ESTIMATION OF FUTRE INFLATION IN SRI LANKA USING ARIMA MODEL

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1. Introduction:

Inflation plays a key role in macroeconomic analysis. The importance and necessity of low and stable inflation has become a commonly prevailing viewpoint among the economist for maintaining a stable socio-economic situation in many countries. The negative consequences of inflation are well known. Inflation can result in a decrease in the purchasing power of the national currency leading to the aggravation of social conditions and living standards. High prices can also lead to uncertainty making domestic and foreign investors reluctant to invest in the economy. Moreover, inflated prices worsen the country's terms of trade by making domestic goods expensive on regional and world markets. Therefore, inflation is considered to be a major economic problem in transition economies and thus fighting inflation and maintaining stable prices is the main objective of monetary authorities.

Earlier signal of future inflation is important to make economic decision. Forecasting is the estimation of the value of the variable (or set of variables) at some specific future point in time. Sri Lanka uses Colombo Consumer Price Index (CCPI) to estimate inflation rates. For most Central Banks, inflation is important monetary policy objective. Inflation forecasts that link future inflation to current development. Some Central Banks have even adopted an inflation forecast as an intermediate target of inflation. This proves that inflation forecast should be reliable. Quantitative inflation forecasting can provide useful information on future developments. Therefore, it is very important in an inflation-targeting regime to develop powerful models that explain the dynamic movements of the economy. If the Central Bank had a powerful inflation-forecasting model, it could be able to take pre-emptive actions that reproduce the economic dynamics as well.

Forecast of central macro variables, inflation in particularly plays an important part in policy framing and policy guidance. It is a useful ingredient of the business life. Most business plans exemplify in their forecast with multiple economic variables. Forecasting about the inflation and its turning points are important for economic agents as well. They gain from it and enjoy its benefits. An early signal of a major turn in the inflation rate can help economic agents like Central Bank managers, business leaders, policy makers, investors and employers to prepare themselves and to make the right move to calculate the strength of the anticipated new environment and to take feasible necessary action in their business activities. Forecasting the inflation is a crucial ingredient in the formulation of a monetary policy because all the activities depend on the market variables.

2. Objectives:

The main objective of this study is to estimate future inflation in Sri Lanka using ARIMA methods. The specific objectives of this study are to develop ARIMA models , to identify the best ARIMA model, using AIC, SC and adjusted R-square and to estimate future inflation in Sri Lanka.

3. Review of Literature:

Inflation is one of the most widely investigated areas of economics, in terms of both theory and empirical data. Analysis of inflation forecasting is not a new system in the economic world. Meyler, Kenny and Quinn (1998) and Salam, Salam and Feridun (2006) found that the ARIMA models are theoretically justified, and can be surprisingly robust with respect to

alternative (multivariate) modeling approaches. Bokil and Schimmelpfenng (2005) compared the ARIMA model with the VAR model and with the LIM model. Moriyama and Naseer (2009) compared the ARMA model with leading indicators.

According to literature, there were various empirical studies on inflation in Sri Lanka. Some of those studies have used sources of the inflationary process and its environment, the causes of inflation, the reliability of inflation indicators, the proper policy prescription for the control of inflation and experience on the inflation targeting and its feasibility in Sri Lanka. Bandara (1997) examined the seigniorage and the welfare cost of inflation in Sri Lanka using the Sidrauski type optimization model, the Cobb Dougless utility function and the CES utility function. He also used the Cagan money demand function and the Laffer curve to find the relationship of seigniorage on inflation. Nicholas (1990) examined a preliminary study of inflation in Sri Lanka, using regression technique. Karunaratna (2000) examined the necessity of Central Bank independence, to achieve inflation targeting in Sri Lanka. Thenuwara (1998) and Jayamaha, Thenuwara, Weerasingha, Silva, Karunathilake, Ratnasiry, Chandrawansa, Gunaratne and Perera (2002) described the feasibility of inflation targeting in Sri Lanka. Most of their studies revealed the basic features, prerequisites, and issues involved in adopting an inflation-targeting framework in Sri Lanka. Some of them investigated and found that Sri Lanka did not satisfy the precondition of inflation targeting due to the presence of seigniorage revenue, lack of Central Bank independence and poor model to forecast inflation.

