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Forecasting the Inflation Rate in Central Java Using ARIMA Model

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Abstract

One of the important aspects of the economy is the maintenance of prices in general. Indonesia's economy is still mostly focused on Java Island, one of which is Central Java. This study aims to analyze the projection of inflation rate in Central Java in the future by using the Box Jenkins method or what is called the Auto-Regressive Integrated Moving Average (ARIMA). The data used is monthly time series inflation data in the period January 2016 - April 2021 which is obtained from the Central Java Province Statistics Agency. The analysis conducted in this study, it shows that the best model is ARMA (3,0,3) or AR (3) and MA (3). The results show that inflation will tend to increase in the next few months. In the future, it is estimated that Bank Indonesia will continue to implement an expansionary monetary policy to stimulate the economy and achieve the inflation target, which is currently still low.

Keywords: ***Inflation, Forecasting, Box-Jenkins, Economic, Central Java***

Abstrak

Salah satu aspek penting dalam perekonomian adalah terjaganya harga-harga secara umum. Perekonomian Indonesia masih banyak bertumpu di Jawa Tengah. Penelitian ini bertujuan untuk menganalisis proyeksi laju inflasi di Jawa Tengah ke depannya dengan menggunakan metode Auto Regressive Integrated Moving Average (ARIMA). Data yang digunakan adalah data inflasi runtut waktu (times series) bulanan dalam kurun waktu Januari 2016 – April 2021 yang diperoleh dari Badan Pusat Statistik Provinsi Jawa Tengah. Dari analisis yang dilakukan dalam penelitian ini menunjukkan bahwa model terbaik adalah ARMA (3,0,3) atau AR (3) dan MA (3) dengan stasioneritas pada tingkat level. Hasil penelitian menunjukkan bahwa inflasi akan cenderung meningkat dalam beberapa bulan ke depan. Ke depan, Bank Indonesia diperkirakan akan terus menerapkan kebijakan moneter ekspansif untuk mendorong perekonomian dan mencapai sasaran inflasi yang saat ini masih rendah.

Kata Kunci: Inflasi, Peramalan, Box-Jenkins, Ekonomi, Jawa Tengah

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INTRODUCTION

Indonesia, as an export destination country (small open economy), has the consequence that Indonesia must always try to balance the global and domestic financial markets so that the currency remains stable. The high cost of imported inputs potential will have an impact on the price of domestic goods which will also increase. This continuous increase in goods price is often referred to as inflation. Furthermore, Mishkin (2019:8) states that inflation is a tendency to increase prices in general and continuously in a certain time and place.

Reflecting on the monetary crisis in 1998, Indonesia had experienced heavy inflation, reaching 77.6 percent with the IDR exchange rate dropping to IDR 16,000 per 1 USD. This was motivated by the depreciation of the IDR against foreign currencies, especially the USD due to the domino effect due to the weakening of the baht (Thai currency) exchange rate. The economy became turbulent again in 2005 and 2008 at which time the inflation rate increased by more than 10%, one of which was triggered by the increase in world oil prices and volatile foods.

Furthermore, Atmadja (1999) suggests that inflation is not only a short-term phenomenon but also a long-term phenomenon, so it can be said that inflation has a broad influence on macroeconomic conditions. Therefore, a country must take appropriate policies to control inflation so that it remains stable. A controlled inflation rate will be able to increase the profits of entrepreneurs, encourage investment in the future which in turn will accelerate business creation and economic growth (Sutawijaya, 2012)

The island of Java is the largest contributor to Indonesia's GDP. As much as 59 percent of economic activity is centered on the island of Java, which makes it a magnet and the foundation of the Indonesian economy. One of the provinces in Java that has contributed to the Indonesian economy is Central Java. Inflation provides the fact that price stability is a barometer of the stability of economic growth. By controlling prices, it will also maintain people's purchasing power. However, prices in Indonesia tend to fluctuate, including in Central Java. The following is the inflation rate in the 2015-2020 period.

