuda, Asif, & Abid, 2005; Suleman & Sarpong, 2012) whose performance is assumed to provide support for theory. This is common concept that a good forecasting performance constitutes a "seal of approval" to the empirical model and therefore of the theory on which model is based (Riaz, 2012). Several modeling approaches have been employed in the study of inflation both in Ghana and globally (Catao & Terrones, 2001; Dewan, Hussein, & Morling, 1999; Dordunoo, 1994 and Alnaa & Ahiakpor, 2011).

Other modelling approaches mostly used in the analysis of inflation rates in Ghana include the error correlation models (Bawumia & Abradu-Otuo, 2003; Ocran, 2007) where the focus was respectively on the determinants of inflation in the short-run and monetary growth, exchange rates and inflation in Ghana. In practice, several economic times series data are non-stationary and can be modelled only by removing the non-stationary source of variation. The ARIMA models as used by (Adams, Awujola & Alumgudu, 2014; Alnaa & Ahiakpor, 2011) lacks the aptitude to handle the seasonal component of the data. In order to deal with the seasonality, the SARIMA models have need formulated as a generalisation of the ARIMA models.

In the context of modelling CPI in Ghana, there is in-exhaustive empirical works in this topic. The goal of this research, therefore, is to develop a model for the consumer price index (CPI) inflation of Ghana using SARIMA modelling approach. With the SARIMA model process, monetary policies are better developed and possess information on economic situations. This study will add to the economic background of research of the country as far as CPI inflation is concern.

Methods and Procedures

The study was carried out in Ghana using secondary data on monthly consumer price index (CPI) inflation from 2000:1 to 2011:12. The data was obtained from the Bank of Ghana database.

SARIMA

As cited in (Luguterah, Nasiru, & Anzagra, 2013) the compressed form of the seasonal autoregressive integrated moving average model is denoted by ARIMA (p, d, q) X (P, D, Q)s, where p and q are respectively the non-seasonal AR and MA components; P and Q are the orders of the seasonal AR and MA components; and the orders of differencing for the seasonal and non-seasonal are D and d respectively.

A more general seasonal ARIMA model of orders (p, d, q) X (P, D, Q) with period s (Montgomery, Jennings, & Kulahci, 2008) is:

$$\varphi(\beta^s)\varphi(\beta)\varphi(1-\beta)^d(1-\beta)^D y_t = \delta + \theta(\beta^s)\theta(\beta)\varepsilon_t$$

The estimation of the model, however, involves three steps: identification, estimation of parameters and model diagnostics.

Unit Root Test

To determine the order of integration, the Augmented Dickey-Fuller (ADF) test was employed with visual aid from the autocorrelation function (ACf) and partial autocorrelation function (PACF) graphics. The regression model employed by (Dickey & Fuller, 1979) is given by:

$$\Delta y_{t-1} = \alpha + \beta t + \delta y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta y_{t-1} + \epsilon_t$$

Where α is a constant, β is the coefficient on time trend series, $\sum_{i=1}^{p} \gamma_i \Delta y_{t-1}$ is the sum of the lagged values of the dependent variable Δy_t, p is the lag order of the autoregressive process and δ is the parameter of interest in the ADF test. The null hypothesis of unit root is rejected if the test statistic

$$ADF = \frac{\hat{\delta}}{SE(\hat{\delta})}$$

is greater than the critical value (p-value is less than significance level).

Results and Discussion

The time series plot of the CPI inflation shows that the data is not stationary in the mean (Fig. 1) and to obtain the proper ordering of differencing, the unit root test was performed using the ADF test, which confirmed the existence of a unit root (Table 1). Fig. 2 presents the time series plot of the series after both seasonal and non-seasonal differencing was applied to the data.