Developing a powerful model to forecast the future path of inflation is necessary to adopt IT framework in any countries. Forecasting inflation is necessary for the agents, authorities and all interested professionals to reduce the incidence of risk in macroeconomic activities. Unfortunately, most developing countries do not have dynamic inflation forecasting model. The Central Bank of Sri Lanka took several foundation steps to implement inflation targeting framework in its monetary policy regime. There were some research works briefly express about inflation forecasting in Sri Lanka. This gap has induced by this researcher to formulate an accurate inflation-forecasting model to adopt an inflation-targeting framework.

4. Data and Methods:

Data for this research has been collected by secondary sources such as annual reports of the Central Bank of Sri Lanka and statistical bulletin of the Department of Census and Statistics. The monthly Colombo consumer price index (CCPI[1]) data is used to develop ARIMA models in this study. These data are collected for the period covering from 1953: Jan. to 2009: Dec.

5. Univariate ARIMA (Box Jenkins) Method[2]:

The ARIMA methods for forecasting time series are essentially agnostic. The Autoregressive Integrated Moving Average (ARIMA) modeling is a specific subset of univariate modeling. A general class of the univariate model is the Autoregressive Integrated Moving Average (ARIMA) model. This model represents past values of a time series (the Autoregressive component AR) and past values of the error term (the Moving verage terms MA). The integrated components (I) refer to the number of times in a series that must be differentiated to induce stationary. A general notation for ARIMA model is ARIMA (p, d,

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1 publications. CCPI data from 2008:May to 2009:December was collected personally from the director of DCS.

2 This section mostly depends on Box and Jenkins, (1976), Time Series Analysis: Forecasting and Control.

and q); where 'p' denotes the number of Autoregressive terms, 'd' denotes the differentiated number of times in a series, to induce stationary and 'q' denotes the number of Moving Average terms.

The ARMA (p, q) model with past values of time series and past error term.

$$Y_t = \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \phi_3 Y_{t-3} + \ldots\ldots\ldots + \phi_p Y_{t-p} + e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2} - \theta_3 e_{t-3} - \ldots\ldots - \theta_q e_{t-q}$$

$$Y_t - \phi_1 Y_{t-1} - \phi_2 Y_{t-2} - \phi_3 Y_{t-3} - \ldots\ldots\ldots - \phi_p Y_{t-p} = e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2} - \theta_3 e_{t-3} - \ldots\ldots - \theta_q e_{t-q}$$

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

$$(1 - \phi_1 B - \phi_2 B^2 - \phi_3 B^3 - \ldots\ldots - \phi_p B^p) Y_t = (1 - \theta_1 B - \theta_2 B^2 - \theta_3 B^3 - \ldots\ldots - \theta_q B^q) e_t$$

$$\phi(B) Y_t = \theta(B) e_t$$

Then the backshift operator for ARIMA (p, d, q) model can be written as,

$$\phi(B) \Delta^d Y_t = \theta(B) e_t$$

The following steps is necessary to fit suitable ARIMA model.

1. Collection of data
2. Model identification
3. Estimation
4. Diagnostic Checking

5.1. Determining Stationary of Time Series

The pre-requisite for the application of an ARMA model was that the time series should be stationary. A stationary time series is one that has statistical properties such as mean, variance and autocorrelation constant over a set period. In other words, data fluctuate around a constant mean independent of time and the variance of the fluctuation remains essentially constant. However, most economic and financial time series shows these trends over time. The mean and the variance of the data series during one year will be different from another year. If the initial time series is not stationary, there is a need for some transformation to make it stationary. Often the series become stationary by the differences of it or by other mathematical transformation. The ADF (Augmented Dickey – Fuller) test is used to test stationary in this study.

5.2. Model Identification & Estimation

The third step is to find an appropriate ARMA order from the stationary series. Once we find out the appropriate ARMA model then we can estimate the parameters for the ARIMA model. In the time series analysis, they commonly used the penalty function statistics to identify the order of the ARMA model (Makridakis, Wheelwright and Hyndman, 2003). They used the penalty function criteria such as the Akaike Information Criterion (AIC) and the Schwarz Criterion (SC) to assist the time series analysis for reconciling the need to minimize error with the conflicting desire for model parsimony (Meyler, Kenny and Quinn, 1998). Ideally, we select the model that minimizes error, by selecting the lowest statistics.

