PROJECTION OF THE INFLATION RATE IN PANGKALPINANG CITY USING THE AUTOREGRESSIVE MOVING AVERAGE (ARMA)

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ABSTRACT

Inflation is one of the variables in the macro economy that can affect people's welfare and is defined as a complex phenomenon due to general and continuous price increases. This study aims to project the inflation rate in Pangkalpinang City, Bangka Belitung Islands Province in the period of October, November, and December of 2022. The historical inflation data used in this study is presented in a monthly period from January 2004 ends in October 2022 and January 2023 obtained from the publication of the Central Statistics Agency (BPS) of the Bangka Belitung Islands Province. The process projection is done using the Autoregressive Integrated Moving Average (ARIMA) model after passing the model fitting process first. The projection results obtained using historical inflation data show that the ARIMA model that is suitable for the projection process is the ARMA model (4,4) with the best RMSE value of 1.21 and MAE of 0.89. Through the results of this projection, it is also obtained that the percentage value of the inflation rate in Pangkalpinang City has decreased by 0.03% in the period of October 2022 and has increased in the period of November by 0.05%, then the inflation rate in Pangkalpinang City will again decline in the period of December 2022. by 0.3% and an increase of 0.33% in January 2023.

1. INTRODUCTION

One of the concerns in a country, both developed and developing countries and even attention in a region, is the amount of inflation that occurs. This is because inflation is a serious problem due to the inhibition of the growth rate of a country or region. Inflation is one of the variables in the macro economy that can affect people's welfare and is defined as a complex phenomenon due to general and continuous price increases [1]. This is what can have an impact on other economic indicators. The occurrence of an inflation can be identified by a price spike which will affect other goods within a certain period [2]. The previous Covid-19 pandemic had also had its own impact on the Indonesian economy, especially in meeting daily needs [1]. Several studies have shown that the COVID-19 pandemic has had a positive impact on inflation in Indonesia [3]. This also correlates with the issue of a recession which is predicted to occur in Indonesia in the year 2023.

A recession is a condition in which real economic growth grows negatively or in other words there is a decline in the Gross Domestic Product (GDP) for two consecutive quarters in one year [4]. In an economic recession, countries will usually take the form of fiscal and monetary policies to carry out economic recovery or prevent a deeper recession from occurring [5]. The city government of Pangkalpinang, Bangka Belitung Islands Province must also be swift in determining the type of policy to be taken in response to this. The local community's dependence on tin products must also be conditioned in preparing for the issue of this recession considering that tin is a non-renewable natural resource. When compared to the national inflation rate and the city of Palembang as the closest city to the Bangka Belitung Islands Province, then during the 2012-2016 period, the inflation rate of Pangkalpinang City was always [6]. This phenomenon should become the concern of regional leaders in conducting macroeconomic studies for the sake of regional progress. In Indonesia there are many provinces that experience very high inflation, one of which is the Bangka Belitung Islands. Nearly 90% of Bangka Belitung's food needs are met by Java Island and South Sumatra Island. Bangka Belitung's inability to control the price of imported food ingredients has driven high inflation in Bangka Belitung [7].

In 2015-2019, in several countries such as Italy, France, Germany and Europe the optimal percentage rate of inflation is at intervals of 0.8% to 1.8% [8].This research also gives the result that the percentage rate of inflation in the steady state for these three countries is at the level of 1.1%-1.7% in order to achieve prosperity in these three countries. In Indonesia itself, especially in Pangkalpinang city as the capital of the province of Bangka Belitung islands, the inflation rate for the September 2022 period was at a level of 1.04%. This figure will certainly be the basis for determining studies related to macroeconomic indicators which are very important in the world of business and economics. For economists and entrepreneurs this is a major concern because it is closely related to currency values. By observing various indicators that influence the increase in inflation, one of them is by looking at historical data with various prediction methods. Various methods of predicting Indonesian inflation have been published. However, the search for a more accurate inflation prediction method is still an interesting topic. With the time series data prediction method, we can study data patterns that have been sorted by time [9].

