Modelling and Prediction of Rice Price in East Java using Approach to the Multiplicative Time Series Analysis

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Abstract: About 78% of Indonesia's population take a rice to meet daily carbohydrate intake. However, the fluctuating of the rice price is one of the problems that should be faced by Bulog in East Java. Therefore, this research aims to model and predict the rice price in East Java. We use the ARIMA Multiplicative Time Series analysis to model and predict the rice price. The basis of the Multiplicative time series analysis is that the factors affecting the pattern of the data set in the past and present tend to change little in the future. Thus, the time series analysis can assist the researchers to make some decisions. The appropriate model for the rice price data in East Java is ARIMA seasonal model. These are due to the harvest time. Based on the smallest MSE, the result shows that the appropriate model for the rice price data in East Java from January 2008 to December 2016 is ARIMA(0,1,1)(0,1,1)12 or IMAISMA. There are no significant differences between prediction price of rice in East Java for the period of January 2017 to August 2017 and sample data.

1 INTRODUCTION

About 78% of Indonesia's population take a rice to fulfill the carbohydrate intake (Prawira, 2013). Rice becomes a very important food requirement for the people of Indonesia and according to an article released by International Rice Research Institute (IRRI) in 2014 Indonesian’s rice consumption reaches 125 Kilogram (Kg) per capita per year. Therefore, the government established a logistics agency called BULOG (Logistic Business Entity) which plays an important role in regulating the supply of rice, rice stock, minimum stock, rice price, and others. East Java is one of the rice barns and serves as a national food buffer. East Java is able to supply more than 17 percent of the national rice and supply rice in 15 other provinces through Bulog's national distribution. Nationally, referring to Central Bureau of Statistics (BPS) data, observed the average price of rice in September 2014, grinding rate for medium quality has increased price by 6.18 percent. Thus, the average medium price of rice at the milling rate of 8,125.93 IDR increased by 1.45 percent. Central Bureau of Statistics (BPS) reported inflation in September 2014 was quite low at 0.27 percent. Nevertheless, rice commodities returned to be a contributing factor to inflation with a share of 0.02 percent. Previous research that discussed about rice forecasting has been done is to predict the price of rice in Perum BULOG East Java Division using ARIMA method and double exponential smoothing. Double Exponential Smoothing is used because the data has a trend pattern but not seasonal. The results show that interpretation of time series models is the best method is ARIMA (Hartinungrum, 2012). Therefore, in this study, we aim to make a model forecasting rice price of milling in East Java using time series analysis. The time series data is a set of data in the form of numbers obtained within a certain period of time. Time series data is usually in the form of annual, semiannual, quarterly, monthly, weekly, daily, and so on (Bisgaard & Kullahci, 2005; Wei, 2006). According to Santoso (2001) the basis of time series data analysis is that the factors that affect the pattern of the data set in the past and now tend not to change much in the future. Thus, it can be done time series data analysis to help researchers in making decisions (Hartinungrum, 2012). Generally, the time series can be grouped into two large chunks i.e. univariate and multivariate time series, both seasonal and non-seasonal (Santoso, 2001).

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2 METHODOLOGY

Based on the purpose of the research, there are two steps of analysis are as follows:

I. Modeling the rice price in East Java using Multiplicative Time series analysis approach can be done through the following steps:

Step1: Plot the data to see the stationary of mean and variance. For non-stationary data, the following process is performed: a) Box-Cox Transformation: to stability in variance b) Differencing: to stationary the data in the mean.

Step 2: Estimation of ARIMA model with the following steps: a) Plot ACF (Autocorrelation Function) to identify Moving Average model b) Plot PACF (Partial Autocorrelation Function) to identify the Autoregressive model.

Step 3: Diagnostic checking for phased models with the following steps: a) Test the significance of ARIMA model parameters with t-test b) White noise test with L-Jung Box test with hypothesis: H_o: $\rho_1=\rho_2=\ldots=\rho_k = 0$ vs H_1: there is at least one $\rho_i \neq 0$ where i=1,2..,k and c) The residual normality test with plot is normalized using Kolmogorov-Smirnov test with hypothesis: H_o: the residual is normally distributed vs H_1 : residual is not normally distributed. If not obtained the best model then repeat step 3 to get the best ARIMA model that has significant parameters, meet the assumption of white-noise and normality for residual.

