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Time Series Model Using Autoregressive Integrated Moving Average (ARIMA) Method For Inflation In Indonesia

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Abstract

Inflation are related to changes in the price of an item that have the potential to change the market in the short term and create a certain monetary policy. Inflation data tends to fluctuate from time to time, so it is interesting to make useful predictions to provide information on future inflation rates. The consumer price index indicator, which is the best benchmark for inflation, is the main inflation indicator. This research focuses on time series modeling using the autoregressive integrated and moving average (ARIMA) method. Fluctuating data results in the desired model determination and forecasting is carried out so that it is likely to occur in the future. The results showed that inflation predictions for the period January 2010 to December 2022 were obtained using the ARIMA model (0,1,1)(1,0,2)[12] with an error value of MAPE 6.61%, RMSE of 0.42. From the prediction results, it is obtained that the average in the first quarter is 5.44% in the coming year and gradually decreases with a range of 3% - 4%. Based on the predictions of the model, it is obtained that the average in the first quarter is 5.44% in the coming year and gradually decreases with a range of 3% - 4%. Taking into account the agreement between the government and Bank Indonesia to consistently maintain inflation within the target range of 3.0% ± 1% in 2023, for 2023 the government needs to take strategic steps so that inflation can be controlled as expected, especially towards the first quarter of 2023, so that efforts to promote sustainable economic growth.

Keywords: ARIMA model and Inflation

Abstrak

Inflasi berhubungan perubahan harga pada suatu barang yang sangat berpotensi dalam mengubah pasar dalam jangka pendek, dan menciptakan suatu kebijakan moneter tertentu. Data inflasi cenderung bersifat fluktuatif dari waktu ke waktu sehingga menarik untuk dilakukan prediksi yang bermanfaat untuk memberikan informasi laju inflasi di masa mendatang. Indikator consumer price index yang merupakan patokan terbaik inflasi sebagai indikator inflasi utama. Penelitian ini berfokus pada pemodelan *time series* dengan metode *autoregressive integrated* and *moving average* (ARIMA). Data yang fluktuatif maka diperoleh ketetapan model yang diinginkan dan dilakukan forecasting sehingga kemungkinan terjadi di masa mendatang. Hasil penelitian diperoleh bahwa prediksi inflasi selama periode Januari 2010 sampai Desember 2022 diperoleh dengan menggunakan autoarima model (0,1,1)(1,0,2)[12] dengan nilai error MAPE 6.61 %, RMSE sebesar 0.42 dengan tingkat pengujian p-value $\alpha = 5\%$. Dari hasil prediksi diperoleh rata-rata pada triwulan pertama sebesar 5.44% pada tahun mendatang dan berangsur-angsur menurun dengan rentang 3% – 4%.

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Kata kunci: Model ARIMA dan Inflasi

INTRODUCTION

Inflation is an economic phenomenon that often occurs both globally and within a country. Inflation can be characterized by the presence of symptoms of increasing prices in general and taking place continuously which will have an impact on various fields, both economic, social and political (Setiartiti & Hapsari, 2019). Inflation globally has increased tremendously in 1974 with annual national consumer prices of 17%. Over time, the global economy has shown an extraordinary decline in inflation from the 1970s, having experienced a decline in inflation to 1.7 percent in 2015 which represents the lowest level (Ha et al., 2019).

The phenomenon of ups and downs of inflation often occurs in both developing and developed countries. The symptoms of the highest inflation ever experienced by Indonesia were caused by the monetary crisis which had a negative impact on the economy. As a result, the salaries of Civil Servants, labor salaries, and other private employees experience a decrease in real value, even though the nominal value has not changed (Tarmidi, 2003).

Inflation fluctuations will always occur in every country. Inflation that is too high can cause an overheating economy which can lead to a recession. If a mild recession actually has a positive effect in the sense that it can encourage a better economy and vice versa (Simanungkalit, 2020).