Of course, it is not only by looking at the value of the inflation rate to see the condition of economic growth in a region. This can also be seen through the value of the Gross Regional Domestic Product (GRDP) generated to determine the level of economic growth and the level of prosperity of the people in the region [10]. This economic growth will certainly affect the infrastructure in the region. In the Bangka Belitung Islands Province in particular, the readiness of this infrastructure is the main point in developing tourism destinations for the progress of the area [11]. This is also considering that the Bangka Belitung Islands Province as a tourist destination must have adequate infrastructure. Reflecting on Hong Kong, the decline in Gross Domestic Product (GDP) for two consecutive quarters is a technical category of recession [12].For Indonesia, the political dynamics and economic recession in Hong Kong and its potential impact on the global crisis must be properly anticipated so as not to disrupt national resilience.

Given the importance of knowing the projected value of the inflation rate, this study will look at how the projected value of the inflation rate is, especially in Pangkalpinang City, using the Autoregressive Integrated Moving Average (ARIMA) model. This model is one of the popular models in predicting time series data [13]. Those included in this time series model include Autoregressive, Moving Average, Autoregressive Moving Average and Autoregressive Integrated Moving Average [13]. The ARIMA model is often referred to as the Box-Jenkins model because it was first popularized by Box and Jenkins [14].

2. RESEARCH METHODS

Time series analysis is a statistical analysis that uses time series data patterns, with the assumption that the time series are correlated or dependent on each other, such as daily sales data, rainfall, pandemic diseases and others. Time series data has discrete time measurements because the observations use time intervals [15].The main characteristic of time series modeling is the dependence or dependency of observations at time t on previous observations [16].

This study uses time series data in the form of the inflation rate in Pangkalpinang City, Bangka Belitung Islands Province starting from January 2004 and ending in September 2022 obtained from the publication of the Central Statistics Agency (BPS) of the Bangka Belitung Islands Province. The model used to see predictions of the inflation rate is the ARIMA model to see the predicted value of the inflation rate from October 2022 to January 2023.

ARMA Model

This prediction model is usually used to predict short-term time series data because this model has poor accuracy for long-term predictions. The ARIMA model is defined as follows:

1. Autoregressive Model (AR)

The general form of the model The general form of the autoregressive model with order p ($AR(p)$) or ARIMA model $(p, 0,0)$ is stated as follows:

$$Y_t = \alpha_0 + \theta_1 Y_{t-1} + \cdots + \theta_p Y_{t-p} + e_t \tag{1}$$

Information:

Y_t = the observe value at the time t
α_0 = constant
θ_p = parameter autoregresive to p
e_t = error value at t

2. Moving Average (MA)

The general form of the q order moving average model ($MA(q)$) or ARIMA $(0,0,q)$ is expressed as follows:

$$Y_t = \theta_0 + \theta_1 e_{t-1} + \cdots + \theta_q e_{t-q} \tag{2}$$

Information:
θ_0 = constant
θ_q = parameter moving average to q
e_{t-q} = error value at $t - q$

3. Autoregressive Moving Average Process (ARMA)

The general model for a mixture of pure AR(1) and pure MA(1) processes, say ARIMA(1,0,1) is expressed as follows:

$$Y_t = \alpha_0 + \theta_1 e_{t-1} + \cdots + \theta_q e_{t-q} + \alpha_1 Y_{t-1} + \cdots + \alpha_p Y_{t-p} \tag{3}$$

4. Autoregressive Integrated Moving Average Process (ARIMA)

If non-stationary is added to the ARMA process mix, then the general ARIMA model (p, d, q) is met. The equation for the simple case of ARIMA $(p, 1, q)$ is as follows:

$$Y_t = (1 - \alpha_1)_{t-1} + \cdots + (1 + \alpha_p)y_{p-1} + e_t + \theta_1 e_{t-1} + \cdots + \theta_q e_{t-q} \tag{4}$$

Before carrying out the process of projecting the inflation rate using the ARIMA model above, the first step that must be taken is to test the unit root using the Augmented Dicky Fuller (ADF) test. If the data used is not stationary at the level, then a differencing process must be carried out so that the data is stationary. Selection of the best ARIMA model is chosen through a model fitting process with the smallest RMSE value and the largest R-Squared value among other ARIMA models. There are even several studies that suggest the use of R-Squared as a standard measure in evaluating scientific analysis [17]. As the final stage in this analysis

process is to look at the projected results of the inflation rate produced for the period from October 2022 to January 2023.

