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Modelling and Forecasting Inflation Rates in Sri Lanka

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Abstract: ***Sri Lanka faces a macroeconomic problem of inflation for a long period of time. The problem in somehow slows the economic growth in this country. As we all know, inflation is one of the major economic challenges facing most countries in the world especially those in South Asian countries including Sri Lanka. Therefore, forecasting inflation rates in Sri Lanka becomes very important for its government to design economic strategies or effective monetary policies to combat any unexpected high inflation in this country. This paper studies seasonal autoregressive integrated moving average model to forecast inflation rates in Sri Lanka. Using monthly inflation data from January 1988 to July 2017, after checking the stationarity of the series using ADF test the plots of ACF and PACF of first differenced data were observed to identify the appropriate model ARIMA $(1,1,2)(2,0,1)_{12}$. But based on the minimum AIC and BIC values and the significant of the model parameters the chosen model was reduced to ARIMA $(1,1,0)(0,0,1)_{12}$ can represent the data behaviour of inflation rate in Sri Lanka well which fits the monthly inflation data well as it satisfied all the assumptions of model adequacy. Based on the selected model, we forecast eight (8) months inflation rates of Sri Lanka outside the sample period (i.e. from August 2017 to March 2018). The observed inflation rate of August and September which was published by Sri Lanka Statistical Service Department fall within the 95% confidence interval obtained from the designed model. The forecasted results show a decreasing pattern and in the subsequent months, the pattern shows an increasing and decreasing pattern one thing away.***

Keywords: Sri Lanka, Inflation rate, Forecasting, SARIMA model, Unit Root test, ARCH–LM test, ADF test, HEGY test

1. Introduction

Inflation is a universal occurrence and substantial macroeconomic challenge facing several countries all over the world which affect the economic growth of practically all countries of the world such as South Asian Countries including Sri Lanka. Economic policy makers and strategies mainly focus on inflation because it causes extreme impacts on a country's economic growth pattern and wealth distribution. Inflation is also well-defined as the determined rise in the level of consumer prices or the deterioration in the purchasing power of the money. Inflation is realized when the demand for goods and services overtake their supply in the economy. The consumer price index (CPI) is the most common measure of inflation which measures the changes in the average prices of consumer goods and services. In real terms, either very insufficient goods available for sale, or too much money in circulation in the country can cause inflation. The effects of inflation can alter the life of people of a country much harder. Because, the people who rely on a fixed income will be highly affected when costs of products and services increases, those people will not be able to purchase the amount of commodities they bought previously. This circumstance demotivate savings because the money is valued great currently compared to the future. The reduction of savings lead to a decline of economic growth as the economy of a country requires a certain level of saving to enhance the economic growth through financial investments. Local and international investors are discouraged because of inflation because they expect high return from their investment to make valid financial decisions regarding the business plans and the production criteria. The uncertainty condition of the future prices of commodities, exchange rate and interest rates are caused by inflation. In general, while certain extent of inflation is inevitable and is perhaps essential to go with development; inflation outside a certain boundary is considered undesirable. A minor rate of inflation within 4 % per year is good for an economy, but many developing countries of the world are undergoing inflation above the minor rate which is unsafe for the economy. Therefore, controlling the inflation has come to be one of the main intentions of Government involvement in various developing nations. The recent observations of Central Bank of Sri Lanka has shown a strong effort to maintain the country's economic and price stability in Sri Lanka like in many other developing countries. The persistency to maintain the price stability arises due to maintain the overall macroeconomic stability as it forms a better environment for investment, employment, and financial development etc. Recently, both developed and developing nations have experienced a sudden rise in the prices of fundamental commodities; mainly food stuffs and oil varieties. This instability affected just all the nations of the world. Therefore, all the country over the world are supposed to recover the pressure of controlling the inflation level and the Central Banks of those countries have under taken a number of actions to maintain the price stability.