Since the last ten years, the average inflation in Indonesia has been around 4.30%. In 2010 the average inflation rate was 5.1% and will gradually decrease in 2022 with an average inflation rate of 4.2%. However, if you pay attention to it at the beginning of 2022, inflation has increased to 5.51%. This figure is far above the inflation rate in 2021, which is 1.87%. This surge in inflation could be influenced by the increase in fuel prices in September 2022 (Arif Widianto, 2023). The inflation rate in Indonesia is expected to be in the range of 2% to 4%, because this range is in accordance with the stipulations of the government and the DPR in the 2023 State Budget Law, namely the inflation rate of 3.6% (Yohana Artha Uly, 2022).

Inflation can occur by considering various indicators that can influence inflation fluctuations. By looking at previous data, inflation predictions can be made using various methods. The use of prediction methods has been widely published. One of the prediction methods that can be approached is by using the ARIMA model. This method is used for time series data which can describe data patterns that have been sorted by time. After that,

a prediction model is built based on existing data patterns. Searching for the best predictive model can be done by looking at the resulting error rate, where if the error value obtained is smaller, it is the best model (Meyler et al., 1998).

The ability of a model to predict is one of the analytical techniques that can assist policy makers in determining the basis for strategic decision makers that can provide predictions about economic stability caused by inflation. An estimate in modeling will be much more meaningful by analyzing scientifically than intuitively (Wang et al., 2019).

This is supported by previous studies on time series using the ARIMA model which is applied to the problem of inflation being able to follow actual data movements and make predictions (Mohamed et al., 2018), (Djawoto, 2017).

Referring to the information above, because of the importance of inflation in determining economic policy making through monetary policy in order to maintain economic stability, this research is focused on forecasting the rate of inflation in Indonesia using the autoregressive integrated and moving average (ARIMA) method. The ARIMA method can be applied to predict through past time series data to the present.

LITERATURE REVIEW

Forecasting is part of mathematical modeling to predict the possibility that will occur in the future as an effort to find out the movement of inflation both private institutions, government and policy makers, so they can make more informed decisions. Because of this, forecasting methods require historical data and then manipulate the data mathematically to look for closeness of values so as to provide a more effective picture of patterns and be able to make predictions in the future.

To do forecasting, one of the methods that can be used is the Autoregressive Integrated Moving Average (ARIMA) method. This method is often called the Box-Jenkins method. ARIMA is a combination of autoregressive (AR) and moving average (MA) models and with the addition of a differencing process if there is no stationarity of the data (Qasim et al., 2021).

The ARIMA method, often referred to as the Box-Jenkins method, is a very powerful model building approach for analyzing time series. ARIMA was intensively developed by George Box and Gwilym Jenkins in 1970. This method is a combination of smoothing methods, regression methods and decomposition methods. This method is widely used for forecasting prices, stocks, sales, and other time series variables. This time series model is usually used when little is known about the dependent variables that can be

used to explain the independent variables of interest (Kondo Lembang, 2017).

ARIMA uses past and present data from the dependent variable to produce accurate short-term forecasts. The use of the ARIMA model is applied to univariate time series data which effectively provides relevant information related to time series data. ARIMA completely ignores independent variables in making forecast.

The ARIMA model consists of two aspects, namely autoregressive and moving average. In general, the ARIMA model can be written with the notation (p, d, q) where p represents the order of the autoregressive (AR) process, d represents the differencing (I), and q represents the order of the moving average (MA). The AR model with degrees p and MA degrees q goes through a process (p, d, q) with the assumption that non-stationary data is taken with a certain lag difference or differencing is done until the data becomes stationary. The ARIMA model (p, d, q) can be expressed based on the following mathematical.

$$\Phi_p(B)(1-B)^d Y_t = \Theta_0 + \Theta_q(B)a_t \quad (1)$$

where the stationary AR operator can be expressed in term (2)

$$\Phi_p(B) = 1 - \Phi_1(B) - \Phi_2(B)^2 - \cdots - \Phi_p(B)^p \quad (2)$$

and the invertible MA operator can be expressed in term(3) as follows:

$$\Theta_q(B) = 1 - \Theta_1(B) - \Theta_2(B)^2 - \cdots - \Theta_q(B)^q \quad (3)$$

