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Forecasting of Rubber Export Values in West Kalimantan Using the ARIMA Method

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ABSTRACT

Rubber is one of the largest commodities in Indonesia, after palm oil. Rubber has become the primary export commodity in West Kalimantan. In 2023, the export value of rubber in West Kalimantan experienced fluctuations every month. These changes can have a negative impact on the economy in West Kalimantan. Forecasting the value of rubber exports is crucial because the data on rubber export values is often used as a basis for economic planning in a region. This research aims to determine a suitable model for forecasting the value of rubber exports in West Kalimantan and to forecast the value of rubber exports in West Kalimantan for the next 12 periods using the Autoregressive Integrated Moving Average (ARIMA) method.In the stage of determining the best model, it was found that the best model for forecasting the value of rubber exports in West Kalimantan is the ARIMA (1,1,0) model, with a MAPE (Mean Absolute Percentage Error) value of 20.7%. This means that the forecasting results fall into the acceptable category. The forecasting results can be used as an early warning for policy-making related to rubber exports in the upcoming periods.

Keywords: Rubber, Export, ARIMA.

INTRODUCTION

Rubber is a commodity that plays an important role in international trade and can be processed into various types of household products. Indonesia is a country with hot temperatures and a humid environment, making it one of the world's largest producers of natural rubber. Based on data from the Ministry of Agriculture (Directorate General of Plantations) published by the Central Bureau of Statistics under the title "Statistics Indonesia 2023", the accumulated amount of all provinces in Indonesia, from Aceh to Papua, states that rubber production throughout 2022 reached 3,135.3 thousand tons. West Kalimantan is in fifth place, with rubber production reaching 255.8 thousand tons. Natural rubber production in West Kalimantan province comes from smallholder rubber plantations, most of which are exported abroad. However, the Pontianak Class 1 Agricultural Quarantine Center stated that the export value from January to November 2023 amounted to IDR285.5 billion or decreased by 54.3 percent when compared to the previous period last year.

The Business Networking session at the meeting on Improving International Market Access and Business Matching for Plantation Business Actors in 2023 highlighted the situation and challenges facing rubber products in West Kalimantan and Indonesia in general. Of the 16 rubber processing factories in West Kalimantan, only six are still operating but total production is below installed capacity. This is due to the lack of raw material Bokar (rubber processing material) supplied from small-scale rubber plantations. Moreover, the price of rubber in West Kalimantan is getting worse yearly because most farmers no longer cultivate rubber. Over the past 10 years, it has been rare to hear of rubber prices staying at a level that satisfies farmers by continuing to hover around IDR5,000 to IDR7,000/Kg only.

Not only farmers but also many rubber collectors no longer have rubber. The amount of rubber that can be stockpiled is decreasing, and it is feared that it will not be able to cover transportation costs if sold in Pontianak, located about 600 km from Kapuas Hulu. Based on data from West Kalimantan in 2023 released in the Official Statistics, the area of small-scale rubber plantations in the 2018-2022 period has decreased. The area of smallholder rubber plantations in 2018 reached 605.1 hectares, but in 2022 the area was only 586.1 hectares. In addition, the low productivity of rubber plants still in use is partly due to many rubber products being replaced by synthetic rubber made from chemicals. In addition, the quality of rubber obtained from the community sometimes does not meet export standards (both in terms of the ratio of moisture content, the mixture of latex freezing agents, and the way rubber is stored, causing a lot of garbage mixed with rubber pads), disease attacks and local clone trees that need to be rejuvenated (old rubber trees).

For this reason, an effective strategy is needed to sustainably increase exports' value. The success of these strategies is highly dependent on the ability of the government and economic actors to forecast future market conditions. Therefore, forecasting the future value of rubber exports is an urgent need. One of the models that can be applied in forecasting the amount of rubber exports in the coming year is the ARIMA time series quantitative forecasting method by studying past events to understand the structure and important properties using data Rubber exports January 2018 to August 2023. The data is collected monthly based on PEB document reports grouped in HS-8 digit codes originating from the Directorate General of Customs and Excise (DGCE), Ministry of Finance.

METHODOLOGY

This study uses monthly data on the value of rubber exports in West Kalimantan from 2018-2023, which consists of 68 months of observation. The method used in this research is forecasting using the ARIMA model.