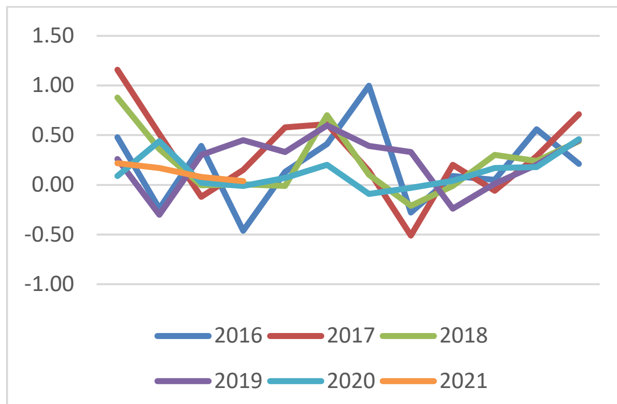


Figure 1. Graph of Central Java inflation rate 2016-2020

Source: Central Java Statistics Agency, 2020

For this reason, price stability as reflected by the inflation rate must be controlled. One of the efforts made is to project the inflation rate to take anticipatory steps towards future possibilities. Nopirin (2007:25) defines inflation as a process of increasing the general prices of goods continuously. Inflation can occur due to several factors. Mankiw (2007) stated that in general, inflation occurs due to 2 factors, 1) Demand-pull inflation, which is inflation that occurs due to high aggregate demand. 2) Cost-push inflation, which is shocks on the supply side that push production costs up. The measurement of the inflation rate is carried out using the Consumer Price Index (CPI). The CPI is used because it reflects the level of change in the prices of goods and services paid by consumers.

Economists have expressed various views on inflation. From a monetarist perspective, inflation occurs as a result of the growth in the money supply exceeding the demand for money. When the amount of money in circulation is very high, the amount spent will increase so that it encourages production to increase or increase prices. Assuming that the national output level is at full employment, the relationship between the money supply and prices is obtained (Arief, 1996).

Meanwhile, from a structuralist perspective, it is emphasized that inflation occurs due to the supply of economic sectors such as food and export goods which have an impact on the money supply. So that the money supply (JUB) is an impact, not a cause of inflation(Pennant-Rea R, 1990) Forecasting is an activity carried out to predict or estimate uncertainty in the future (Tersine, 1996; Wei, 2018). Then Rescher (1998, p. 11) states that knowledge resources can be predicted substantially, although there is a risk of error.

Forecasting is needed to predict future values to formulate policies that can minimize the occurrence of unwanted losses. This is as stated by Granger & Machina (2006) which explains that the estimation of the future value of a variable or the probability of an event aims to plan or take policy on the problem. Several studies have been conducted to predict the inflation rate using Box-Jenkins. In a study conducted by Lubowa et al., (2017) which predicts inflation in Uganda with ARIMA and Vector Autoregressive (VAR), where the predicted value is close to the actual value although with a fairly long lag (3,1,3) where lag is selected for AR and MA based on the smallest AIC.

Furthermore, Abdulrahman et al., (2018) also forecast the inflation rate in Sudan in 1970-2016, where this study uses annual inflation data. The ARIMA model used is (1,2,1) which shows that the ARIMA modeling is carried out by performing a second differentiation to obtain data stationarity. Another study was conducted by Mohamed (2020) who projected price levels in Somaliland using the Box Jenkins method through a differentiation process and the model selection is based on greatest log-likelihood and lower AIC, BIC AICc so that the ARIMA model (0, 1, 3) is the best.

In Indonesia, the use of the Box Jenkins or ARIMA model has also been carried out by various researchers. Djawoto (2017) predicts the inflation rate in December 2010 using monthly time series data of the 2005-2010 Consumer Price Index (CPI) using the ARIMA (1,1,0) model. Where the results of his research show the CPI is estimated to rise 7.2 percent. Djawoto added that forecasting using the ARIMA model has a fairly large percentage of accuracy.