Part of the seasonal model by shifting the seasonal model by multiplying the non-seasonal model (4):

$$\left(1-\Phi_p B\right)\left(1-\theta_p B^{12}\right)(1-B)(1-B^{12})Y_t = (1+\phi_q B)(1+\Theta_q B^{12})a_t \quad (4)$$

where Y_t is the observed value at t, Φ_p is the autoregressive parameter (AR), B is the reverse shift operator, d is the differentiating parameter, Θ_0 is the constant parameter, Θ_q is the moving average parameter (MA) and a_t is the error term to indicat the residual value.

the ARIMA model (p, d, q) is also called the ARMA (Autoregressive and Moving Average) model, where d = 0. If p = 0 without making a difference is called the MA model, and q = 0 without making a difference is called the AR model. The model chosen should be the model that is the simplest in terms of both AR and MA processes.

An autoregressive model with moving averages (ARIMA) is a type of linear model that can be used for stationary or non-stationary time series. The ARIMA model is similar to the ARMA model, except that the data must be differentiated first, thus giving the difference between ARMA and ARIMA. For forecasting on both ARMA and ARIMA

models where forecasting accuracy is very good in the short term. Whereas for long-term forecasting the accuracy of forecasting tends to be flat so that it cannot give good results.

METHOD

This study uses secondary data in the form of monthly time series data from the inflation rate for the past 12 years ending in December 2022 which was collected at Bank Indonesia. In order to be able to process data with the ARIMA model, the steps that will be presented in the figure 1 flowchart are carried out.

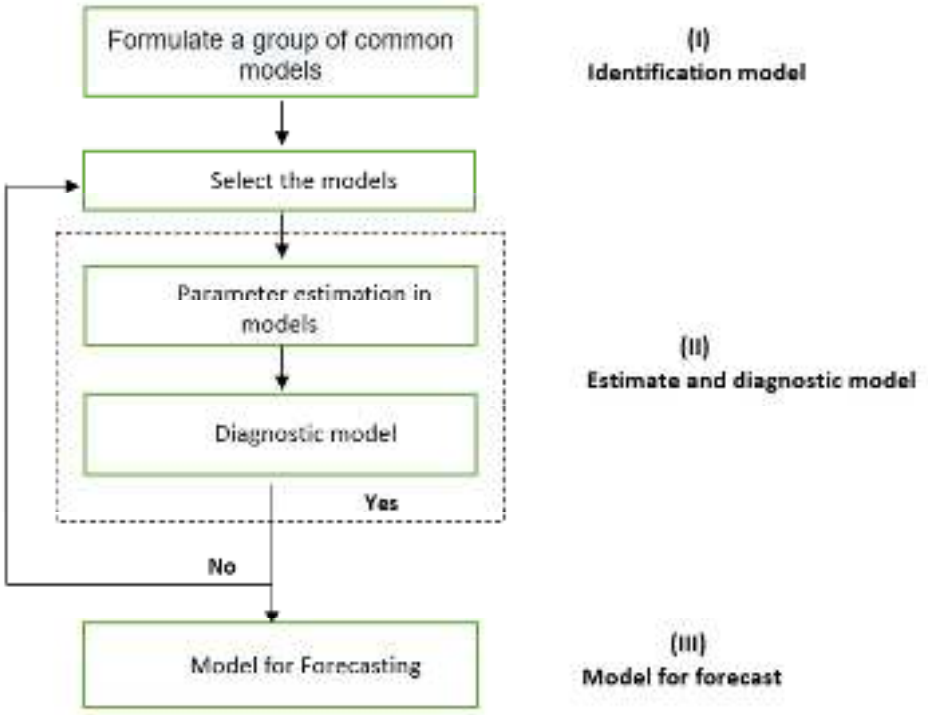

Figure 1. Box-Jenkins ARIMA Method Flowchart

A time series model will be better if the error value is smaller and in accordance with reality. In order to obtain a good analysis, it is necessary to pay attention to the steps of the ARIMA method, including: (1) Checking the stationary data; (2) Identify the model by knowing the ACF (Autocorrelation function) and PACF (Partial autocorrelation function) so that a model can be determined that can be used for predictions; (3) Model determination (p, d, q); (4) Determination of the model equation from the coefficients resulting from the analysis of model parameters with the smallest error; (5) Validate predictions and make predictions.

