Study of X-13 ARIMA SEATS Modeling for Rice Price Index Data in Indonesia

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Abstract. Outlier on a data can cause several problems, including a model that is formed to produce a large residual, and the variance of data will increase. A robust method for outlier problems is needed in order to produce an unbiased model. X-13 ARIMA SEATS is one of robust method in time series. X-13 ARIMA SEATS is a seasonal adjustment method capable of detecting, resolving the presence of outliers, and overcoming seasonal and calendar effect. The X-13 ARIMA SEATS consists of two stages that is using regARIMA model, and using X-12 seasonal adjustment. In this paper, X-13 ARIMA SEATS method is compared with ARIMA method to prove its ability to overcome outliers based on the smallest error value. In this paper, the X-13 ARIMA SEATS method is applied to model and forecast the rice price index in Indonesia in January 2010- December 2018. The results showed that the X-13 ARIMA SEATS method produces a model with smaller MAPE and RMSE values than the ARIMA model.

1. Introduction
Rice price trends generally tend to fluctuate. Rice price fluctuations and uncertainty in the future demand the need for rice price forecasting. Fluctuation allows for the existence of an outlier that causes the data to be non-stationary in both variety and average. Outliers must be overcome to produce an unbiased model, so that it can be used to forecast and produce accurate forecast values. Forecasting will provide relevant information to find out rice price in the future to provide useful information in formulating policies in a better direction.

Outliers and structural changes are common in the analysis of a data to produce incorrect conclusions. The presence of outliers and structural changes decrease efficiency in model estimation. Outliers will cause a discrepancy model, so it is very important to detect [6]. According to [6] outliers contained in the time series economics which is often the subject of an observation is very real problem. Outlier is distinguished into 4 types namely, Additional Outlier (AO), Innovation Outlier (IO), Temporary Change (TC) and Level Shift (LS) [2]. A robust method of outliers is needed to avoid the effect of outlier on a data, i.e. the robust estimator is a method that uses assumptions of unfulfilled residual normality or there are some extreme outliers that affect a model [6]. The robust method is used to detect outliers and provide results that are resistant to the presence of outliers.

X-13 ARIMA-SEATS is a seasonal adjustment method that can automatically detect and overcome the outlier problem of ARIMA models, and can overcome seasonal moving factors [8]. The X-13 ARIMA SEATS method is a development of the X-12 ARIMA. In this study, researchers will use rice price index data from January 2010 to December 2018 in Indonesia. This study will compare the X-13 ARIMA SEATS method and the ARIMA method. ARIMA method was used as a comparison to
the suitability of rice price index modeling and forecasting in Indonesia in January 2010- December 2018 with the robust method, namely the X-13 ARIMA SEATS.

2. **X-13 ARIMA SEATS**

X-13 ARIMA SEATS is a further development of the X-12 ARIMA SEATS developed by the U.S. Census Bureau. These improvements assist users in detecting and fixing any deficiencies in seasonal and calendar effect adjustments obtained based on the selected program. The X-13 ARIMA version can produce spectral stability and diagnostics for SEATS seasonal adjustments. X-13 ARIMA SEATS modeling is designed to build regARIMA models with seasonal economic time series. According to [4], the regARIMA model is one of form a calendar variation model that can be used to forecast data based on seasonal patterns with varying period lengths. Based on this objective, several predetermined regression variable categories are available in X-13 ARIMA-SEATS including trend constants or overall averages, fixed seasonal effects, trading day effects, holiday effects, additive outliers, level shifts, temporary changes and ramp effects. X-13 ARIMA-SEATS uses standard seasonal ARIMA model notation (p d q)(P D Q)s. (p d q) indicates non-seasonal autoregressive (AR), differencing, and moving average (MA). Meanwhile, (P D Q)s indicates seasonal autoregressive, differencing, and moving averages. Subscripts are seasonal periods, e.g. s=12 for monthly data [8]. The use of X-13 ARIMA SEATS can produce a fairly good seasonal adjustments in a time series [7].

The X-13 ARIMA SEATS method is a non-parametric approach that fits the ARIMA model with seasonal components. In addition to the coefficients required for ARIMA models, X-13 ARIMA SEATS have additional T parameters for level shifts, tempary changes and ramp effects. X-13 ARIMA-SEATS uses standard seasonal ARIMA model notation (p d q)(P D Q)s. (p d q) indicates non-seasonal autoregressive (AR), differencing, and moving average (MA). Meanwhile, (P D Q)s indicates seasonal autoregressive, differencing, and moving averages. Subscripts are seasonal periods, e.g. s=12 for monthly data [8]. The use of X-13 ARIMA SEATS can produce a fairly good seasonal adjustments in a time series [7].