Sri Lanka's economy is not exceptional regarding this issue subsequently it seriously depends on these two items. After the economic liberalization, the expanded economic strategies followed by the government and the Central Bank of Sri Lanka lead to improvements in several macroeconomic indicators together with economic growth.

The economy of Sri Lanka is nowadays considered as one of fruitful developing countries in South Asia and the world as an entire. In this study, our foremost objective is to model and forecast eight (8) months inflation rate of Sri Lanka outside the sample period. The post-sample forecasting is very important for economic policy makers to predict forward of time the possible future necessities to plan economic strategies and effective financial guidelines to fight with any expected high inflation rates in the country of Sri Lanka. Forecasts will similarly play a vital role in commercial, manufacturing, government, and institutional organization because many important decisions depend on the predicted future values of inflation rate.

This research paper composed into four sections. Materials and methods are given in section 2, in section 3 empirical results and discussions of the paper are illustrated. Further conclusions and recommendations are given in section 4.

2. Materials and Methods

With the intention to model the inflation rate, the study started by investigating the extensive performance of monthly inflation rates of Sri Lanka. In this research, 355 monthly observations of inflation rate of Sri Lanka from January 1988 to July 2017 were analysed and the data was obtained from World Development indicators of World Bank National Accounts Data. Since this study is carried out mainly for modelling and forecasting the monthly inflation rate of Sri Lanka, it is compulsory to identify the appropriate model. The purpose for selecting this kind of model is established on the nature of our time series data. Once it comes to forecasting, wide amount of methods and approaches available there to perform enhanced forecasting. Similarly if the history of inflation forecasting is considered SARIMA model have pointed out as the convenient model for a better forecast compared to other models. The E-Views (version 9) and Minitab (version 16) were used to analyse the data.

2.1 Model Specification

The objective of this study is to model and forecast the monthly inflation rate of Sri Lanka. To prosper that intention the subsequent methods were adopted from the preceding studies. Once the Box-Jenkins approach was employed, SARIMA models were applied to the chosen time series data to model and forecast future monthly inflation rates of Sri Lanka. In the year of 1976, Box and Jenkins proposed a group of models, named Auto Regressive Integrated Moving Average (ARIMA) models which can be applied to a massive variety of conditions. On the other hand, choosing a proper ARIMA model possibly will not be easy. ARIMA models are specifically appropriate for short term forecasting. Therefore the model displays more importance on the recent past rather than far-off past. This importance on the recent past suggests that the short-term forecasts from ARIMA models are more reliable than long-term forecasts [11].

2.2 Estimation Procedures

Complete analysis of the existing research study comprised of several stages of analysis, such as the identification stage of model construction, we determine the probable models based on the data pattern. But before we begin to search for the best model for the data, the first condition is to check whether the series is stationary or not. The ARIMA model is applied in the situation where the series is non-stationary and an initial differencing can make ARMA model applicable to an integrated stationary process (i.e. the mean, variance, and autocorrelation are constant through time).

The ARMA(p,q) model can be written as,

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \cdots + \alpha_p y_{t-p} + \beta_1 e_{t-1} + \cdots + \beta_q e_{t-q} + e_t \qquad (2.1)$$

The characteristic equation of autoregressive moving average model can be written as,

$$\emptyset_p(B) y_t = \alpha_0 + \theta_q(B) e_t \qquad (2.2)$$

The stationarity condition confirms that the autoregressive parameters in the estimated model are steady within a certain range as well as the moving average parameters in the model are invertible. If this condition is assured then, the estimated model can be forecasted [7]. The existence of stationarity is usually tested through unit root whether a deterministic trend exists in the series or not. There are several statistical tests available for checking the occurrence of unit root in a series. For series having seasonal and non-seasonal patterns, the test must be directed below the seasonal part along with the non-seasonal part. In this study the Augmented Dickey- Fuller test, was employed for testing the availability of non-seasonal unit root in the time series. Also the unit root test for seasonal time series was used is Hylleberg-Engle-Granger-Yoo (HEGY) test in this frame, [9]. When the series is stationary, the next step is to build ARIMA model.