- $\text{AIC} = \log\left(\frac{rss}{n}\right) + \left(\log(n) * \frac{k}{n}\right)$

- $SC = \log\left(\frac{rss}{n}\right) + k\frac{\log(n)}{n}$

Where; K = number of coefficient estimated
rss = residual sum of squares, n = number of observation

5.3. Diagnostics Checking

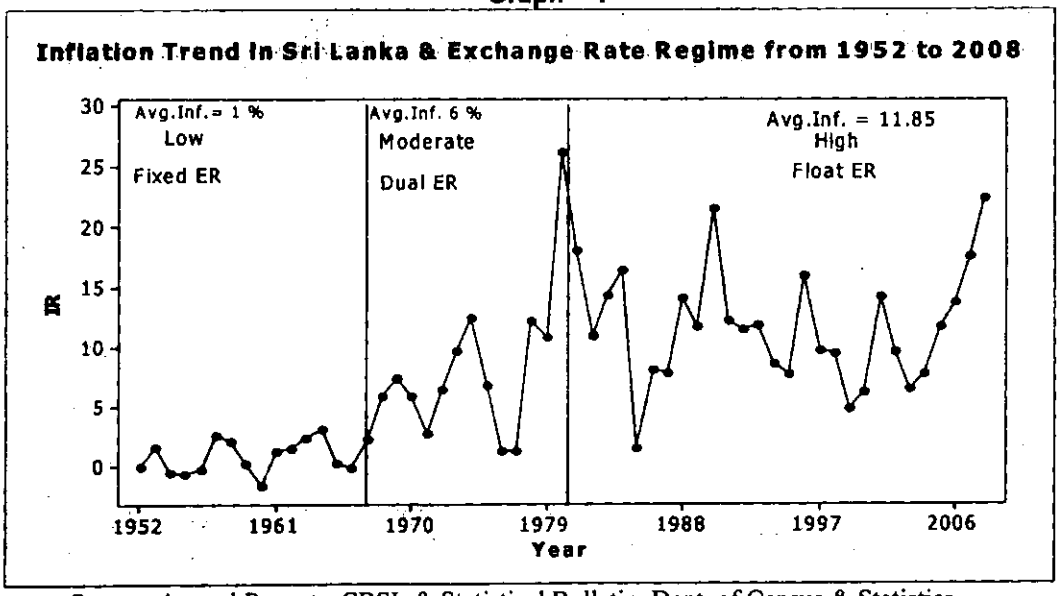
The fourth step of ARIMA model is the diagnostic tests. There are many diagnostic tools available to ensure a satisfactory model. Plotting the residuals of the estimated model is a useful way for diagnostic check.

6. Inflation in Sri Lanka:

The primary originator of monetary policy in Sri Lanka is the Central Bank of Sri Lanka. It has been authorized to implement monetary policy through price stability, exchange rate convertibility, long-term growth, and stable economy (Thenuwara, 1998). Inflation forecasting is a key ingredient to achieve this target. The current monetary policy of the Central Banka of Sri Lanka is to reduce high inflation and inflationary expectations while supporting a sustainable high economic growth and development.

Over the years, inflation has had much great impact on the Sri Lankan economy. Inflation in Sri Lanka from the time of independence to the late 1970's has been low by international standards. During the 1950's, 1960's and the 1970's the average annual rate of increase in the retail price was very much lower than in other developing countries. Towards the end of the 1970, there were signs of reversal of this pattern. Graph - 1 illustrates the inflation and Exchange rate (ER) behavior during the post independent era. The Graph shows the average annual rate of inflation between the periods of 1952 – 1967 was 1 % and between 1968 and 1978 was 6 % percent. However, it increased to 11.85 percent between the period of 1977 and 2008.