The X-13 ARIMA SEATS process in general

1. Eliminating the effect of moving holidays using the RegARIMA model
2. Extending the observational data by backcasting and forecasting based on the RegARIMA model
3. Decompose the expansion data using the X-12 ARIMA decomposition.

3. **Methodology**

3.1. **The Data**

The response variable of this study is the rice price index, and the explanatory variable used is time (January 2010 - December 2018). The data used of this study is secondary data obtained from Central Bureau of Statistics of Indonesia, namely the rice price index at the wholesale trade level (IHPB in the rice agricultural sector) in January 2010 - December 2018 in Indonesia.

3.2. **Data Analysis**

Data analysis was used R software in this study. X-13 ARIMA SEATS method was used seasonal packages for modeling. Outliers checking to find out whether the rice price index data is contaminated by outliers using tsoutlier package. See [7].

The data analysis are as follows:
1. The data exploration by checking outliers
2. Divide the data into training data (rice IHPB data for January 2010- December 2017) used for modeling and test data (rice IHPB data for January 2018- December 2018) used for validation.
3. Modeling using the ARIMA method with training data.
4. Modeling using the X-13 ARIMA SEATS method with training data.
5. Forecast using the best method based on the comparison obtained in steps (3) and steps (4) by using MAPE and RMSE values.

4. Result and Discussion

4.1. Data Exploration
Rice price index data contains T = 108 months from January 2010 to December 2018 in Indonesia. Based on Figure 1, it shows that there are identified 4 points as outlier. Meanwhile, one of the months in 2013, 2014 and 2016 it was identified as level shift.

![Outlier identification plot of rice price index](image1.png)

Figure 1 Outlier identification plot of rice price index

Based on Figure 1, we need a method that is able to overcome time series data that contains seasonality, linear trends, outliers and level shift to produce accurate and robust modeling of the problems contained in the rice price index data.

4.2. ARIMA
The differencing process was carried out to stationary the rice price index data. Rice price index data requires 1 time differencing so that the data becomes stationary. Stationary is also seen in the ACF and PACF plots in Figure 2. The plots in Figures 2a and 2b were used to determine the best candidate model. However, the ACF and PACF plots did not show any significant values, so the model formed was the random walk model.

![ACF plot (a) and PACF plot (b) of rice price index after 1 time differencing](image2.png)

Figure 2 ACF plot (a) and PACF plot (b) of rice price index after 1 time differencing

The ACF and PACF plots do not show any significant values, so the only model that can be formed is ARIMA(0,1,0) with an AIC value of 511.79. Furthermore, a diagnostic check was carried out for the ARIMA(0,1,0) model to determine the feasibility of the model. Figure 3 shows the diagnostic plot for the ARIMA(0,1,0) model. The standardized residuals plot shows the remains do not form a specific or random pattern, the residual plots show no real residuals and the Ljung Box p-value plot shows all points have p-value > 0.05, this indicates that there is no autocorrelation or fulfills the white noise assumption. Whereas based on the normal Q-Q plot, it is clear the remains are around the normal line, this indicates that the normal assumptions are met.
The results of the modelling goodness measure using the ARIMA method obtained MAPE value of 1.399 and RMSE of 3.484.

4.3. X-13 ARIMA SEATS

Through the logarithmic transformation process of rice price index data using the X-13 ARIMA SEATS method, the best five regARIMA model candidates were obtained as presented in Table 1.

Table 1 The best candidate of the regARIMA model for rice price index

| Model   | RegARIMA                  | BIC  |
|---------|----------------------------|------|
| Model 1 | (0,1,1)(1,0,0)             | 5.805|
| Model 2 | (0,1,1)(1,0,1)             | 5.794|
| Model 3 | (0,1,2)(1,0,0)             | 5.764|
| Model 4 | (1,1,1)(1,0,0)             | 5.763|
| Model 5 | (2,1,0)(1,0,0)             | 5.763|

Model 1 is the best model with the smallest BIC value = -5.805 compared to the other four models. Thus, the regARIMA (0,1,1)(1,0,0) model has fulfilled all the most suitable assumptions used for modeling and forecasting rice price index data. In modeling the rice price index using the regARIMA(0,1,1)(1,0,0) model obtained 5 significant estimator coefficients and presented in Table 2.