II. Predicting and analyzing rice price in East Java using Multiplicative time series analysis approach can be done through the following step:

Step 1: Predict the price of grinding rice in East Java from January to August 2017 using the best ARIMA model.

Step 2: Creating plot data forecast and plot data out sample.

Step 3: Comparing plot of predicted data with plot of data out sample whether it has the same trend.

Step 4: Analyzing the results of the prediction.

3 RESULT AND DISCUSSIONS

3.1 Description of Rice Price Data in East Java from January 2008 to December 2016

Based on data obtained from Bulog East Java from January 2008 to December 2016, the average price of rice in East Java is as follows:

Table 1: Description of Average Rice Price in East Java from January 2008 – December 2016.

Variable	Total Count	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Maximum
Harga Beras	108	0	6458	135	1407	3975	5034	6861	8866

3.2 Modelling Price Rice in East Java from January 2008 to December 2016 using Multiplicative Time Series Analysis Approach

In the ARIMA process the first step that must be done is checking the data stationarity by looking at the time series plot, ACF plot, PACF plot, and Box-Cox Plot of the data used.

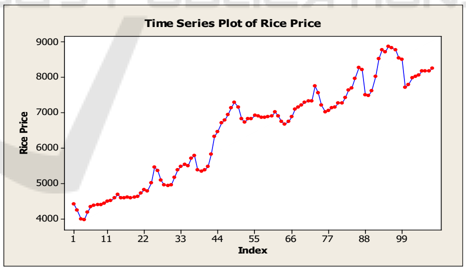

Figure 1: Time Series Plot of Rice Price Data in East Java, January 2008 – December 2016.

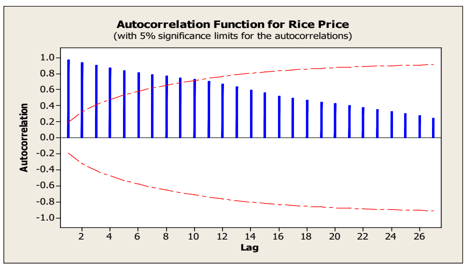

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Figure 2: ACF Plot of Rice Price Data in East Java, January 2008 – December 2016.

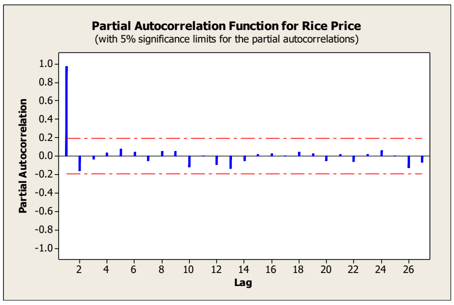

Figure 3 : PACF plot of rice price data in East Java, January 2008 – December 2016.

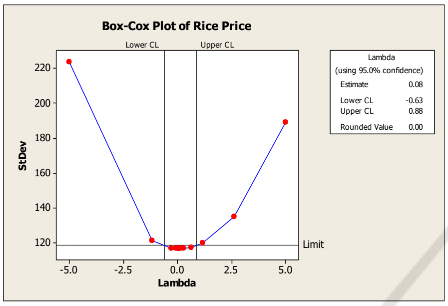

Figure 4 : Transformation Box-Cox of rice price data in East Java, January 2008 – December 2016.

It can be seen from Figure 1, the data has a rising trend and in Figure 4 shows that lambda (λ) = 0, so the data is not stationary in variance, it is necessary to do Box-Cox transformation so that the data is stationary in variance.

After that, check whether the data used statistically in the mean. Stationary in the mean can be seen by looking at the graph of ACF function. Here is a picture of an ACF chart pattern from the Box-Cox transformed rice price data.

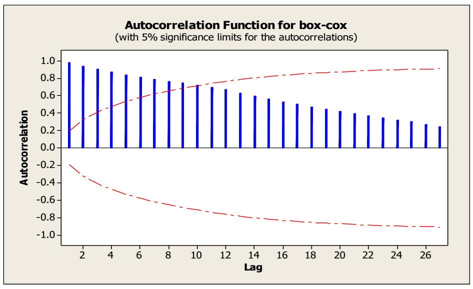

Figure 5: ACF plot of rice price data in East Java in January 2008 – December 2016 after Box-Cox Transformation.