Graph – 1



Source: Annual Reports, CBSL & Statistical Bulletin, Dept. of Census & Statistics

The low inflation for the period between 1952 to1966 was due to a number of factors including the maintenance of a fixed exchange rate since 1949, the shortages of essential food items because of imports, the maintenance of price controls, the rationing, subsidies on essential foods and textiles and the slow rate of money expansion. The moderate inflation during that period 1966-1979 was mainly due to the policy of devaluation of the rupee in 1967, the dual exchange rates and the foreign exchange entitlement certificates (FEECs). Also higher imports prices particularly of crude oil, the higher money supply, the shortages in consumer items and the growth of the black market were also affecting the inflation. The inflation rate increased after 1976, which had risen to nearly 13 percent between 1987 and 1994. High inflation rate during this period was mainly due to the removal of price control, the rationing, the currency depreciation, the liberalization of the exchange rate, the removal of subsidies, the introduction of large-scale investment programs, the high budget deficits, financed by expansionary sources and the sharp increase in import prices, particularly a second oil price hike. During the period from 1994 to 2004, the inflation dropped down to an average of 9.02 percent per year. They achieved it through the reduction in administered prices of the flour and kerosene with an improved agricultural production by the reduction of tariffs and by the low world market prices of imported food items (Korale, 2001). There were high inflation rates after 2005, which have risen to nearly 16.3 percent between 2005 and 2008. Several factors have contributed to this occurrence most notably the rapid increase in public expenditure over the past three to four years. In addition, budget deficit, public debt and internal war were leads increase the domestic borrowings and money supply.

In general, inflation rate was started to increase after the open economic era. Responsible features for the behavior of high inflation in this period can be classified into two categories; supply side factors and demand side factors. The primary sources of inflationary pressures attributed to the post 1978 era were the supply side factors, the external price hikes, depreciation of the rupee and the adjustment and liberalization of certain key administered prices. Two important factors affected the movements of the consumer price index during this period. Firstly, the indices reflected the significant increases in administered prices. With the introduction of new economic reforms in the late 1970's, the government began to implement the process of reducing the wide array of subsidies and began to move from the administered prices that governed a wide range of commodities to market prices. Secondly, the international price increases also affected the inflation, which were beyond Sri Lanka's control. As about half of the price indices comprise trade goods, therefore movements in international prices and in the exchange rate had an important behavior on price increase in the domestic economy (Atapattu, 1995).

Sri Lanka depends heavily on imports to meet the requirement of her essential consumer and capital goods. Furthermore, most of the imported goods are non-competitive items for which the demand is relatively inelastic with respect to the price. These affected domestic prices through the price increase in imported consumer goods directly or in the cost of manufacturing goods indirectly. In fact, the sharp increase in the rate of inflation registered in 1980 and 1990 (26.1% and 21.4%) was the direct result of the rise in the price of imported goods, particularly petroleum. The decline in the external value of the rupee has been a significant factor that contributed to the rising cost of imported items in addition to an independent increase in the world market prices. Prior to 1977, Sri Lanka had a fixed exchange rate system, which was subjected to periodical devaluations supported by a system of managed floating exchange rates, which allowed market forces to play a substantial role in the determination of the exchange rates.

During the post 1978 period, demand side factor such as the budget deficit and money supply have tended primarily to have a propagating influence on inflation. The government's budgetary policy characterized by the fiscal imbalances has been a major source of financial

instability during this era. The budget deficit financed from the banking system particularly from the Central Bank led to an increase in the money supply. Such increase in the presence of limited availability of goods and services lead to higher prices and thereby causing inflation. On a number of occasions during the post 1978 period, the government had resorted to printing money as a source of financing the budget deficit (Atapattu-1995).

7. Empirical Results:

Essentially, the Autoregressive Integrated Moving Average (ARIMA) models assume the fact that the time series has been generated by a probability process with future values related to past values as well as to past forecast error. To apply the ARIMA model we developed the following procedure.

7.1. Testing for stationary of the variable

The time series under consideration must be stationary before one can attempt to identify a suitable ARMA model. The researcher used the Augmented Dickey – Fuller test statistics to test the stationarity of the series. The following table summarizes the ADF test statistics for the series of CCPI.

Table – 1, ADF statistics for CCPI series from 1953:1 to 2009:12

	ADF Statistics	Critical Value		
		1%	5%	10%
Level without intercept and trend	8.305749	-2.5753	-1.9422	-1.6158
1st Difference without intercept and trend	-13.4876	-2.5753	-1.9422	-1.6158

According to the table, the CCPI series is not stationary at the level and need to take first difference to make the series stationary. At the first difference, the CCPI series is stationary at 1% level of significant. The Graph of Correlogram of the CCPI series also clearly indicates that the ACF does not die down at all lags. This clearly suggests that the CCPI series is not stationary and we needed to take first difference. The correlogram for the first difference series of CCPI shows stationary. The ACF drops to zero quickly.