The data was seasonally and non-seasonally differenced to obtain a stationary series (Table 2). Based on the (Box & Jenkins, 1976) approach, the order of the Autoregressive and Moving Average for both seasonal and non-seasonal components was obtained from the ACF and PACF (Fig. 3) after the order of integration was determined. The ACF plot shows significant spikes at the non-seasonal lag 13 and seasonal lag 12 (Fig. 3). The PACF plot also shows prominent spikes at the non-seasonal lag 13 and seasonal lag 12 (Fig. 3). Based on the AIC selection criterion, the ARIMA (0, 1, 1) X $(0, 1, 1)_{12}$ was identified as the tentative model for the CPI inflation data in Ghana (Table 3).

Diagnosing the model, ARIMA (0, 1, 1) X $(0, 1, 0)_{12}$, the standardized residuals revealed that the residuals of the fitted model have zero mean and constant variance (Fig. 5). From Fig. 4, the ACF of the residuals can be interpreted as being uncorrelated and the Ljung-Box statistics clearly indicates no significant departure from white noise for the residuals as the p-values of the test statistic exceeds the 5% significance level for all the lag orders. However, there was no ARCH effect in the estimated model (Table 4). The closeness of the model residuals to white noise was visualized plotting the residuals against time (Fig. 4).

CONCLUSIONS

Based on the available data, the ARIMA (0, 1, 1) X (0, 1, 1) was identified as the tentative model for the CPI inflation of Ghana. The model checks however indicate a zero mean and constant variance. The model is also free from higher-order serial correlation as well as conditional heteroscedasticity following the ARCH-LM test.

Further analysis using additional specifications of CPI inflation expectations which are more current in Ghana would be very useful.

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APPENDIX

List of Tables

Table 1: ADF test of CPI Inflation in level form

	lag		
	12	24	36
Test statistic	0.7609	0.5436	0.2595
p-value	0.8566	0.7873	0.6968

Table 2: ADF test after seasonal and non-seasonal first differenced series

	Lag		
	12	24	36
Test statistic	-5.4112	-2.5914	-2.2364
p-value	0.0100	0.0102	0.02514

Table 3: Tentative SARIMA models

Model	AIC
ARIMA (0,1,0) $(0,1,1)_{12}$	619.09
ARIMA (0,1,1) $(0,1,1)_{12}$	614.82
ARIMA (1,1,0) $(0,1,1)_{12}$	615.06
ARIMA (1,1,1) $(0,1,1)_{12}$	616.79
ARIMA (0,1,0) $(1,1,1)_{12}$	621.08
ARIMA (0,1,1) $(1,1,1)_{12}$	616.55
ARIMA (1,1,0) $(1,1,1)_{12}$	616.71
ARIMA (1,1,1) $(1,1,1)_{12}$	722.23
ARIMA (0,1,0) $(2,1,1)_{12}$	622.66
ARIMA (0,1,1) $(2,1,1)_{12}$	618.04
ARIMA (1,1,0) $(2,1,1)_{12}$	618.16
ARIMA (1,1,1) $(2,1,1)_{12}$	620.04
ARIMA (0,1,0) $(3,1,1)_{12}$	622.71
ARIMA (0,1,1) $(3,1,1)_{12}$	618.76
ARIMA (1,1,0) $(3,1,1)_{12}$	618.94

ARIMA (1,1,1) (3,1,1)$_{12}$	620.86

Table 4: ARCH-LM test of model residuals

Lag	Statistic	p-value
12	12.7633	0.3865
24	22.3794	0.5566
36	42.2759	0.2182
48	32.0128	0.9632

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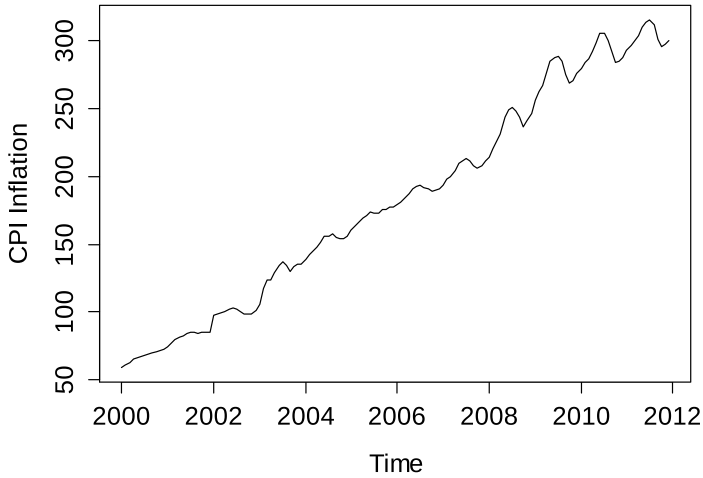