3. RESULTS AND DISCUSSION

This research gives the result that the inflation rate that occurred in the city of Pangkalpinang, Bangka Belitung Islands Province tends to fluctuate in the last few months, especially in October, November and December 2022. The time series data plot for this inflation rate can be seen in **Figure 1** below:
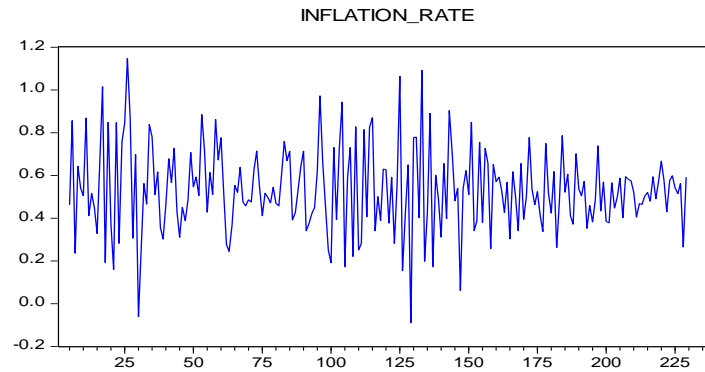

Figure 1. Inflation rate plot in Pangkalpinang city

Figure 1 above is a plot of time series data used as historical data in this study. It can be seen that the data is stationary in level so there is no need to do the differencing data stage. Next, a model fitting process will be carried out to select the best ARMA model from several alternative model choices. It can be concluded that the model that is suitable in this study is the ARMA model because it does not go through the differencing (integrated) process as described earlier. This stage gives results like **Table 1** below:

Table 1. Fitting Model of ARMA

No	ARMA Model	R-Squared	AIC
1.	ARMA (4,4)	0.040	3.26
2.	ARMA (4,5)	0.004	3.31
3.	ARMA (4,6)	0.010	3.30
4	ARMA (4,7)	0.010	3.29

It can be seen in **Table 1** that the ARMA model (4,4) is the best ARMA model because this model has the largest R-Squared value and the smallest Akaike Info Criterion (AIC) value among the other models. The results of the ARMA model (4,4) are as follows:

```
Dependent Variable: INFLATION_RATE
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 10/19/22   Time: 12:10
Sample: 2004M01 2019M09
Included observations: 189
Convergence achieved after 17 iterations
Coefficient covariance computed using outer product of gradients
```

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.533643	0.112445	4.745792	0.0000
AR(4)	-0.609978	0.198251	-3.076795	0.0024
MA(4)	0.777308	0.168550	4.611731	0.0000
SIGMASQ	1.469420	0.119291	12.31792	0.0000

R-squared	0.040575	Mean dependent var	0.536455	
Adjusted R-squared	0.025017	S.D. dependent var	1.240851	
S.E. of regression	1.225231	Akaike info criterion	3.267332	
Sum squared resid	277.7203	Schwarz criterion	3.335940	
Log likelihood	-304.7629	Hannan-Quinn criter.	3.295127	
F-statistic	2.607971	Durbin-Watson stat	2.037878	
Prob(F-statistic)	0.053024			