On the other hand, Teapon (2015) predicts the inflation rate of Ternate using the ARIMA model, where the data used is inflation data from the food ingredients group which produces the best ARIMA model (6,0.6). Other research on inflation forecasting was also conducted by Suparti & Sa'adah (2015) Rahayu et al., (2018) and Al Rosyid et al., 2021). Suparti & Sa'adah (2015) forecast inflation in Indonesia where the results show that the ARIMA ([1,12],1,0) model with the addition of outlier is better than the ARIMA ([1,12],1,0) model without outliers.

While Rahayu et al., (2018) also forecast inflation in Demak were the results of the analysis using R and Minitab show that the best ARIMA model is ARIMA (2,0,0). It means that in forecasting the data is stationary at the level so there is no need for a differentiation process. While Al Rosyid et al., (2021) forecasted in Central Java with the price of shallots as an indicator. The data used for ARIMA analysis is consumer price data for shallots in Central Java Province from July 2017 to April 2021 with a total of 46 consumer price data.

Based on the results of the study, it can be concluded that the best ARIMA model used for forecasting consumer prices of shallots in Central Java Province is ARIMA (3,1,2). Inflation is always interesting to be studied by various researchers, one of which is by forecasting in the future. A country or region itself has various characteristics that differ from geographical, political, and social conditions that affect its economic condition so that inflation movements are always dynamic in each region.

Therefore, many studies give different results, as well as the selected model. Some studies use the differentiation process to get stationary data, some are already stationary at the level. The development of the times followed by changes in economic conditions allows for differences in research results. Covid-19 (Coronavirus Disease) is an RNA virus with a size of 120-160 nm (Meng et al., 2020). This virus belongs to the category of the genus Betacoronavirus.

The existence of a pandemic that has spread in various countries has caused various countries to carry out self-restrictions, including restrictions on international trade, including Indonesia. Indonesia's economic growth in the second quarter of 2020 has reached -5.32%. As is happening now, namely the emergence of the Covid-19 pandemic, which was an unexpected event that brought many changes to the economy, including in Central Java. Therefore, the authors are interested in analyzing inflation forecasting in Central Java using the ARIMA model.

RESEARCH METHODS

This research is a quantitative descriptive research using data in the form of nuwmbers which is then processed by using analytical tools assisted by E-views software. This study uses time series data (time series) of monthly Central Java inflation obtained from the Central Java Provincial Statistics Agency in the period January 2016 to April 2021. Inflation is calculated from changes in the Consumer Price Index (CPI). Inflation used in this study is on a monthly basis (month on month). Where in the calculation can be formulated as follows :

$$Inflation\ rate\ (\%) = \frac{IHK_n - IHK_{n-1}}{IHK_{n-1}} x\ 100 \quad ....(1)$$

Where:

IHKn = Consumer Price Index month n

IHKn-1 = Consumer Price Index month n-1

The data analysis technique used is the Auto Regressive Moving Average (ARMA). The ARIMA model was first introduced by George Box and Gwilym Jenkins which was eventually used as the model name. Whitten et al., (2007) explains that ARIMA represents three models, namely Autoregressive model (AR), Moving Average (MA), and Auto Regressive and Moving Average (ARMA). According to Gujarati & Porter

(2012) there are some stages conducted in using this model.

Identification, which is to determine the appropriate value to occupy p,d,q which is done by looking at the Correlogram Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) which are then used for model estimation. Before doing the correlogram test, first, test the stationary of the data through the unit root test.

The first test is carried out at the level level, where the t-statistical value must be statistically significant, if it is not significant at a certain level, it is continued with a test at the difference level. Next is to estimate the parameters of the autoregression and the moving average included in the model with diagnostic checks.

The autoregressive model assumes that the current period's data is influenced by the previous period's data. In general, the AR model is symbolized by (p) or when entered into ARIMA is ((p, 0, 0). AR can be formulated as follows :

$$Y - \partial = a\_1 \,(Y\_(t-1) - \partial) + a\_2 \,(Y\_(t-2) - \partial) + \ldots + a\_p \,(Y\_(p-1) - \partial) + \text{u}\_t \text{ ....(2)}$$

Where :

Y	=	Autoregressive level p or AR (p)
∂	=	Average of Y
T	=	time
Ut	=	Error term

After choosing a particular ARIMA model, it is necessary to test the feasibility of the model where the residual estimate is white nose so that it can accept a certain suitability, otherwise we have to repeat. That's why the Box Jenkins method is an iterative process, and after that value forecasting using the best selected model. The Box- Jenkins model consists of 3 models, namely autoregressive (AR), moving average (MA), and autoregressive moving average (ARMA).