Consider a process $\{y_t\}$ is said to be ARIMA(*p*, *d*, *q*) ; $\{e_t\} \sim WN(0, \sigma^2)$. Where e_t follows a white noise (WN). When the series contains both seasonal and non-seasonal behaviour, the extension of ARIMA model to the SARIMA model arises. This behaviour of the series makes the ARIMA model inefficient to be applied to the series. This is because it may not be able to capture the behaviour along the seasonal part of the series and therefore mislead to a wrong order selection for non-seasonal component. The ARIMA(p,d,q) model can be illustrated as:

$$dy_t = \alpha_0 + \alpha_1 dy_{t-1} + \cdots + \alpha_p dy_{t-p} + \beta_1 e_{t-1} + \cdots + \beta_q e_{t-q} + e_t \qquad (2.3)$$

The characteristic equation of ARIMA model is:

$$\emptyset_p(B) \nabla^d y_t = \alpha_0 + \theta_q(B) e_t \qquad (2.4)$$

The model SARIMA(p,d,q)(P,D,Q)$_{12}$ can be illustrated as:

$$dy_t = \alpha_0 + \alpha_1 dy_{t-1} + \cdots + \alpha_p dy_{t-p} + \beta_1 Dy_{t-1s} + \cdots + \beta_P Dy_{t-Ps} + \gamma_1 e_{t-1} + \cdots + \gamma_q e_{t-q} + \delta_1 e_{t-1s} + \cdots + \delta_Q e_{t-Qs} + e_t \qquad (2.5)$$

The characteristic equation of SARIMA model is:

$$\emptyset_p(B) \Phi(B^S) (1-B)^d (1-B^S)^D y_t = \alpha_0 + \theta_q(B) \Theta(B^S) e_t \qquad (2.6)$$

To identify the non-seasonal terms and the seasonal term the sample autocorrelation function (ACF) and partial autocorrelation function (PACF) have been used according to the pattern of the series. While checking the ACF and PACF plots, both the non-seasonal and seasonal lags should have to be observed. Usually the ACF and the PACF has spikes at lag k and cuts off after lag k at the non-seasonal level. Also the ACF and the PACF has spikes at lag ks and cuts off after lag ks at the seasonal level. The number of significant spikes recommends the order of the model. After obtaining the parameters, several models with different orders can be considered. The final model can be carefully chosen using a consequence function statistics such as Akaike Information Criterion (AIC) or Bayesian Information Criterion (BIC), [14]. The AIC, and BIC are a measure of the goodness of fit of an estimated statistical model and best model will be chosen according to their ranked AIC or BIC with the one having the lowest information criterion value being the best.

There are several researchers all have done wide range of studies regarding modelling and forecasting of inflation rate. For instance, Junttila, J. (2001), [10] investigated the inflation of Finnish using ARIMA forecasting, Fedderke, J. W., & Schaling, E. (2005), [4] modelled the inflation of South Africa, Diouf, M. A. (2007), [3] modelled the inflation for Mali, Pufnik, A., & Kunovac, D. (2006). Short-term forecasting of inflation in croatia with seasonal ARIMA processes, Hendry, D. F. (2001), [8] modelled the inflation of UK, Barungi, B. M. (1997), [1] investigated the exchange rate policy and inflation of Uganda. According to the results of the above mentioned researches, SARIMA approach produces somewhat improved values of forecasting and modelling the most appropriate choices than the exponential smoothing approach.

3. Results and Discussions

Before build the most appropriate model for the monthly inflation rate (IR) data, their features of original data was observed through the time series plot and the stationarity patterns were investigated through ADF unit root test. The movements of the variable IR was graphically illustrated in Figure 1.