7.2. Model Identification

Finding out the appropriate ARMA form of the stationary series is one of the most important stages of the development in the Box Jenkins procedure. The objective model identification for identifying the correct ARMA model is one of the alternative approaches in literature. To identify a suitable ARMA model we used the Penalty function Statistics AIC, SC and we selected the lowest information criterion. Table-2 presents the possible models and their statistics.

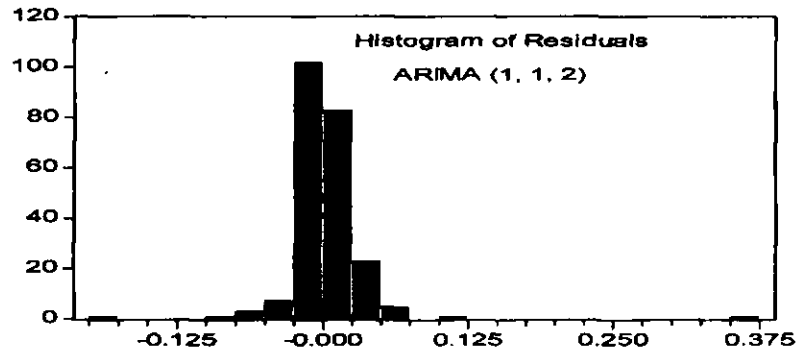
Table – 2 Model identification Statistics for ARIMA method

Model	Statistics				
	Adjusted R-square	AIC	SC	F Stat	Durbin-Watson Stat
ARIMA (1, 1, 0)	0.0168	-3.784	-3.754	3.37	2.02
ARIMA (1, 1, 1)	0.0196	-3.778	-3.733	2.23	1.998
ARIMA (2, 1, 0)	0.02	-3.775	-3.73	2.26	1.992
ARIMA (0, 1, 2)	0.02	-3.783	-3.738	2.32	1.995
ARIMA (1, 1, 2)	0.105	-3.86	-3.800	8.72	2.09

Based on the Table -2 all ARIMA models give a good criterion statistics under the AIC, SC F statistics, Adjusted R square and Durbin Watson D statistics. However compared with other models, the ARIMA (1, 1, 2) model gives the lowest criterion statistics and good R

square and F statistics. The residual plot of ARIMA (1, 1, 2) model is illustrate that residuals are normally distributed.

Graph 2, Residual Plot for ARIMA (1, 1, 2) Model



The estimated model of ARIMA (1, 1, 2) is given in table 3. Therefore ARIMA (1,1,2) is selected as a best model to forecast inflation in Sri Lanka.

Table – 3 Estimated Model

Variables	Coefficient	't' – Statistics	Probability
Constant	0.028274	5.329875	0.0000
AR(1)	0.984083	131.8210	0.0000
MA(1)	-1.151901	-19.52556	0.0000
MA(2)	0.161487	2.500974-	0.0131

8. Conclusion:

Accurate forecasting is useful for effective policy planning. Inflation is one of the important variables in economy. ARIMA method is one of the important time series methods used for forecasting purposes. Main purpose of this study is to select the best ARIMA model for forecast inflation in Sri Lanka. Various ARIMA model were utilized and the best model is selected by model selection statistics such as AIC, SC, Adjusted R square and F statistics. ARIMA (1, 1, 2) model is selected as a best model in this study.

References:

1. Bokil, M. & Schimmelpfenng, A. (2005), '*Three attempts at inflation forecasting in Pakistan*', International Monetary Fund, IMF Working Paper, WP/05/105.

2. Box, G. & Jenkins, G. (1976), *'Time series analysis: forecasting and control'*, San Francisco.

3. Central Bank of Sri Lanka, *Annual Report*, Various Issues.

4. Department of Census and Statistics, Statistical Bulletin, Various Issues.

5. Gupta, S. & Sexegaard, M. (2009), *'Measuring of Underlying Inflation in Sri Lanka'*, IMF Working Paper, WP/09/167.

6. Hagger. A.J. (1997), *'Inflation; Theory and Policy'*, the Macmillan Press Ltd., London.