Moving Average has the assumption that the value of the current period is influenced by prediction errors in the period t to t-q (Sartono, 2006) states in general, the MA model is symbolized by (q) or when entered into ARIMA is ((0,0,q). MA is a linear combination of white nose error terms. MA can be formulated as follows :

$$Y_t = \mu + \beta_0\mu_t + \beta_1\mu_{t-1} + \beta_2\mu_{t-2} + \cdots + \beta_q\mu_{t-q} \text{........(3)}$$

Where :

μ	:	constant
β	:	parameter moving average
μt-q	:	error value at time t-q

There is definitely a possibility that Y has AR and MA characteristics so that it becomes an Autoregressive Moving Average (ARMA). So the existing assumption states that the current period data is influenced by the previous period's data and also the residual value of the previous period (Assauri, 1984). The following is an ARMA process, with an example of ARMA (1,0,1)

$$(1 - \phi_1 B)\, X_t = \mu` + (1 - \theta_1)\, e_t \text{...................(4)}$$

Meanwhile, in ARIMA at the difference level, it is formulated as follows. For example ARIMA (1,1,1) Where B is a backshift operation and c is a constant. While θ is the autoregressive parameter, e is the error term, and is the coefficient of the moving average parameter. If the data is stationary at the level, then it is called ARMA (p,0,q) while if it is stationary at the difference level, it is called ARIMA (Autoregressive Integrated Moving Average), namely (p,1,q) or (p,2,q).

$$(1 - B)(1 - \phi 1\ B)Xt = \mu` + (1 - \theta 1B)\ et.......(5)$$

RESULTS AND DISCUSSION

ARIMA modeling uses inflation data that has been collected from January 2016 to April 2021, which is then processed with the E-views 9 software. Table 1 is the inflation rate data in Central Java in the range of 2016-2021.

Table 1. Inflation in Central Java 2016-2021 (%)

Month	2016	2017	2018	2019	2020	2021
January	0.48	1.16	0.88	0.26	0.09	0.22
February	-0.24	0.51	0.36	-0.3	0.44	0.17
March	0.39	-0.12	-0.0004	0.3	0.02	0.08
April	-0.46	0.15	0.0004	0.45	-0.01	0.04
May	0.13	0.58	-0.01	0.33	0.07	
June	0.41	0.61	0.7	0.6	0.2	
July	1	0.14	0.1	0.39	-0.09	
August	-0.28	-0.51	-0.21	0.33	-0.03	
September	0.09	0.2	-0.01	-0.24	0.04	
October	0.05	-0.06	0.3	0.01	0.17	
November	0.56	0.29	0.24	0.2	0.18	
December	0.21	0.71	0.44	0.45	0.46	

Source: Bank Indonesia (processed)

Table 1 shows that the highest inflation rate occurred in January 2017 but then decreased and even deflated in the following month. In 2017 Central Java experienced three times of deflation as well as in subsequent years. In general, most of the inflation occurred due to an increase in the index of several expenditure groups such as food, beverages, equipment, and recreation. Meanwhile, the education group is relatively stable.

From these data, the next step is to test the stationary of the data by using the unit root test. In using the ARIMA model stationary data is needed, which means that there is no increase or decrease in data where the average series of observations throughout the observation time is always constant. A series is said to be stationary if the value of the series does not have a trend and seasonal element or over time the mean and variance remain (Mulyono, 2000).

Table 2. Stationarity test

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.104333	0.0000
Test critical values:	1% level	-3.538362	
	5% level	-2.908420	
	10% level	-2.591799	

*MacKinnon (1996) one-sided p-values.