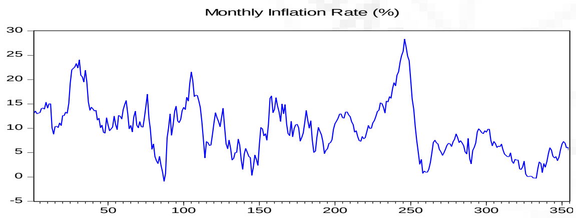

Figure 3.1: Monthly Inflation Rates of Sri Lanka (1988:1–2017:7)

The figure 3.1 illustrates an unstable pattern and a slightly decreasing trend. The volatility in monthly inflation rate series of Sri Lanka can be attributed to quite a few economic factors. Some of those factors mainly responsible for inflation in Sri Lanka consist of surges in income redistribution, fall in real income, negative interest rate, business uncertainty, reduction in exchange rate, increased petroleum prices, and low agricultural manufacture. For illustration, inflation rates are high during the year 2008 from June, July and August 28.31%, 26.63% and 24.83% respectively and negative inflation rates were observed in the month of March 1995 (-0.89%) and from 2015 July, August and September it shows -0.22%, -0.22% and -0.27% respectively.

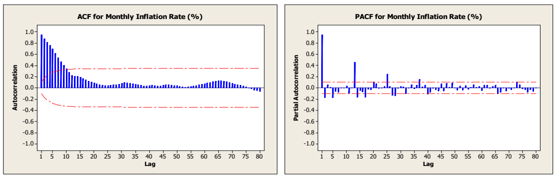

Figure 3.2: ACF and PACF of Monthly Inflation Rates

Figure 3.2 shows both non-seasonal and seasonal pattern in the series. To endorse the accurate order of differencing, we can execute both non-seasonal and seasonal unit root test. Using ADF test and HEGY test, we can test non-seasonal and seasonal unit root in the series. Since, there exist a non-stationarity pattern in the series unit root test was applied. ADF test was run on the series to determine the non-seasonal order of integration of our non-stationary time series to convert into stationary, which the results are offered in Table 3.1, that all the variables is integrated at order one.

Table 3.1: ADF Stationary test result

Variable (IR)	p-value		Result
	Level	First Difference	
Constant	0.0904	0.0000**	I (1)
Constant & linear trend	0.0562	0.0000**	I (1)

Note: ***, ** and * denotes significance at 1%, 5% and 10% level, respectively

The seasonal frequencies in the monthly data are $\frac{2\pi}{3}, \frac{2\pi}{5}, 2\pi, \frac{\pi}{2}, and\ \pi$. These are equal to 4, 2.4, 12, 3, and 6 rotations per year, [13]. The null hypothesis; there exist seasonal unit root is tested using HEGY test.

Table 3.2: HEGY test for seasonal unit root

Auxiliary Regression	Seasonal Frequency	Constant	Constant & Trend
t-test:			
$\pi_1 = 0$	0	-3.375*	-4.307*
$\pi_2 = 0$	$\frac{\pi}{3}$	-5.544*	-5.481*
F-test:			
$\pi_3 = \pi_4 = 0$	$\frac{2\pi}{3}$	31.147*	30.21*
$\pi_5 = \pi_6 = 0$	$\frac{2\pi}{5}$	75.614*	76.595*
$\pi_7 = \pi_8 = 0$	2π	49.336*	48.611*
$\pi_9 = \pi_{10} = 0$	$\frac{\pi}{2}$	60.327*	60.891*
$\pi_{11} = \pi_{12} = 0$	π	48.725*	50.046*

Note: * seasonal unit root null hypothesis is rejected at 5% significant

Table 3.2 represent the consequences on data from the HEGY test. According to the results, the null hypothesis of unit root at the seasonal frequency can be rejected at 5% level. Hence, at seasonal level, we should not need to make differences for data. Since, the non-seasonal series is stationary at its first difference the orders of the model have to be identified using the ACF and PACF of the first differenced series.