RESULT AND DISCUSSION

The data used in this study is secondary data in the form of monthly inflation data in Indonesia from 2010 to 2022 obtained from Bank Indonesia. The data size n = 156 is formed by the ARIMA model. The procedure for establishing the ARIMA model uses the Box-Jenkins procedure. The inflation data exploration used can be described in figure 2 below showing the plot of inflation data in Indonesia.

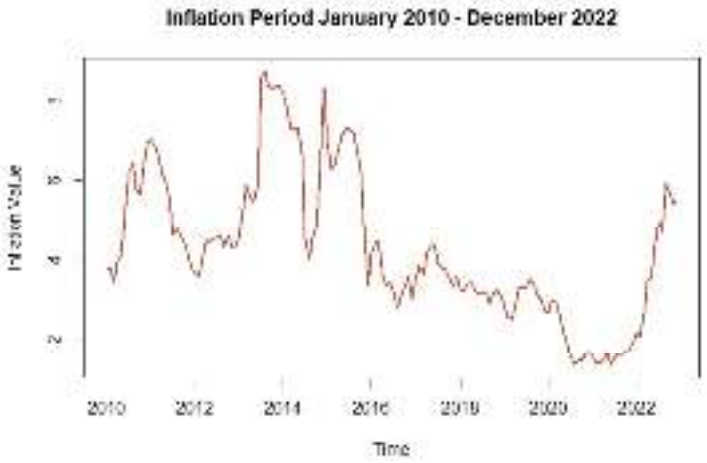

Figure 2. Inflation January 2010 to December 2022 in Indonesia

Based on figure 2, it can be explained from the graph that the data is not stationary either in mean or in variance. An increase in variance occurs annually and is evident from 2021 to 2022. Some seasonal trends occur during certain periods. From 2017 to 2021 there will be a downward trend, so the data patterns that occur indicate that the inflation data needs to be stationary in terms of both mean and variance, because it is still changing times.

In addition to the description of the data based on figure 2, it can also be done by knowing the characteristics of the autocorrelation function (ACF) and partial autocorrelation function (PACF).

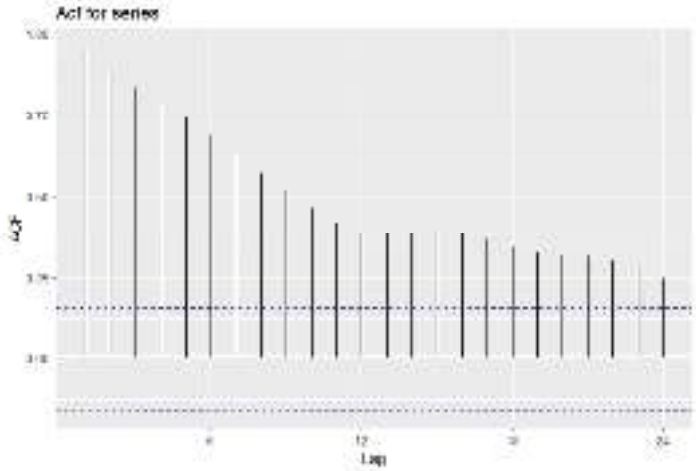

Figure 3. Autocorrelation function (ACF) series data

Figures 3 show that the autocorrelation coefficients differ significantly from zero and decrease slowly, whereas all partial autocorrelation coefficients approach zero after the first lag. The two figures show that the data is not stationary, especially not stationary in the average, whereas in the ARIMA method data is required to be stationary. Therefore, it is necessary to make differencing.

After differencing, the time series has been stationary through the first differencing order (figure 4). From these data it can be observed that the data is stationary. The differencing process that has been carried out d = 1 indicates the first order differencing.