Source: Data processed by the author, 2021

The stationary test was carried out using the ADF test (Augmented Dickey-Fuller Test) method. From the results of the unit root test, it can be seen that the data is stationary at the level as seen from the ADF t-test value of 7.104333 which is greater than the critical values of 1 percent, 5 percent, and 10 percent. The probability value is significant, which is greater than 0.1 (α=10%) with a 90 percent confidence level. Once it is known that it is stationary, it has fulfilled the assumptions of the ARIMA model.

The result of this test is in line with research from Rahayu et al., (2018) which forecast inflation in Demak. The test result shows that the data is stationary at the level and does not need differentiation. Then the results of this study are not following research from

Wibowo (2018) that predict inflation in Palangka Raya uses first differentiation to station data.

The difference occurs due to several things including the different economic conditions of each region. Demak relies on the industrial sector, while Palangka Raya relies on the agricultural sector with different income. The next step is to determine the amount of lag (p, q) that is carried out by looking at the ACF (Auto Correlation Function) and PACF (Partial Auto Correlation Function) patterns from the correlogram test on table 3.

Table 3. Correlogram Test

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |*. |	. |*. |	1	0.097	0.097	0.6327	0.426
.*| . |	.*| . |	2	-0.116	-0.127	1.5486	0.461
**| . |	**| . |	3	-0.340	-0.324	9.5722	0.023
. | . |	. | . |	4	0.003	0.054	9.5727	0.048
.*| . |	.*| . |	5	-0.079	-0.174	10.015	0.075
. |** |	. |** |	6	0.278	0.230	15.635	0.016
. | . |	. | . |	7	0.053	-0.008	15.844	0.027
.*| . |	.*| . |	8	-0.095	-0.147	16.520	0.036
**| . |	.*| . |	9	-0.310	-0.145	23.912	0.004
. | . |	. | . |	10	-0.006	-0.014	23.915	0.008
. |*. |	. |*. |	11	0.158	0.138	25.897	0.007
. |** |	. |*. |	12	0.279	0.119	32.202	0.001
. | . |	.*| . |	13	-0.034	-0.084	32.299	0.002
.*| . |	. | . |	14	-0.131	-0.052	33.753	0.002
**| . |	.*| . |	15	-0.243	-0.083	38.832	0.001
. | . |	. | . |	16	-0.022	-0.008	38.873	0.001
. |*. |	. |*. |	17	0.181	0.132	41.803	0.001
. |** |	. |*. |	18	0.314	0.121	50.854	0.000
. | . |	. | . |	19	0.006	0.003	50.858	0.000
.*| . |	. | . |	20	-0.174	-0.028	53.761	0.000

Source: Data processed by the author, 2021

If the ACF and PACF patterns are known, what should be done then is determining the order for the AR and MA models. From the plot ACF and PACF, both experienced a cut-off, where PACF (AR) was not significant at lag 1,2 then significant at lag 3, and no longer significant at lag 4. While the ACF (MA) is also significant at lag 3 and then cut off at lag 4. The order selection is based on the maximum order value (Teapon, 2015). So several candidate models are suitable for this study, AR (3) MA (3), MA (9), MA (18). Furthermore, the model is estimated to obtain a tentative model.

From the table 4, it can be seen that the ARMA (3,0,3) model is the best model. In the ARMA regression output (3,0,3) both parameters of the estimation results show significant results, which means that the inflation rate is partially influenced by inflation in the previous 3 months, and is also influenced by prediction errors from the previous month.