From the Figure 5, it can be seen that the ACF value drops slowly towards 0 which means that the data is not stationary in the mean, it will be done differencing.

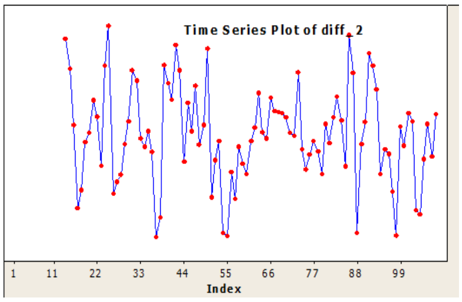

Figure 6: Time series plot of rice price data in East Java in January 2008 – December 2016 after Box-Cox transformation and differencing.

Based on Figure 6, it can be concluded that the data has no trend so that the data is stationary in the mean or variance and continued with ACF plot to see whether the data used is statistically in the mean. Here's an ACF plot for rice price data after Box-Cox transformation and differencing.

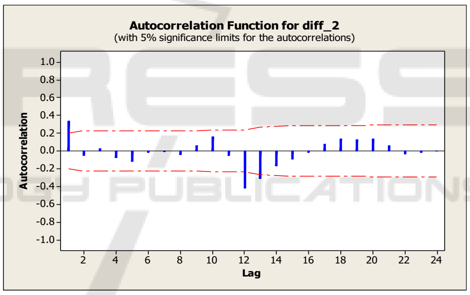

Figure 7: ACF plot of rice price data in East Java in January 2008 – December 2016 after Box-Cox transformation and differencing.

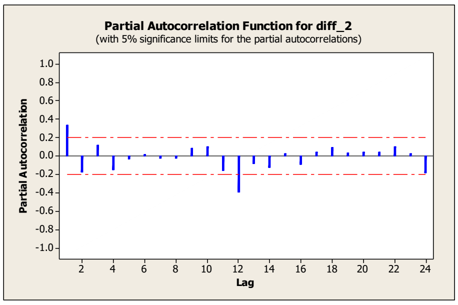

Figure 8: PACF plot of rice price data in East Java in January 2008 – December 2016 after Box-Cox transformation and differencing

It can be seen from Figure 7; the data is stationary in the mean and there is an indication of a seasonal pattern because the lag coming out of the line is 1 and 12. Next PACF plot is done to see the possible model for testing. Here's the PACF plot for the price data of rice after Box-Cox transformation and differencing.

Based on Figures 7 and 8, the possible models for testing are AR (1), SAR (1), MA (1), SMA (1) and SMA (2). The requirements for the best model of white noise, the parameters are marked by *p-value* < α, have the smallest MSE, and the residual is normally distributed. Table 2 is the summary results for each possible model.

Table 2: ARIMA parameter estimation of rice data.

Model	Par	Estimates	*p*-value	MSE
ARIMA $(1,1,1)\times(1,1,1)^{12}$	AR 1	-0.3436	0.212	0.0005282
	MA 1	0.007	0.961	
	SAR 1	-0.6237	0.007	
	SMA 1	0.8369	0.000	
ARIMA $(0,1,1)\times(1,1,1)^{12}$	MA 1	-0.3489	0.001	0.0005424
	SAR 1	0.0478	0.757	
	SMA 1	0.8310	0.000	
ARIMA $(1,1,0)\times(1,1,1)^{12}$	AR 1	0.2049	0.049	0.0005512
	SAR 1	0.0270	0.857	
	SMA 1	0.8269	0.000	
ARIMA $(1,1,1)\times(0,1,1)^{12}$	AR 1	-0.2826	0.265	0.0005489
	MA 1	-0.6063	0.004	
	SMA 1	0.7453	0.000	
ARIMA $(1,1,1)\times(1,1,0)^{12}$	AR 1	-0.2784	0.216	0.0006867
	MA 1	-0.6444	0.000	
	SAR 1	-0.4587	0.000	
ARIMA $(0,1,1)\times(0,1,1)^{12}$	MA 1	-0.3110	0.002	0.0005589
	SMA 1	0.7320	0.000	
ARIMA $(0,1,1)\times(1,1,0)^{12}$	MA 1	-0.4207	0.000	0.0006943
	SAR 1	-0.4448	0.000	
ARIMA $(1,1,0)\times(0,1,1)^{12}$	AR 1	0.2552	0.014	0.0005769
	SMA 1	0.7229	0.000	
ARIMA $(1,1,0)\times(1,1,0)^{12}$	AR 1	0.2725	0.008	0.0007225
	SAR 1	-0.4582	0.000	
ARIMA $(1,1,0)\times(1,1,2)^{12}$	AR 1	0.1989	0.058	0.0005410
	SAR 1	-0.5167	0.887	
	SMA 1	0.3717	0.918	
	SMA 2	0.4919	0.880	