Table 1. Export Value Data January 2018-August 2023

Month	**Rubber Export Value (IDR)**					
	2018	**2019**	**2020**	**2021**	**2022**	**2023**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Januari	19986904.52	23321694.97	9573766.64	12321364.77	11558670.37	8752277.64
Februari	22060374.04	15896910.30	15389012.30	8962182.14	6325512.12	8644484.32
Maret	24945787.37	18184287.81	13395673.14	11428798.72	11342991.30	10397657.21
April	22256103.77	24194112.55	8708563.39	9703380.00	13152923.15	4274208.55
Mei	22473692.54	26695723.41	4513013.94	10780492.34	9806587.37	11177124.86
Juni	15174904.34	24400680.67	5048556.57	14382607.40	9404108.94	8115660.00
Juli	25300392.26	32923009.63	5109586.90	13165990.08	7528244.93	7019460.00
Agustus	25386651.88	30205859.73	3545220.72	10258606.05	11475753.27	9756573.64
September	27303394.50	28328704.22	5849937.49	5417684.84	11183346.09	
Oktober	26034916.54	30687441.66	7716101.00	10411660.64	11346620.34	
November	24489614.02	18849533.68	7345619.93	5182520.00	11697756.16	
Desember	17550531.64	18168229.15	6733109.05	10586073.50	8096472.36	

Source: Directorate General of Customs and Excise (DGCE), Ministry of Finance. (processed)

The data is divided into 2 parts: training data and testing data. Training data consists of 48 months of observation, namely data from January 2018 – December 2021. The testing data consists of 20 months of observation, namely data from January 2022 – August 2023. The testing data will be used to find the MAPE value of the forecasting results that have been carried out.

ARIMA Model

A research technique widely known as George Box and Gwilym Jenkins have developed the Autoregressive Integrated Moving Average (ARIMA) method. The name is often associated with the ARIMA process of analysing and forecasting time series data. ARIMA combines moving average and autoregressive methods to forecast time series data using historical and current information, creating accurate predictions for the short term.

The general Box-Jenkins model can be represented in the notation ARIMA(p, d, q), where p is the order or degree of Autoregressive (AR), d is the order or degree of Differencing, and q is the order or degree of Moving Average (MA). The ARIMA(p, d, q) model's general formulation is listed in equation (1).

$$\phi_p(B)(1-B)^d Y_t = \theta_0 + \theta_q(B)a_t \qquad (1)$$

With AR operator is

$$\phi_p(B) = (1 - \phi_1 B - \cdots - \phi_p B^p) \qquad (2)$$

With MA operator is

$$\theta_q(B) = (1 - \theta_1 B - \cdots - \theta_q B^q) \qquad (3)$$

Description :

p = Autoregressive order of-p
d = Differencing of order-d
q = Moving Average order of-q
B = Backshift Operator
c = Constant/intercept
ϕ_p = Autoregressive Parameter order of -p
θ_q = Moving Average Parameter order of-q
Y_t = actual data at time-t
a_t = error at time-t

Stages of the ARIMA Method

The ARIMA method applies an iterative approach to determine the best model among the available options. The provisional model selected is then retested using historical data to evaluate the suitability of the model. A model is considered fit if the residuals (the difference between the predicted results and the historical data) have a normal distribution. The implementation steps of the ARIMA method involve data plotting, model identification, model parameter estimation, model significance testing, and finally, the forecasting process. The path diagram below visually depicts the forecasting steps using the ARIMA model.

