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A TIME SERIES APPROACH TO FORECASTING INFLATION IN THE MALDIVES

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1. Introduction

The aim of this paper is to introduce an approach to forecast inflation one-year ahead in Maldives. The approach introduced in this paper heavily relies on the widely used Autoregressive-Moving-Average (ARMA) time series processes. As the ARMA time series processes express their conditional means as a function of both past observations and the past shock, the processes fails to factor in expected future innovations, such as changes in regulations or anticipated shocks in exogenous factors. To remedy this shortcoming, an expert opinion is used in addition to forecasts from the ARMA time series processes.

The final one-year ahead forecast is an average of the forecasts from the ARMA processes and the expert opinion, as a simple average outperforms a single forecast or more complicated and sophisticated combination models (Clemen, 1989) and are robust to estimation errors (Jose & Winkler, 2008).

Using the approach outlined in this paper, by the end of 2014, inflation[1] is forecasted to reach 3.22%. Inflation for the year 2014[2] is forecasted to be 2.77%.

1 Inflation is calculated as the percentage change of CPI over a one year period.

2 Inflation for a year is calculated as the percentage change of the average CPI for the year from the previous year.

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2. Nature of Inflation

Inflation is measured as the growth rate of Consumer Price Index (CPI). It provides a general measure of changes in prices of consumer goods and services purchased by the Maldivian households (Department of National Planning, 2012). Over the period, the basket of goods and services and their corresponding weights (importance) used in sampling the price changes have been revised a number of times, subject to changes in consumption behaviour of the Maldivians. The revision is based on Household Income and Expenditure Survey which is carried out by Department of National Planning at regular intervals.

Each survey reveals new information about the changes in the consumption behaviour or the data generating process.

To analyse CPI from a statistical perspective, the series is decomposed into four components: trend (T), cyclical (C), seasonal (S) and irregular (I) using the Census X12 methodology.[3]

The trend component represents long term direction of an economic variable. Cyclical component represents cyclical movements that are longer than one year and are not expected to have a regular pattern. As for the seasonal component, it represents the movements that occur within one year. Such movements are caused by seasonal factors and are expected to have a similar pattern in the following year. An irregular component represents movements that cannot be explained by trend, cyclical or seasonal factors. Irregular movements are difficult to predict in nature.

In decomposing the series it is assumed that CPI results from the multiplication of the four components, i.e. T, C, S and I. Thus, after decomposition, trend will be the only component in terms of CPI while the rest of the components will be indices representing an upward or downward movement from the trend due to the corresponding component.

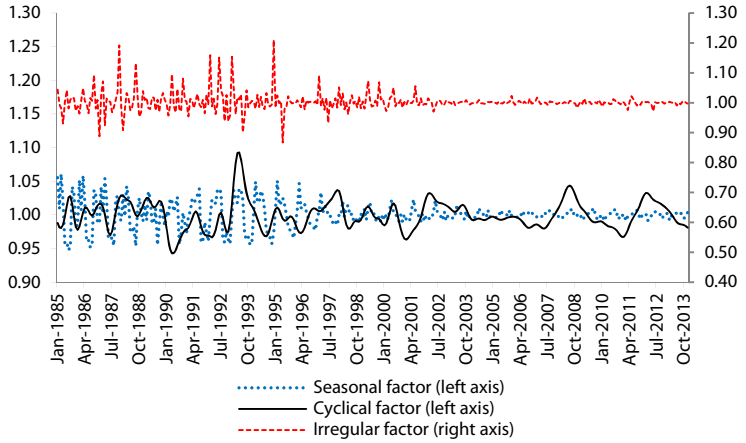
Such decomposition allows identifying the nature and the evolution of CPI along with the predictability of its movements.

The evolution of the components of CPI is shown in Figure 1. Prior to 2000, CPI was characterised by high seasonality and irregularity. However, post-millennium,

3 The CensusX12 method give a trend-cyclical component instead of two separate components for trend and cyclical. The trend component is extracted from the trend-cyclical component using Hodrick-Prescott filter.

Figure 1: Evolution of the Multiplicative Cyclical, Seasonal and Irregular Components of the CPI Inflation, 1985–2013

(June 2004 = 100, percentage change)



Source: Maldives Monetary Authority

the irregularity has been lessened. This is mainly associated with the changes in the consumption pattern of households. Substitutes for fish, such as chicken, have found to be increasing in demand. Thus, the proportion of income spent on fish has been declining. Since fish is the most volatile component in the calculation of CPI, the change in the consumption pattern has led to the reduced irregularity. Moreover, it can also be seen that the effect of seasonal variation has also been reduced post millennium and the cyclical component remained the leading factor.