Table 2 shows the coefficient of rice price index data using the X-13 ARIMA SEATS method. Based on Table 2, the significant level shift coefficient occurred in July 2013 and January 2014 with \( \Pr(> | z |) \) values of 0.000, respectively. A significant additive outlier coefficient occurred in March 2015 with a \( \Pr(> | z |) \) value of 0.000. The seasonal AR and a non-seasonal MA coefficient that is also significant with a \( \Pr(> | z |) \) value of 0.000.

Table 2 Coefficient, Estimate, Z value and \( \Pr(> | z |) \) of rice price index

| Coefficient     | Estimate | Z value | \( \Pr(> | z |) \) |
|-----------------|----------|---------|-------------------|
| Constant        | 0.007    | 2.605   | 0.009             |
| LS2013.Jul      | 0.060    | 6.080   | 0.000             |
| LS2014.Jan      | -0.181   | -18.287 | 0.000             |
| AO2015.Mar      | 0.022    | 3.861   | 0.000             |
| AR-Seasonal-12  | 0.381    | 4.017   | 0.000             |
| MA-Nonseasonal-01 | -0.472  | -5.450  | 0.000             |

The results of the modelling goodness measure using the X-13 ARIMA SEATS method obtained MAPE value of 1.333 and RMSE of 2.445.
4.4. Forecasting

Based on the comparison of the results of the modeling goodness measurement, the model obtained using the X-13 ARIMA SEATS method have the smallest MAPE and RMSE values. So the rice price index forecasting is carried out using the X-13 ARIMA SEATS method.

Figure 4 shows the rice price index forecasting plot in January 2019-December 2019 using the X-13 ARIMA SEATS method. The red line is the fit value and the blue line is the actual value of the rice price index data. The fit value looks quite suitable for predicting rice price index data. The red line that is the result of the forecast is between the two upper and lower red lines which are the minimum error limit and the maximum error limit of the forecast.

![Figure 4 Forecast of rice price index plot in January - December 2019](image)

Based on Figure 4, the data pattern for forecasting the rice price index data increased similar to the data pattern in previous months. Table 3 shows the forecast value of the rice price index for January 2019 - December 2019 using the X-13 ARIMA SEATS method. The forecast value based on Table 3 shows an increase in the price index that continues to increase in January 2019-December 2019 without any decline in value.

| Time           | Actual Value | Forecast Value |
|----------------|--------------|----------------|
| January 2018   | 167.760      | 164.576        |
| February 2018  | 169.820      | 165.382        |
| March 2018     | 164.770      | 166.188        |
| April 2018     | 162.320      | 166.994        |
| May 2018       | 161.340      | 167.799        |
| June 2018      | 160.840      | 168.605        |
| July 2018      | 162.500      | 169.411        |
| August 2018    | 162.890      | 170.217        |
| September 2018 | 166.160      | 171.023        |
| October 2018   | 168.060      | 171.829        |
| November 2018  | 170.800      | 172.635        |
| December 2018  | 172.580      | 173.441        |

| Time           | Forecast Value |
|----------------|----------------|
| January 2019   | 174.247        |
| February 2019  | 175.053        |
| March 2019     | 175.858        |
| April 2019     | 176.665        |
| May 2019       | 177.471        |
| June 2019      | 178.276        |
| July 2019      | 179.082        |
| August 2019    | 179.888        |
| September 2019 | 180.694        |
| October 2019   | 181.500        |
| November 2019  | 182.306        |
| December 2019  | 183.112        |

The results of the forecast goodness measure using the X-13 ARIMA SEATS method obtained MAPE value of 2.047 and RMSE of 3.846.

5. Conclusion

Based on the analysis and discussion that has been done, the rice price index data for January 2010-December 2018 have identified trends and seasonal patterns. The rice price index data is also indicated that there are outliers and level shifts even though the residuals are not very large, so if observed only with the time series plot does not see any indication of outliers and level shifts. The X-13 ARIMA SEATS can detect and handle outliers well. So, The X-13 ARIMA SEATS is the best method for modeling and forecasting rice price index data in Indonesia than ARIMA method based on MAPE and RMSE values.
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