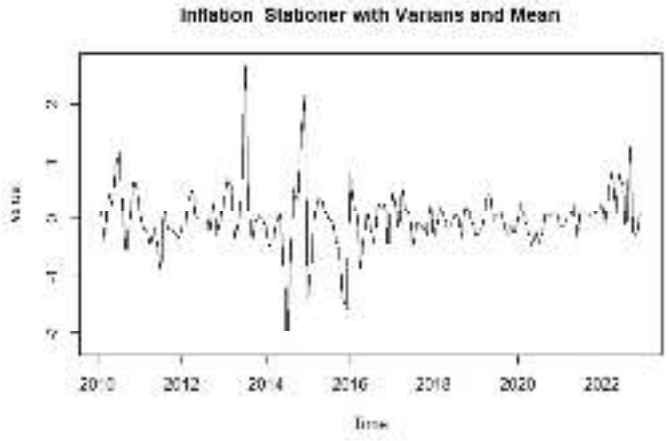

Figure 4. Inflation data Plot first order differenced

After the data is stationary, the ACF plot also gives characteristics that the data is stationary. Similarly, PACF is close to being stationary. The ACF plot as well as PACF can be shown in bellow figure.

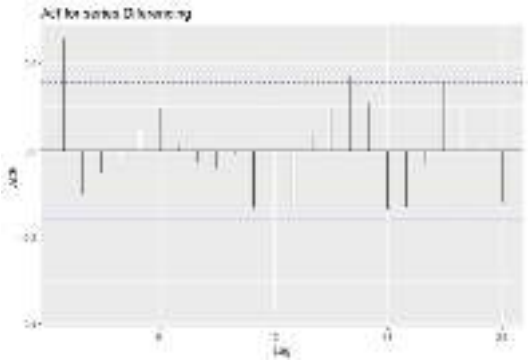

Figure 5. Plot ACF

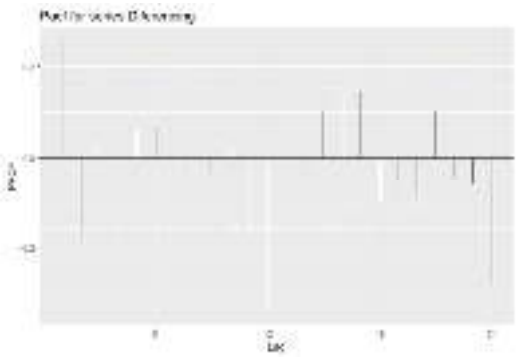

Figure 6. Plot PACF

Figures 4 and 5 show that the ACF and PACF coefficients decrease rapidly or exponentially. If ACF and PACF decrease rapidly or exponentially, this indicates that the ARIMA model (p, d, q) can be used. In addition to being stationary, the time series that has been differentiated has a seasonal pattern at lag 12. Therefore the ARIMA model (p, d, q)(P, D, Q)M taking into account seasonal patterns is an interesting approach in modeling Indonesian inflation in monthly data. 2010 to 2022 to predict the inflation rate.

ARIMA parameter values are more detailed by determining the parameters p, d and q and adding P, D, and Q as a seasonal factor. The use of an automatic ARIMA model will provide the best best model with a small error value so that the model is suitable for prediction.

Another approach in determining the model can be identified by statistically diagnosing the model using Ljung-Box based on bellow figure .

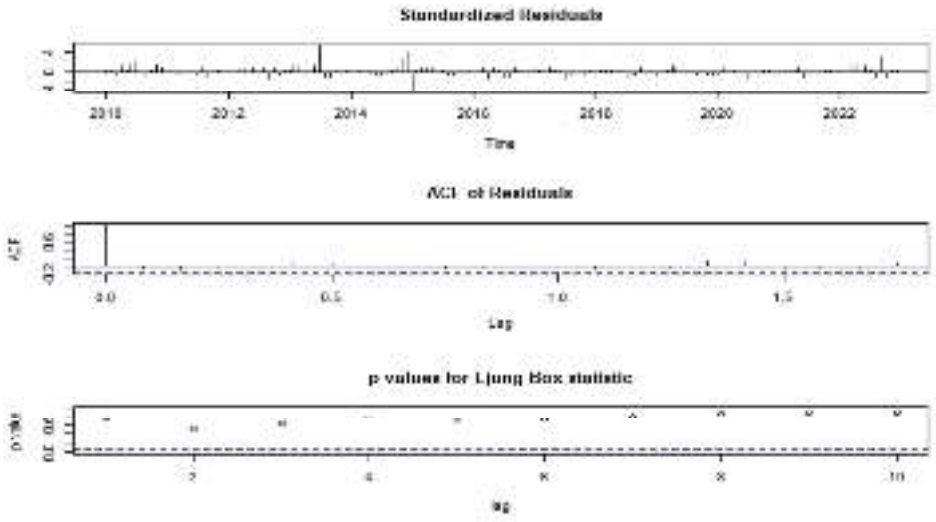

Figure 7. Ljung-Box satistics

Based on the plot in Figure 5 above, the residual data for the ACF plot is a white