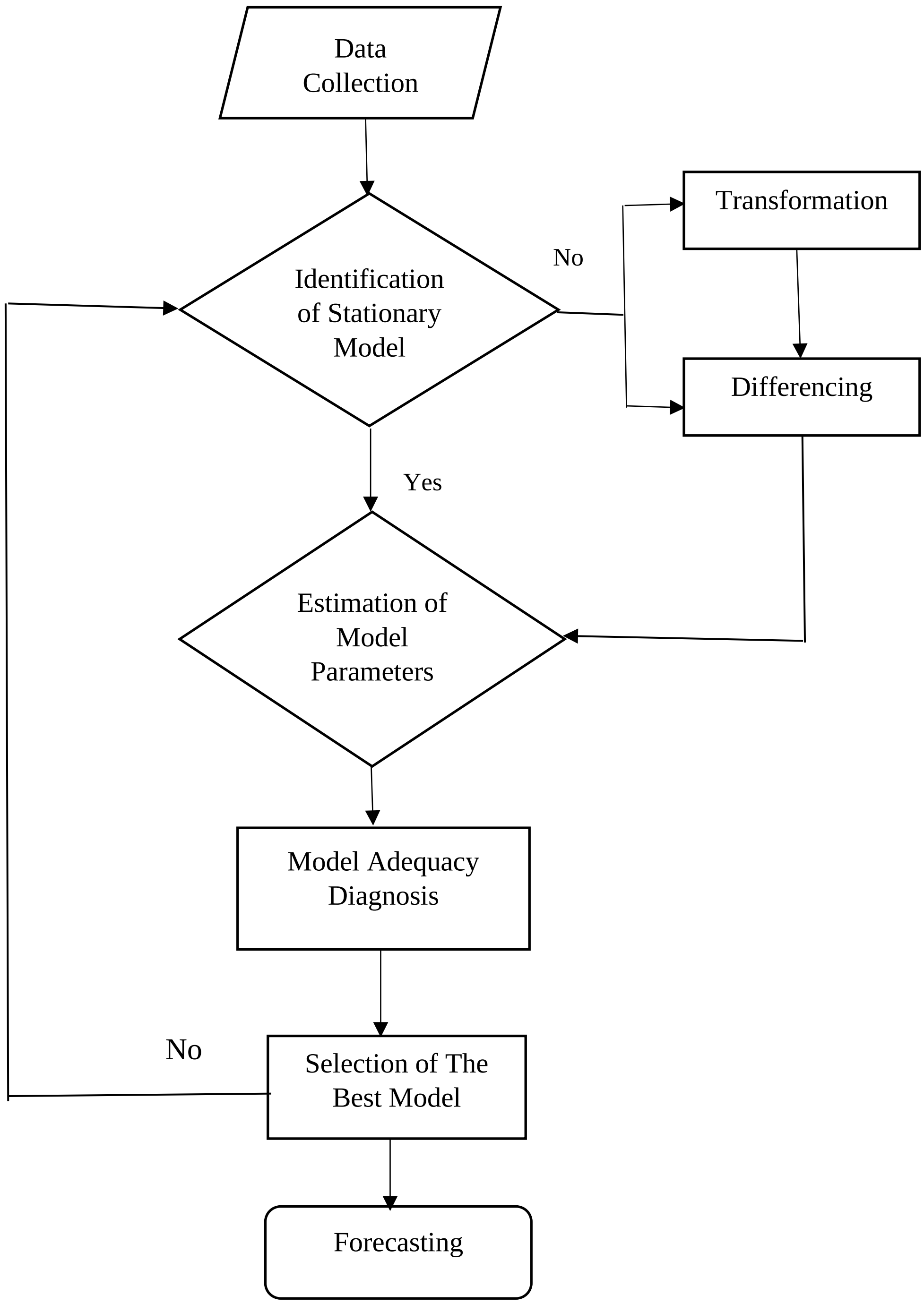

Figure 1. ARIMA Flowchart

RESULTS AND DISCUSSION

This study uses the ARIMA model approach to create a time series model based on data on the value of rubber exports in West Kalimantan collected from January 2018 to August 2023. The following are the steps of the ARIMA model analysis that will be run with the help of Minitab software.

Model Identification

The first step in the ARIMA method is to create a graph of the rubber export value data. This allows us to use the shape of the graph to determine the movement of changes in rubber export values over time. The following is a plot of rubber export value data in West Kalimantan from 2018 to 2023.