In both periods, the predictability of CPI was dampened as the irregular or cyclical component overshadowed the seasonal component. However, cyclical component is more favourable in terms of predictability in the short run compared to the irregular component. This is due to the highly erratic movements in the latter when in comparison with the former.

Nonetheless, forecasting CPI with a narrow error margin in the long run using a time series model remains a challenge as cyclical factors are the main driving force.

3. Forecast Methodology

The medium term forecast produced by the Maldives Monetary Authority (MMA) is a combination of forecasts from three time series models and an expert opinion. A

simple combination of forecasts from multiple models is preferred over a single forecast as evidence has shown that a simple average outperforms a single forecast, or more complicated and sophisticated combination models (Clemen, 1989) and are robust to estimation errors (Jose & Winkler, 2008).

4. Time Series Models: A Retrospective Approach

For time series models, three ARMA processes are used. The three ARMA processes are selected from a possible 155 combinations of up to 12 autoregressive terms and 11 moving average terms.

As the decomposed CPI series indicates a structural break post-millennium. The said 155 models were estimated for the period Jan-2001 to March-2014.

To estimate the times series models, inflation is defined as:

$$\pi_t = \frac{CPI_t - CPI_{t-n}}{CPI_{t-n}}$$

where π_t is the inflation at time period t, CPI_t is the CPI index at time period t and $n = 12$ for monthly data.

After estimation, three models are selected based on (1) the Akaike information criterion, (2) coefficient of determination, (3) bias proportion, variance proportion and covariance proportion of within sample forecasts (4) root-mean-squared error and (5) mean-absolute error.

The following ARMA(p, q)[4] processes are the top ranking models based on the criteria stated above:

ARMA (7, 11) $$\pi_t = \alpha_0 + \sum_{i=1}^{7} \delta_i \pi_{t-i} + \sum_{j=1}^{11} \gamma_j \varepsilon_{t-j} + \varepsilon_t \quad (1)$$

ARMA (5, 8) $$\pi_t = \alpha_0 + \sum_{i=1}^{5} \delta_i \pi_{t-i} + \sum_{j=1}^{8} \gamma_j \varepsilon_{t-j} + \varepsilon_t \quad (2)$$

4 In ARMA(p,q) 'p' refers to the number of autoregressive terms and 'q' refers to the number of moving average terms.

ARMA (12, 9)
$$\pi_t = \alpha_0 + \sum_{i=1}^{12} \delta_i \pi_{t-i} + \sum_{j=1}^{9} \gamma_j \varepsilon_{t-j} + \varepsilon_t \quad (3)$$

where π_t is inflation at time t and ε_t is the error term.

To evaluate the forecasting performance of each model, root-mean squared error (RMSE) and mean-absolute error (MAE) is calculated for each model along with the RMSE and MAE for the average of forecasts from the three models. The results are summarised in Table 1. The average of the forecasts clearly outperforms the forecast from any single model as the RMSE and MAE for the average of the forecasts is lower than that of the individual models.

Table 1: Forecast Performance of ARMA Series Models
(performance of ARMA series models compared with the average of forecasts from the ARMA models for the period Jan-2001 to March-2014)

	RMSE	MAE
ARMA (7, 11)	0.015498	0.011706
ARMA (5, 8)	0.016660	0.012537
ARMA (12, 9)	0.016514	0.012498
Average	0.015376	0.011472