Inverted AR Roots	.62+.62i	.62+.62i	-.62-.62i	-.62-.62i

Figure 2. **ARMA Model Analysis Results (4,4)**

Based on the results of the model analysis in **Figure 2**, it can be seen that the resulting p-value is significant because it is smaller than the alpha value (α=0.05). The next stage of analysis is to make projections for the historical time series data used. The projection method used is the dynamic forecast and static forecast methods. These two methods must choose the best model by comparing the smallest Root Mean Square Error (RMSE) and Mean Absolute Error (MAE) values between the two models. The plot of the projected data from the two methods can be seen in **Figure 2** and **Figure 3** below:
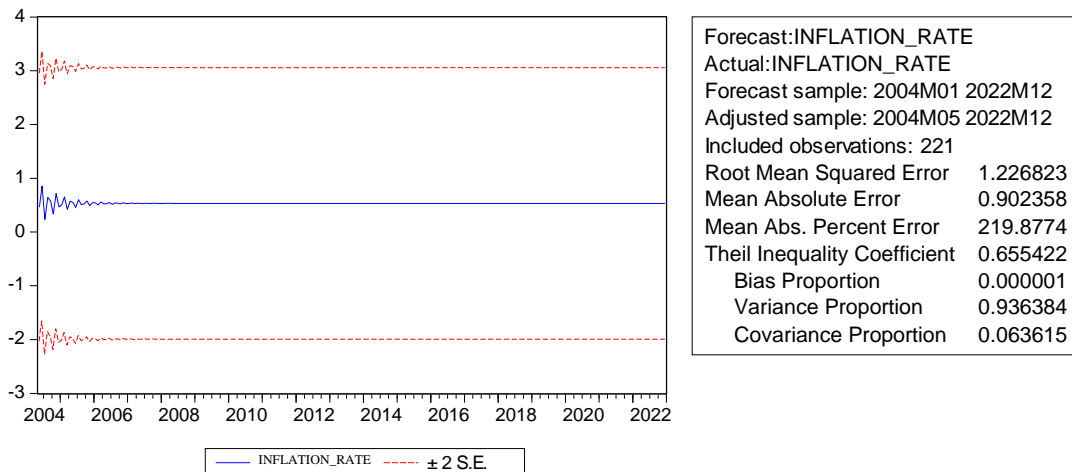

Figure 3. Plot of projection result of dynamic forecast method

The RMSE and MAE values generated through the dynamic method are 1.22 and 0.90. This value will be compared with the RMSE and MAE values generated from the static method. **Figure 4** below is the result of a projection plot using the static forecast method:
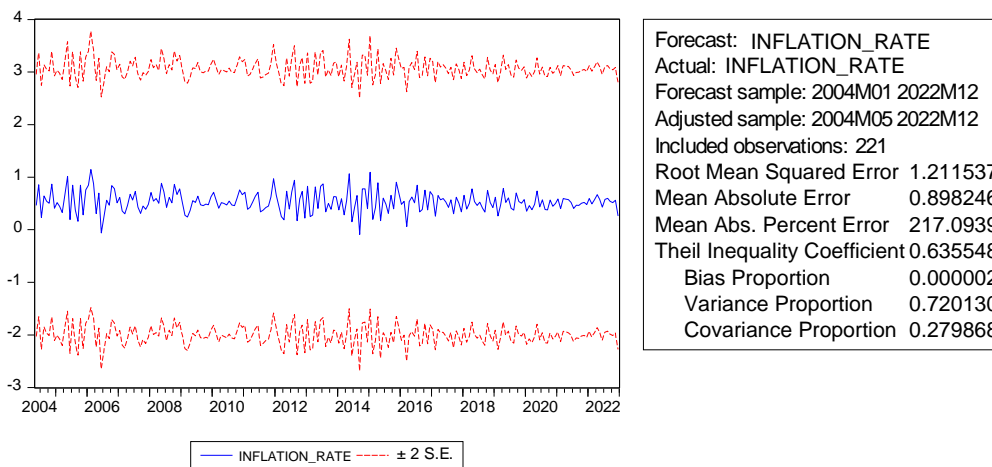

Figure 4. Plot of projection result of static forecast method

Based on the RMSE and MAE values generated from the two methods it can be concluded that the projection method with static forecast is the best method with RMSE and MAE values of 1.21 and 0.89 respectively which are smaller when compared to the dynamic model. After it has been determined that the static method is the best method for projecting inflation rate data in the city of Pangkalpinang, Bangka Belitung Islands Province, the next step is to look at the inflation rate resulting from the projection or forecasting process as shown in **Table 2** below:

Table 2. **Projection of Pangkalpinang City Inflation Rate**

No	Period	Projection
1.	Oktober 2022	0.514839
2.	November 2022	0.562582
3.	Desember 2022	0.264983
4.	Januari 2023	0.591604

The inflation rate data produced in **Table 2** tends to fluctuate from month to month. It is this projected data that can be used by stakeholders in formulating types of economic policies to anticipate or prevent worsening economic conditions, especially in Pangkalpinang City, Bangka Belitung Islands Province.