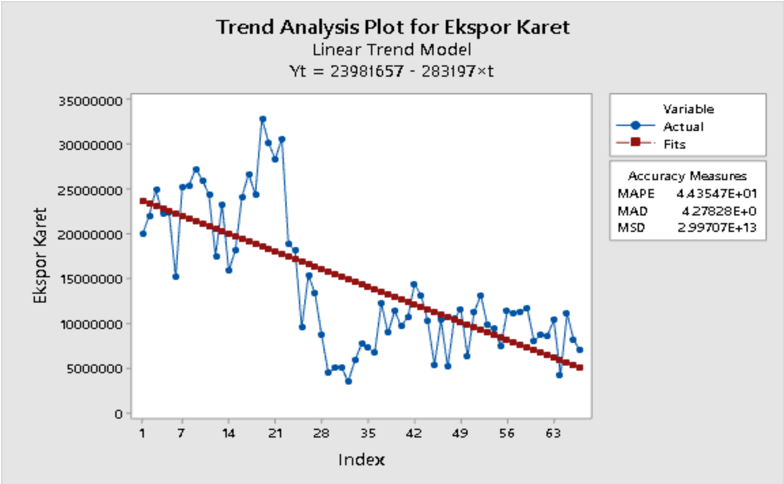

Figure 2. Plot of export value data

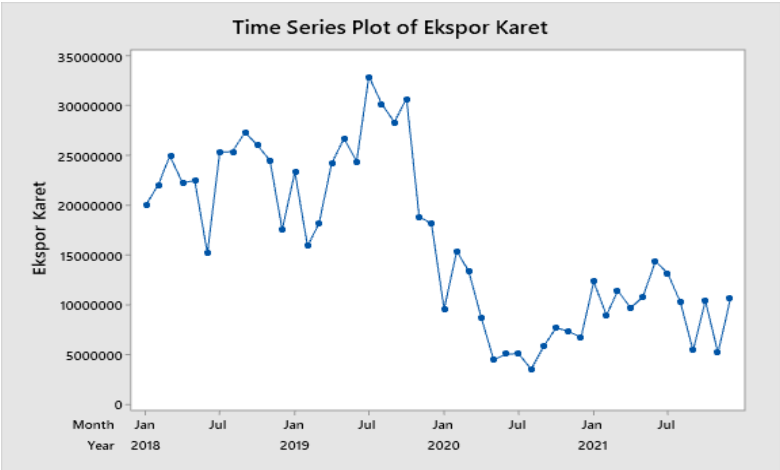

Figure 3. Trend analysis graph

Based on Figure 2 and the trend graph in Figure 3, it shows that the value of rubber exports has decreased over time, and the actual value is still far from the straight line, showing a large variation. This indicates that the time series is non-stationary. To overcome this, further analysis was carried out using Box-Cox transformation to assess whether the data became stationary with respect to variance. The results of the Box-Cqox test of the rubber export value data can be seen in Figure 4.

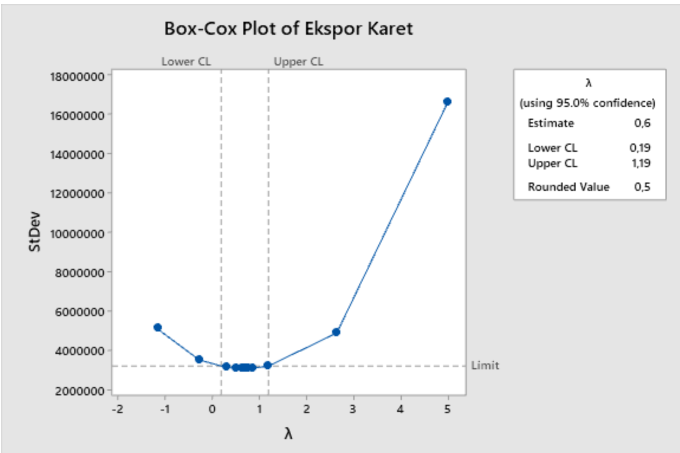

Figure 4. Box-Cox test results

Referring to Figure 4, it can be concluded that the initial data is not stationary with respect to variance, as the rounded value is around 0.50 or λ ≠ 1 on the Box-Cox plot. Data transformation is performed to achieve stationarity with respect to variance. The Box-Cox test results of the transformed data can be seen in Figure 5 below.

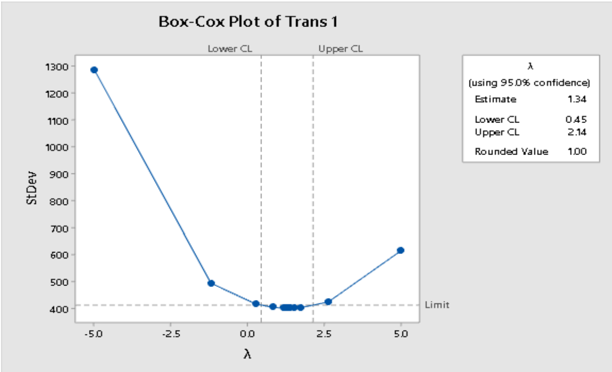

Figure 5. Box-Cox Transformation test results

In accordance with Figure 5, the Box-Cox transformation test results show that the data is stationary after transformation, with the optimal value for the lambda parameter around 1 (λ=1). This supports the success of the transformation in achieving stationarity with respect to variance. The next step in this analysis is to check whether the data is stationary with respect to the mean. This is done using graphical testing of the autocorrelation function (ACF) and partial autocorrelation (PACF). The results of the ACF and PACF graphs can be seen in Figure 6.

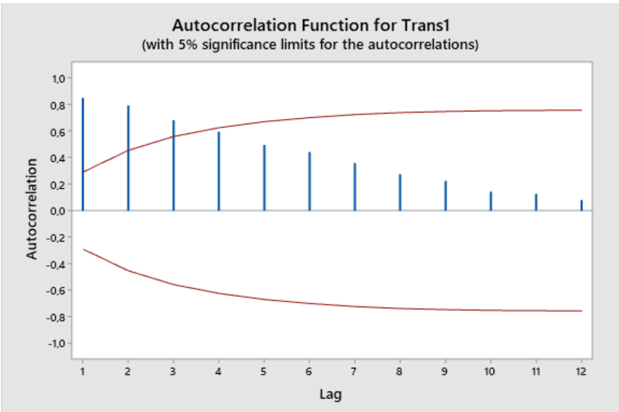

Figure 6. ACF graph

Figure 6 shows that the rubber export value data is still not stationary on average, this can be seen from the lag that comes out of the stationary line of more than 3. To make the data stationary on average, we must do a differencing process.