noise model, meaning that there is no lag outside the interval line. Whereas p-value = 0.8063 is more than α = 0.05 for the Ljung-Box statistic there is no autocorrelation in the data so that it is fulfilled.

If the normality test is carried out with the Jarque Bera Test that the residuals are normally distributed because the p-value = 0.094 is more than α, where α = 0.05, then by choosing the ARIMA(0,1,1)(1,0,2) model[12] . The selection of the seasonal model will be carried out by forecasting related to inflation in Indonesia. Taking a close look at the figure 8., Fit model shows the actual chart with the seasonal model is very close. Therefore, the ARIMA model that will be used is the seasonal ARIMA model (seasonal autoregressive integrated moving average).

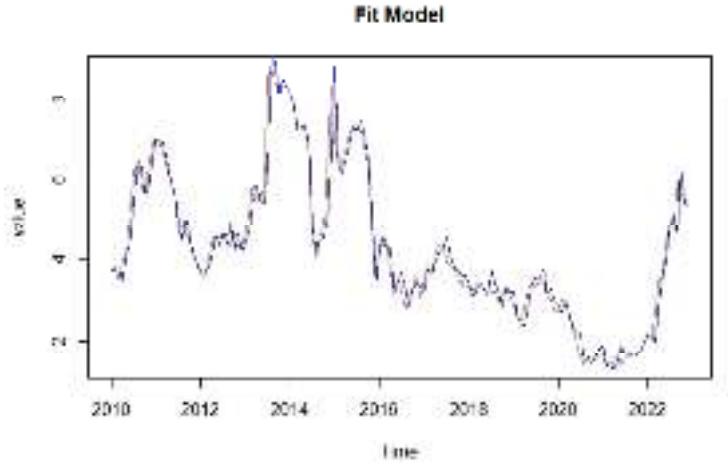

Figure 8. Fit Model

Therefore, the ARIMA model that will be used is the seasonal ARIMA model (seasonal autoregressive integrated moving average). Predictions model that will occur in the next year by Figure 9.

Based on the fit of the model above, the modeling determination is needed in making predictions. ARIMA modeling (0,1,1)(1,0,2)[12] which is interpreted graphically and quantity with forecasting results. From the calculation results, it can be seen that the prediction results for Indonesia's inflation rate from January to December 2023 are as shown in table 1.1 below.