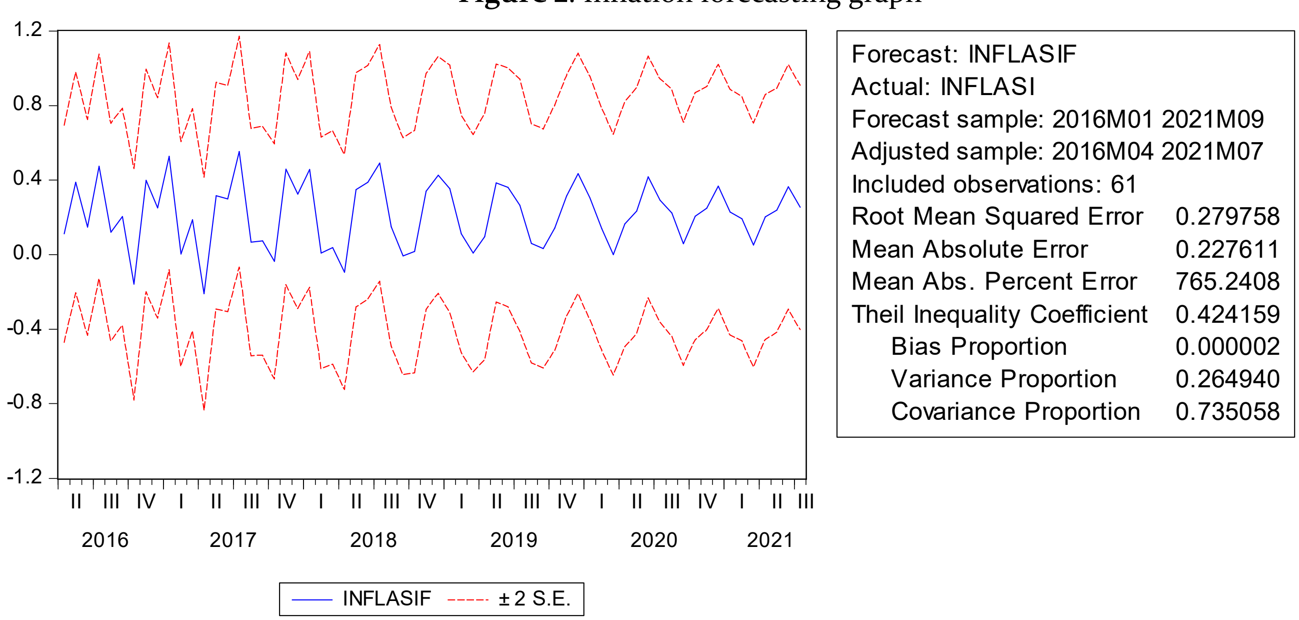
Table 4. Summary of parameter estimates for the ARMA model

Model	Parameter	Koefisien	Probabilitas	Uji t	R-Squared	AIC
AR (3) MA (3) MA(9) MA (18)	AR (3)	-0.842780	0.0000	Significant	0.392333	0.376115
	MA (3)	0.856055	0.0012	Significant		
	MA(9)	-0.274428	0.1787	Not significant		
	MA(18)	0.239881	0.3060	Not significant		
ARMA (3,0,3)	AR (3)	-0.957487	0.0000	Significant	0.255936	0.416338
	MA (3)	0.783630	0.0000	Significant		

Source: Data processed by the author, 2021

Meanwhile, based on F-statistics, it can be seen that together the specified model has an influence on the inflation rate. The next step is to ensure that the model used is free from autocorrelation by using Correlogram-Q statistics. If the probability value of q-statistics is greater than 0.1 (α=10%) or not significant, the model is free from autocorrelation. On the other hand, if there is a q-statistic probability value that is less than 0.1 or significant, the model is affected by autocorrelation symptoms. Appendix 1 is the result of the model autocorrelation test.

Figure 2. Inflation forecasting graph



Source: Output E-views

Appendix 1 shows that all q-statistic probability values are greater than 0.1 or not significant. So it can be concluded that the model is free from autocorrelation. With that, the model can be used for forecasting. The next step is forecasting. Figure 2 is a graph of inflation forecasting. Table 5 shows the forecasting values for the next 5 months. From these results, it can be seen that the inflation rate in Central Java for the next period, namely in May 2021 at 0.25 percent, in June at 0.35 percent, and July at 0.22 percent.