Based on the smallest MSE, i.e. 0.0005589, the appropriate model for the rice price data at the milling level in East Java is ARIMA$(0,1,1)(0,1,1)^{12}$ or IMAISMA.

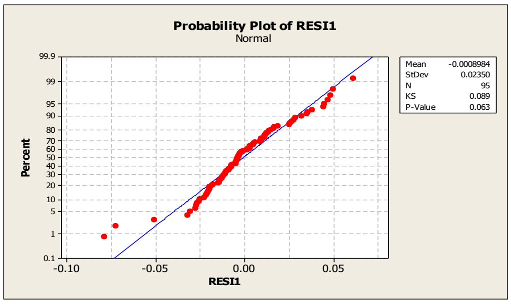

Figure 9: Normality test of the best model residual.

Based on Figure 9, the p-value for the normality test is 0.063, this value is greater than α = 0.05, which means that the model has met the normality assumption.

3.3 Predicting Rice Price of Milling Rate in East Java based on ARIMA$(0,1,1)(0,1,1)^{12}$ or IMAISMA model

Before to predicting the time series data, a validation test is performed to ensure that the forecast result of the data used is close to the actual value, by comparing the actual data of the grinding rice price in East Java in January to August 2017. More details can be is described in table 3.

Table 3: Model validation results for January to August 2017.

Period	ln(Z_t)	Z_t	Data *Out Sample*
109	9,04150	8446,44	8360
110	9,02861	8338,26	8157
111	9,00689	8159,11	7812
112	8,95477	7744,75	7850
113	8,96342	7812,03	7965
114	8,98259	7963,23	7960
115	9,00685	8158,78	8078
116	9,02734	8327,68	8150

Based on table 3 and Figure 10 it can be seen that the validity level of model forecasting trend is quite appropriate. The forecast of the rice price of milling in East Java for the period of January 2017 to August 2017 is close to data sample.

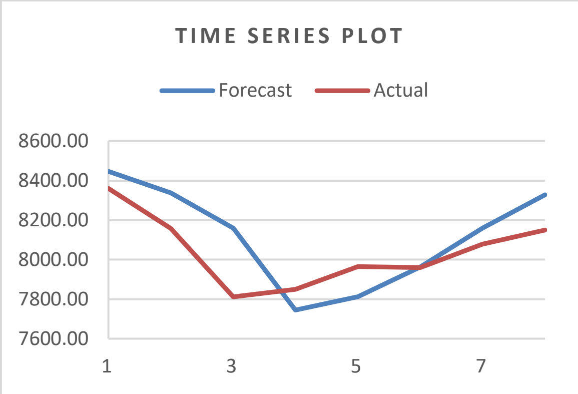

Figure 10: Plot Comparison of Forecasting Data with Data out sample.

4 CONCLUSIONS

Based on the results of the discussion, it can be concluded:

1) The average price of grinding rice in East Java from January 2008 to December 2016 is 6,458.00 IDR. The lowest rice price is 3.975.00 IDR, which occurred in April 2008, while the highest rice price reached 8,866.00 IDR which occurred in November 2015.
2) Based on the smallest MSE, the appropriate model for rice price data of grinding rate in East Java period January 2008 until December 2016 is ARIMA(0,1,1)$(0,1,1)^{12}$ or IMAISMA.

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