Fig. 1: Time series plot of CPI inflation in Ghana

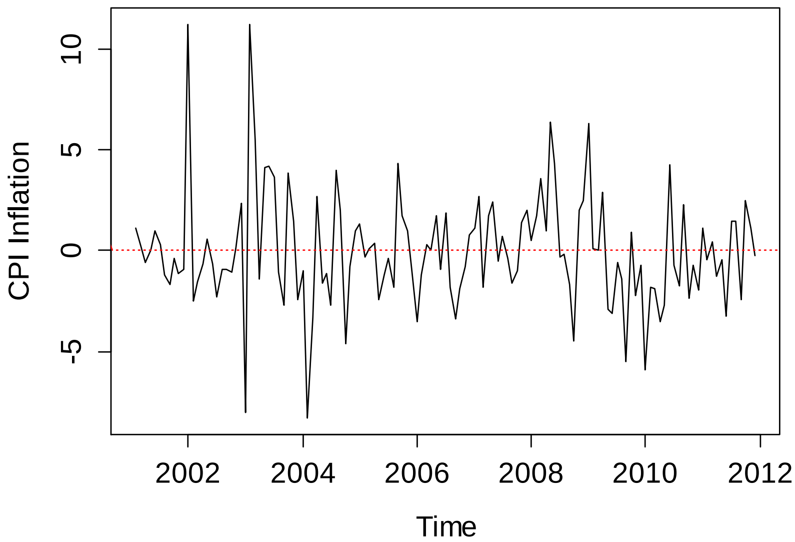

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Fig. 2: Seasonal and non-seasonal first difference of CPI Inflation