Based on **Equation (3)** and the results obtained in **Figure 2**, the model that is suitable for describing inflation rate data in Pangkalpinang City, Bangka Belitung Islands Province is the ARMA model (4,4) and can be written into the following mathematical equation:

$$Y_t = \alpha_0 + \theta_1 e_{t-1} + \cdots + \theta_q e_{t-q} + \alpha_1 Y_{t-1} + \cdots + \alpha_p Y_{t-p}$$

$$Y_t = -0.6\,(0.53) - 0.6\,y_{t-4} + 0.77\,e_{t-4}$$

$$Y_t = -0.318 - 0.6\,y_{t-4} + 0.77\,e_{t-4} \tag{4}$$

After the parameter significance test is fulfilled by selecting the ARMA model (4,4) as the best model, the next step is to determine whether the model contains white noise or not through the residual ACF and PACF test results as shown in **Figure 5** below:
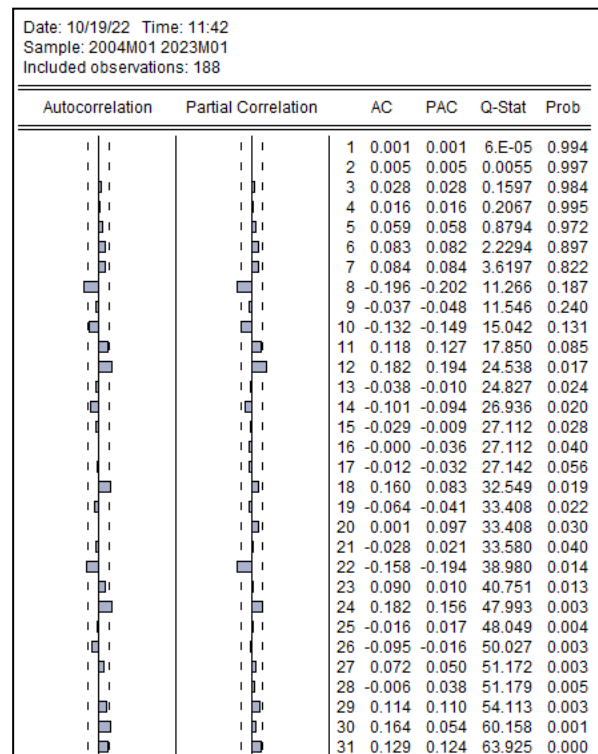

Figure 5. Correlogram test of ACF and PACF

Based on **Figure 5** it can be concluded that there is no white noise or it can be said that the model is appropriate based on the absence of significant lag, meaning that there is no correlation between the residuals, the residuals are homogeneous. The ARMA model (4,4) also gives the result that the inflation rate in Pangkalpinang City which is presented with this monthly time period gives the projected results of the inflation rate which tends to fluctuate. In general, the government wants an inflation rate that is not too high and not too low, but tends to be stable [8]. High inflation will of course result in a decrease in people's real income, the price of goods increases and the value of the currency decreases.

On the other hand, low inflation will result in decreased production, consumption and investment, which of course will have an impact on economic growth. The inflation rate figures in Pangkalpinang City produced in this monthly period certainly have a correlation with the Covid 19 pandemic that hit Indonesia. Research on projected inflation rates before and after Covid 19 can also be carried out to find out the differences regarding the types of government policies regarding social restriction policies, lock down, Work From Home (WFH) which cause public consumption to decrease, production values also decrease.

4. CONCLUSIONS

The projection analysis which is carried out on a monthly basis starting from October 2021 and ending in January 2023 has fluctuating projection results using the ARMA model (4,4). The selection of the ARMA model (4,4) is the best model with the selection criteria through smaller R-Squared and AIC values compared to other ARMA models. Through the data stationarity test, the time series data used is already stationary in level so there is no need to differentiate. This can be seen from the statistical test value given at 0.00 which is smaller than the alpha value of 0.05.

Through the results of this projection, it is also obtained that the percentage value of the inflation rate in Pangkalpinang City has decreased by 0.03% in the October 2022 period and has increased in the November period by 0.05% then the inflation rate in Pangkalpinang city will again decrease in the December 2022 period by 0.3% and an increase of 0.33% in January 2023. Furthermore, it needs serious handling for stakeholders in facing quite high volatility in inflation rates so that people's purchasing power can be maintained.

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