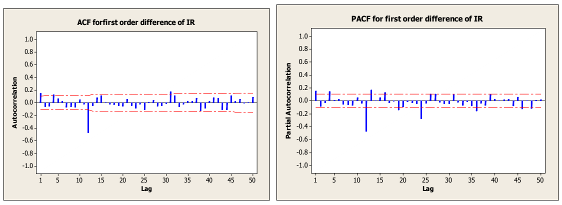

Figure 3.3: ACF and PACF of Monthly Inflation Rates

The succeeding stage in the model building process is to decide the order of the AR and MA for both seasonal and non-seasonal components using the Box-Jenkins methodology through the sample ACF and PACF plots of the first differenced series. According to the Figure 3.3, at lag 2 ACF tails of and the PACF spike at lag 1, signifying that these data in place of upcoming from a moving average and autoregressive process of non-seasonal series respectively. Similarly by the observation on the seasonal lags, ACF spikes at seasonal lag 12 and PACF spikes at seasonal lag 24 and fall to zero for further seasonal lags indicating that and would be essential to designate these data as upcoming from a seasonal moving average and autoregressive process. Therefore ARIMA $(1,1,2)(2,0,1)_{12}$ could be a probable model for the series.

Table 3.3: AIC & BIC for the suggested SARIMA models

Model	AIC	BIC
ARIMA$(1,1,0)(0,0,1)_{12}$	3.542485*	3.586206*
ARIMA$(1,1,0)(2,0,1)_{12}$	3.580976	3.646558
ARIMA$(1,1,1)(0,0,1)_{12}$	3.545499	3.600150
ARIMA$(1,1,1)(1,0,1)_{12}$	3.551066	3.616647
ARIMA$(1,1,1)(2,0,1)_{12}$	3.556707	3.633218
ARIMA$(1,1,2)(0,0,1)_{12}$	3.549895	3.615476
ARIMA$(1,1,2)(1,0,1)_{12}$	3.555509	3.632020
ARIMA$(1,1,2)(2,0,1)_{12}$	3.561152	3.648594

Among all suggested models, ARIMA$(1,1,0)(0,0,1)_{12}$ was chosen as the best model, since the AIC and BIC values are least for this particular model and all the terms of the model are significant at 5% significant level the selected model ARIMA (1,1,2) $(2,0,1)_{12}$ is reduced to ARIMA(1,1,0) $(0,0,1)_{12}$. After choosing the appropriate model the test of model adequacies were done to confirm the fit of that model for monthly inflation rate data for forecasting.

Table 3.4: Estimates of Parameters for RIMA$(1,1,0)(0,0,1)_{12}$

Variable	Estimate	Std. error	95% CI	
			Lcl	Ucl
C	-0.0274	0.0238	-0.0743	0.0195
AR(1)	0.1334	0.0478	0.0394	0.2273
MA(12)	-0.7519	0.0409	-0.8323	-0.6715
$\hat{\sigma}^2$	1.9227			

Therefore the fitted SARIMA model is:

$$dy_t = -0.0274 + 0.1334\, dy_{t-1} - 0.7519\, e_{t-12} + e_t$$

Table 3.5: ARCH-LM Test for Homoschedasticty

Model	Prob. Chi-square
ARIMA$(1,1,0)(0,0,1)_{12}$	0.0542*

Note: * fail to reject null hypothesis of no ARCH effect at 5% level

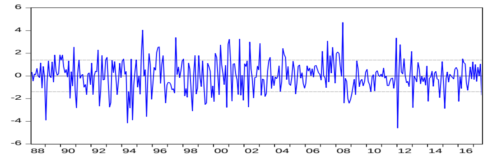

Figure 3.4: Time series plot of Residuals

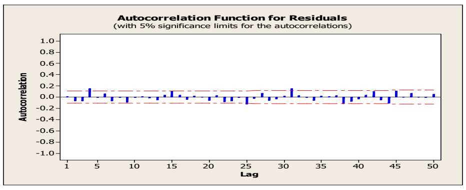

Figure 3.5: ACF for Residual

The null hypothesis of "no ARCH effect" is tested using the ARCH–LM test and Table 3.5 exhibits that there is no heteroschedasticity exist in the final model as the relevant p-value is (0.0542) greater than 5% alpha level. The stationarity of the residuals of the model also has been validated through the Figure 3.4 and Figure 3.5. That is, the time series plot reveals mean approximately zero and a constant variance. Also, the normality test represent a probability of 0.020871 which is less than 5% alpha level suggests that the residuals follow a normal distribution. From this, we accomplish that there is a constant variance between residuals of the certain model and the exact mean of the residuals is almost equal to zero. Hence, it could be decided that the chosen model satisfies all the model assumptions. Since our model ARIMA $(1,1,0)(0,0,1)_{12}$ satisfies all the necessary assumptions, at this instant it can be recommended that the model provide an adequate demonstration of the data. When our model and its parameters have been established, then the model can be implemented to make our prediction.

Table 3.6: ARIMA $(1,1,0)(0,0,1)_{12}$ Forecasting Results for Monthly Inflation Rate

Month	Forecast (%)	95% CI		Actual (%)
		Low. Limit	Upp. Limit	
August	5.657	2.948	8.367	6.0
September	6.080	1.997	10.162	6.2
October	5.561	0.436	10.685	
November	5.692	-0.299	11.683	
December	4.589	-2.158	11.336	
January	4.886	-2.541	12.312	
February	4.169	-3.880	12.218	
March	4.439	-4.188	13.066	

The Table 3.6 shown below indicates the forecasting outcomes of the inflation rates over the period August 2017 to March 2018 with 95% confidence interval. The observed rate for the two months August and September that has been observed and issued by the Statistical Department of Central Bank of Sri Lanka have been compared with the forecasted values and it was found that the predicted values are almost equal to the actual value.

Moreover, all the observed values lay within the confidence interval, we can suggest that, ARIMA $(1,1,0)(0,0,1)_{12}$ model is adequate to be applied to forecast monthly inflation rate in Sri Lanka.

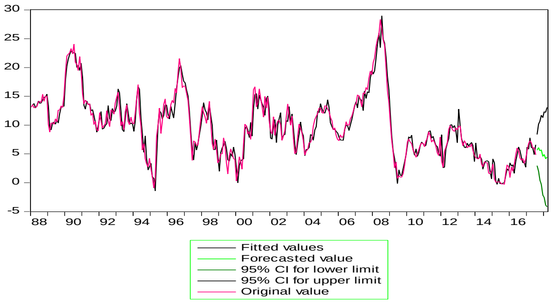

Figure 3.6: Fitted and Forecast values of ARIMA (1,1,0)(0,0,1)12

The forecasted and observed monthly inflation rates are not much deviated from each other. It confirms that the model fit the data better. The figure also displays the behaviour of the forecasted values.

4. Conclusion

After performing the Box-Jenkins approach, Seasonal Autoregressive Integrated Moving Average (SARIMA) was engaged to investigate monthly inflation rate of Sri Lanka from January 1988 to July 2017. The study mostly planned to forecast the monthly inflation rate for the upcoming period of August, 2017 to March 2018.

According to the ACF and PACF plots the suggested model is ARIMA(1,1,2)$(2,0,1)_{12}$ but based on minimum AIC and BIC values, the best-fitted SARIMA model have a tendency to be ARIMA(1,1,0)$(0,0,1)_{12}$. Once the estimation of the parameters of selected model, a series of diagnostic and forecast accuracy test were executed. Hence, displaying satisfaction regarding all the model assumptions, ARIMA(1,1,0)$(0,0,1)_{12}$ model was decided to be the best model for forecasting. In general the forecasting outcomes showed a decreasing pattern of inflation rate over the forecasted period. But while the overall forecasts gradually decreases, slight increase and decrease among the rates can be observed. Founded on the forecasted results, policy creators should gain awareness dependent to more proper economic and monetary policy in other to fight such increase in inflation rate. From the description of the Sri Lanka inflation rates behaviour, it was found that, the retrieval of the agriculture related actions and the progressive performance of the industry and services related activities together with the replacement of Generalised Scheme of Preferences facility are expected to contribute to economic growth.

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