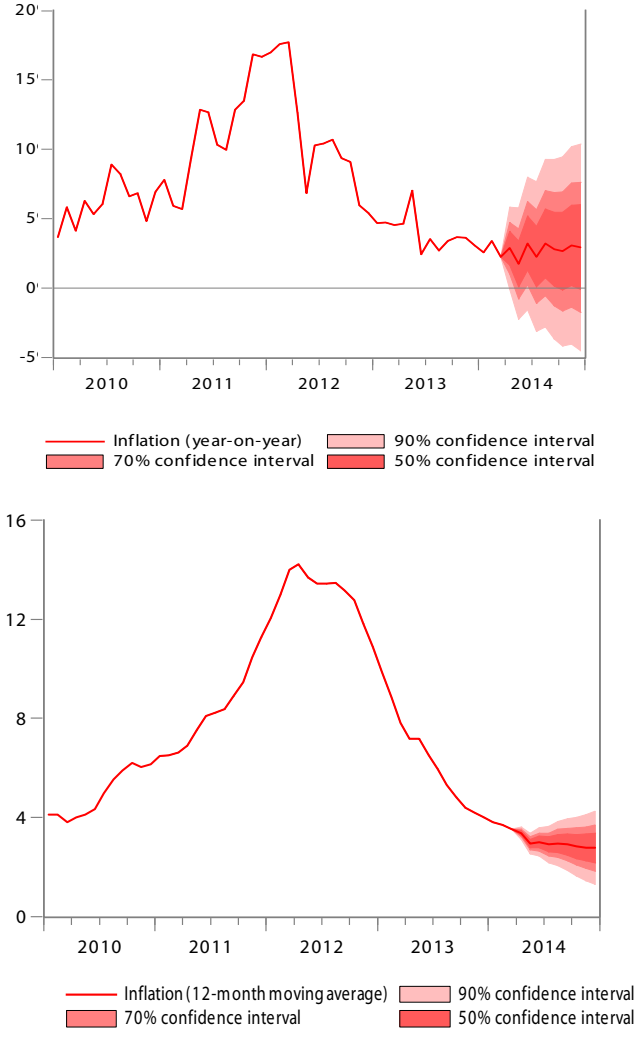
Even though the average of the forecasts has a better RMSE and MAE compared to the ARMA time series models, it has a wider error margin than all of the other forecasts as the average of uncertain random variables is expected to have a greater uncertainty.

The results are summarised in Table 2 for two calculations of inflation; inflation at the end of the year and inflation as a percentage change of average CPI from the previous year. Along with the forecasts, Table 2 also provides the standard deviations and their two-standard-deviation boundaries. Figure 2 depicts the expected path of inflation throughout the year as well as their one-standard-deviation and two-standard-deviation boundaries.

Table 2: Summary of Inflation Forecast for 2014
(percent)

	Mean (μ)	Standard deviation (σ)	$\mu \pm 2\sigma$
Inflation - 2014 (Using end period CPI)	2.96	4.53	(12.01, -6.09)
Inflation - 2014 (Using average CPI)	2.77	0.89	(4.56, 0.98)

Figure 2: Inflation Forecast for 2014
Year-on-year inflation forecast (top), moving average inflation forecast (bottom).



Source: Maldives Monetary Authority, National Bureau of Statistics

5. Expert Opinion: Factoring in the Prospective

As the ARMA time series models are purely based on historical data, they neither take into account the effect of expected changes in the global and domestic economic condition nor the policy changes.

Hence, to compensate for the shortcomings of the times series models, an expert's opinion is used. The expert opinion is based on their observation of the behaviour of the inflation in the past, along with their experience of how inflation interacts with other economic variables such as the global commodity prices or policy changes.

In contrast to the forecasts from the time series models, the expert opinion is a point forecast, and therefore it is not possible to calculate a standard error for the estimate. Any forecast combined with a point forecast will also become a point forecast.

Further, the International Monetary Fund (IMF) commodity price index shows that overall global prices will drop by 2.4% in 2014 on account of projected declines for petroleum, metal and food prices (International Monetary Fund, 2014). Despite the downward pattern in inflation based on the IMF commodity price index and the food prices of the key trading partners, there are some factors that may push the inflation up. This includes the reinstatement of import duties and the newly introduced goods and services tax on telecommunication in the Maldives. Thus, inflation is expected to be moderate to 4% towards the end of 2014.

6. Conclusion

There are many ways to forecast the future rate of inflation, ranging from sophisticated statistical models involving hundreds of variables to hunches based on past experience. Any forecast may not be precisely equivalent to the actual inflation. There could be factors that affect the rate of inflation in a country which might be difficult to predict. Thus, quality of a forecasting technique is not judged based on whether the forecast (also known as a point forecast) is exactly on par with the actual, but whether the actual falls within a provided prediction range. The prediction range is an error band around the point forecast. The error band is generally chosen to be two standard deviations.

Using statistical methods for forecasting such as ARMA models, the standard error of a forecast can be easily obtained. This enables the provision of a prediction interval

within which the actual forecast can be expected to fall, with a higher chance of falling closer to the mean (the point forecast). Thus, for the average forecast computed using the forecasts from the three ARMA models, the prediction interval has been provided in Table 2, and Figure 3 depicts the forecasted path of inflation through 2014 with three prediction intervals. The inflation forecast for the end of 2014 is expected to be at 2.96% with a prediction interval of 12.01 to -6.09.

However, the final forecast which stands at 3.22% is an average of the three forecasts from the ARMA models plus an expert opinion. Hence it is impossible to provide such a range as this forecast is a point forecast without a prediction interval, as a standard error cannot be calculated for the expert opinion.

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