Table 5. Forecasting Results

Month	Actual Value	Forecasting Value
September 2020	0.04	0.06
Oktober 2020	0.17	0.21
November 2020	0.18	0.25
Desember 2020	0.46	0.37
Januari 2021	0.22	0.22
Februari 2021	0.17	0.18
Maret 2021	0.08	0.07
April 2021	0.04	0.21
Mei 2021		0.25
Juni 2021		0.35
Juli 2021		0.22
Agustus 2021		0.18
September 2021		0.08

Source: Data processed by the author, 2021

In April 2021 there was a fairly high difference between the forecast value and the actual value. April 2021 coincides with the month of Ramadan, which usually results in an increase in the prices of goods. However, given the pandemic conditions where people's purchasing power is still low, the prices in the market will not increase as usual. One of the factors that contributed to the decline in inflation in April was the easing of prices for the food, beverage and beverage expenditure group and the food and beverage/restaurant provider group.

One of the significant declines in the food and beverage group was the decline in prices for horticultural commodities such as cayenne pepper. The trend of rising inflation could be due to the opening of several sector so that the economy began to improve. This condition encourages an increase in purchasing power and demand which ultimately reises inflation.

An increase in inflation allows that the demand for goods or services from the public to increase which causes an increase in prices. Based on the results, policymakers should implement appropriate economic and monetary policies to keep inflation at bay as reflected in the forecast. The results of this study are expected to be used as a reference or basis in the development of further research.

In addition, it can also be a consideration and reference for the government as regulator and controller to formulate appropriate policies further. This research is also expected to provide new insights and knowledge about the economy, especially the Indonesian macroeconomy.

CONCLUSION

Based on the results of the analysis of this study it can be concluded that inflation data in Central Java has been stationary at the level. So, that the model used is Autoregressive Moving Average (ARMA). Wherefrom several selected tentative models, one fit model that is used for projection is ARMA (3,0,3). Forecasting ARMA (3,0,3) shows that there will be an increase in inflation in March at 0,06 percent.

This study has limitations where the data used is general monthly inflation in general. For further research other indicators can be used to predict the inflation rate. For example, using Consumer Price Index (CPI) or inflation data for certain commodity groups that are more specific. Besides, researchers can also try other software and model to analyze forecasting, so that the results obtained can be compared.

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APPENDIX

Appendix 1. Autocorrelation Test

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. | . |	. | . |	1	0.068	0.068	0.3078	
.*| . |	.*| . |	2	-0.091	-0.096	0.8700	
. | . |	. | . |	3	0.036	0.050	0.9619	0.327
. |*. |	. | . |	4	0.086	0.072	1.4883	0.475
**| . |	**| . |	5	-0.247	-0.256	5.8419	0.120
.*| . |	. | . |	6	-0.090	-0.038	6.4255	0.170
. | . |	. | . |	7	0.008	-0.032	6.4304	0.267
. | . |	. | . |	8	-0.006	-0.009	6.4333	0.376
. | . |	. | . |	9	-0.019	0.030	6.4614	0.487
. | . |	. | . |	10	0.052	-0.001	6.6746	0.572
. | . |	. | . |	11	0.070	0.041	7.0670	0.630
. | . |	. | . |	12	0.006	-0.006	7.0699	0.719
.*| . |	.*| . |	13	-0.129	-0.141	8.4473	0.673
. | . |	. | . |	14	-0.020	-0.005	8.4820	0.746
. | . |	. | . |	15	0.017	0.003	8.5069	0.809
. | . |	. |*. |	16	0.047	0.085	8.6978	0.850
. |*. |	. |*. |	17	0.090	0.132	9.4328	0.854
. |*. |	. |*. |	18	0.139	0.084	11.198	0.797
.*| . |	.*| . |	19	-0.083	-0.126	11.841	0.810
.*| . |	.*| . |	20	-0.084	-0.091	12.523	0.819
.*| . |	.*| . |	21	-0.099	-0.133	13.483	0.813
.*| . |	.*| . |	22	-0.164	-0.146	16.201	0.704
. |*. |	. |** |	23	0.114	0.275	17.545	0.678
. | . |	. | . |	24	-0.029	-0.058	17.636	0.727
. | . |	. | . |	25	-0.037	-0.000	17.785	0.769
. |*. |	. |*. |	26	0.134	0.092	19.786	0.709
. |*. |	. | . |	27	0.165	-0.053	22.890	0.584
. | . |	. | . |	28	-0.064	-0.024	23.364	0.612

Source: Output E-views