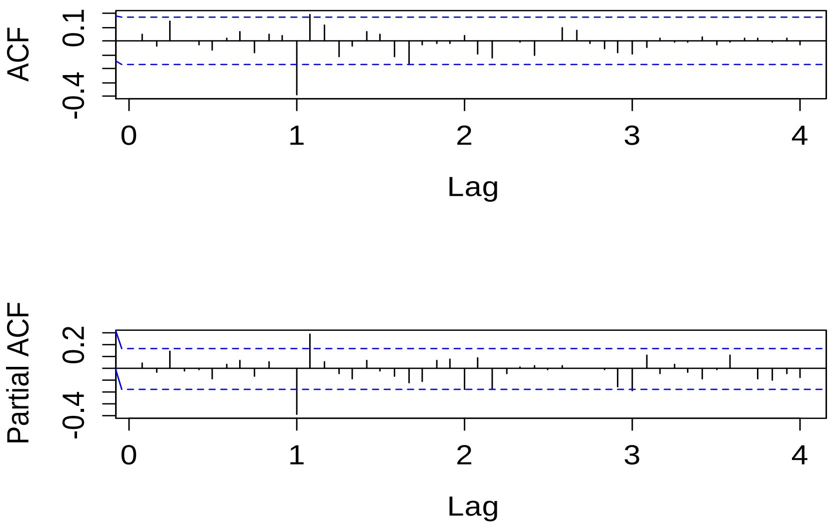

Fig. 3: ACF and PACF of seasonal and non-seasonal first differenced series

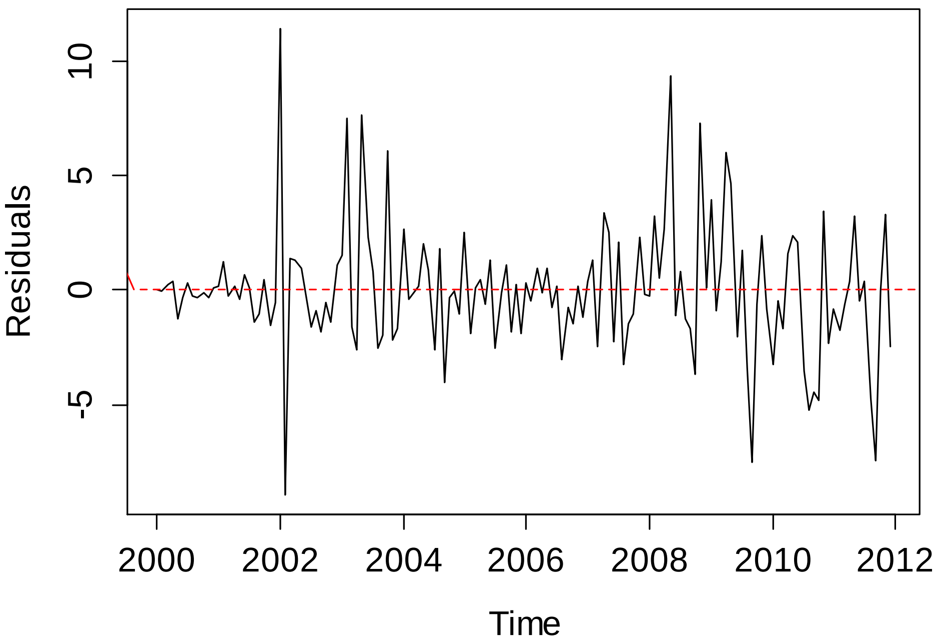

Fig. 4: Time series plot of model residuals

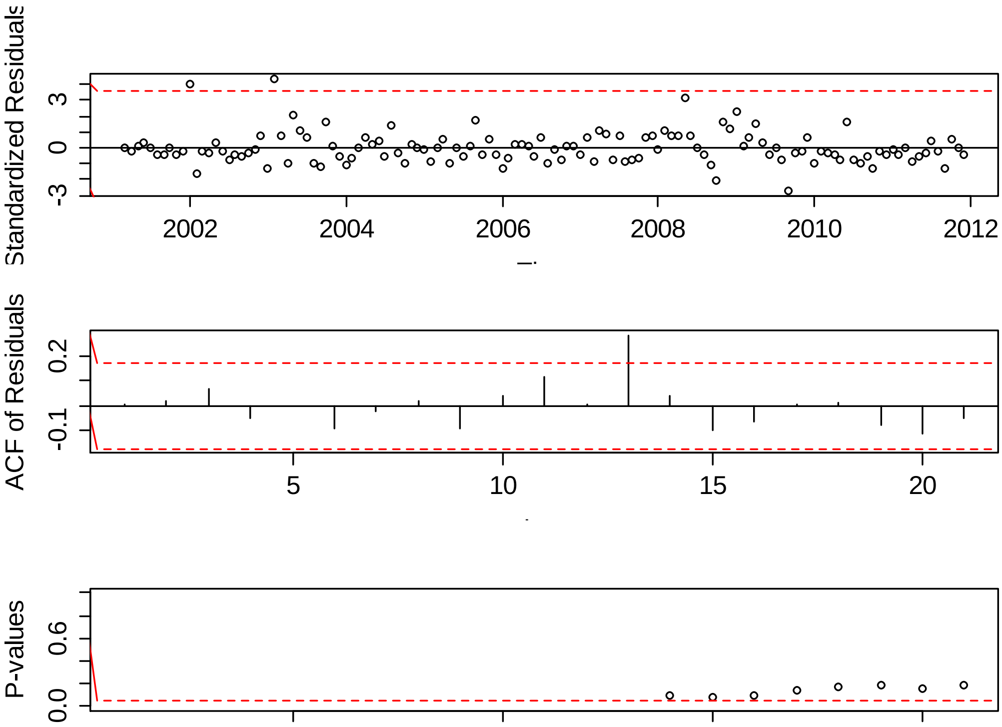

Fig. 5: Diagnostic plot of residuals