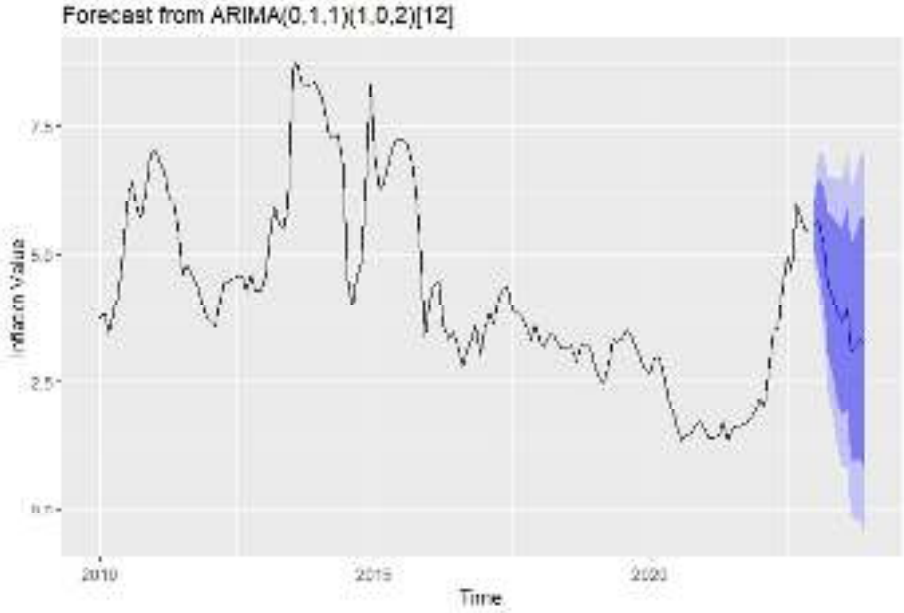

Figure 9. Forecasting

The model determination is needed in making predictions. ARIMA modeling (0,1,1)(1,0,2)[12] which is interpreted graphically and quantity with forecasting results. From the calculation results, it can be seen that the prediction results for Indonesia's inflation rate from January to December 2023 are as shown in table 1.1.

Table 1. Inflation rate prediction value during 2023

Time	Point Forecast
January 2023	5.554908
February 2023	5.628766
March 2023	5.157802
April 2023	4.423089
May 2023	4.157506
June 2023	3.891984
July 2023	3.651694
August 2023	3.891811
September 2023	3.07058
October 2023	3.192239
November 2023	3.319443
December 2023	3.243226

ARIMA prediction results using the model (0,1,1)(1,0,2)[12] show an AICC value of 194.6 with an accuracy level of MAE and MAPE values of 0.26 and 6.61% respectively, RMSE of 0.42 and MASE of 0.16 . Testing the residual model if the p-value is more than $\alpha = 0.05$ or a 95% confidence level, it means that the value passes the t-test with a p-value = 0.69.

From table 1.1 it can be seen that inflation in the first quarter of 2023 is high with an average of 5.44%, the second quarter is 4.15% and the last quarter is 3.25%. The desire to balance the inflation rate in Indonesia in 2023 will be controlled by the government with a range of 2% to 4% according to the 2023 State Budget Law during the 2023 period.

Previous research said that forecasting results using the ARIMA method were able to follow the movement of actual data from the inflation rate (Hartati, 2017). In other studies, it has been concluded that the longer the frequency of a forecast, the less accurate and constant the forecast will be, as seen from the upper and lower that are getting further away (Nawawi, 2017). In other studies, also modeled using e-view software. Both e-view software and R software can be used for ARIMA forecasting. However, it is known that the R software has a higher level of accuracy in terms of stationary tests (Yusnitasari, 2020).

The inflation prediction results in this model on an annual basis of 4.01% and the first quarter of 2023 of 5.44%, the prediction results exceed the threshold set for 2023, which is 2% - 4%. This is different from the inflation projection in research (Asmarani, 2023) where the inflation projection is 3.833%. The Indonesian economy in 2023 is projected to be able to grow in the range of 5.3 – 6.1 percent (Financial Notes and the RAPBN for Fiscal Year 2022). This projection is higher than the projected economic growth in 2022 of 5.0 – 5.5 percent. Taking into account the dynamics of the national economy going forward, the government must project inflation within the national inflation projection range set by the government of 3% ± 1% or 2.0 – 4.0 percent in 2023.

CONCLUSIONS

The prediction results using the ARIMA time series model (0,1,1)(1,0,2)[12] using actual monthly data from January 2010 to December 2022 with a small category error value of 6.61% indicate that the inflation rate tends to be high in early 2023 and will decrease in the middle to the end of 2023. It is hoped that the government will be able to control inflation in early 2023 so that it can emphasize lower prices going forward. Inflation predictions throughout 2023 obtained an average of 5.44% in the first quarter of 2023, this affects Bank Indonesia's target of around 2% - 4% on an annual basis. Inflationary pressure at the beginning of 2023 could be influenced by government policy through an increase in the price of fuel oil in September 20222. High inflation will disrupt the people's economy, especially the price of daily basic needs to be expensive. However, inflation that is too low does not attract entrepreneurs to do business because it does not promise maximum profits. Therefore, inflation that is considered good is 3.0% for 2022

and 2023. This has been determined by the government through the minister of finance, and Bank Indonesia is mandated by law to control inflation.

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