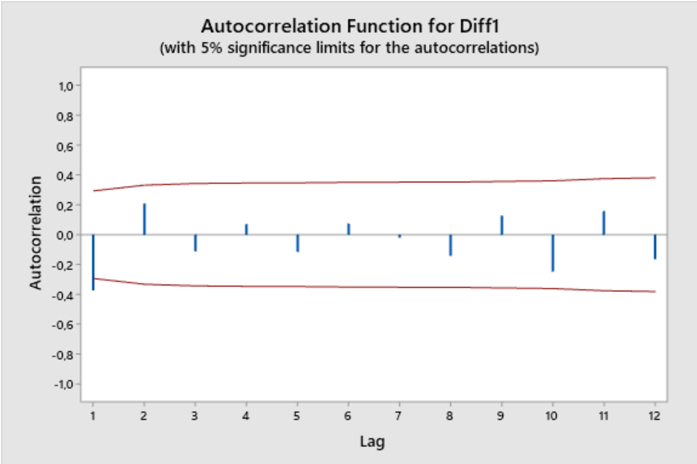

Figure 7. ACF graph after differencing

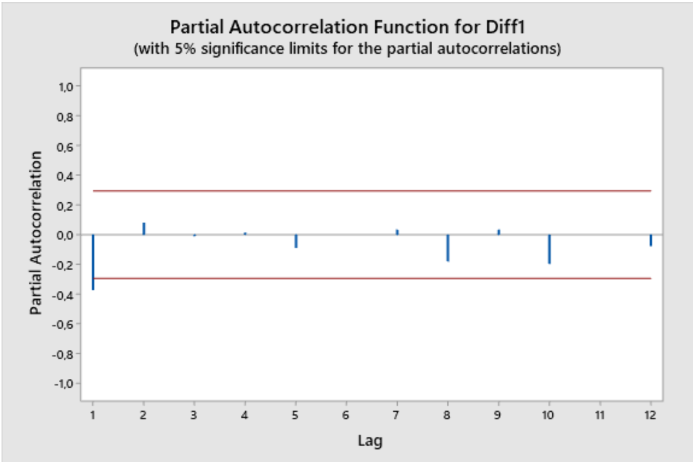

Figure 8. PACF graph after differencing

After the differencing process in Figures 7 and 8, it is obtained that the lag out of the stationary line is no more than 3. In addition, the analysis results show that the data on the value of rubber exports in West Kalimantan in the period January 2018 to August 2023 has reached stationarity on average. This shows that differencing has been successful in removing the trend and making the data stationary to the mean, which is an important requirement for applying the ARIMA model. The next step is to identify the order of the ARIMA model that best fits this data, by looking at the autocorrelation function (ACF) and partial autocorrelation function (PACF) graphs of the differenced data.

Table 2. ACF and PACF values after differencing

ACF Data			
Lag	**ACF**	**Lag**	**ACF**
(1)	**(2)**	**(3)**	**(4)**
1	0.85021	7	0.35871
2	0.79248	8	0.27361
3	0.68180	9	0.22398
4	0.59431	10	0.14132
5	0.49555	11	0.12576
6	0.44308	12	0.07843

PACF Data			
Lag	**PACF**	**Lag**	**PACF**
(1)	**(2)**	**(3)**	**(4)**
1	-0.37319	7	0.03498
2	0.08106	8	-0.18026
3	-0.01013	9	0.034661
4	0.01492	10	-0.19687
5	-0.08836	11	-0.00276
6	0.00022	12	-0.07712

ARIMA Model Conjecture

Based on the ACF and PACF graphs that show a decrease after lag 1, the temporary models that can be identified for ARIMA forecasting are ARIMA (1,1,0), ARIMA (0,1,1), and ARIMA (1,1,1). The next step is to ascertain which model is feasible to use through the model significance test. The model significance test process involves estimating the parameters for each proposed model and testing the significance of those parameters. In addition, criteria such as AIC (Akaike Information Criterion) or BIC (Bayesian Information Criterion) can be used to compare the models' relative performance. Models with lower AIC or BIC values are considered better.

Once a viable model has been selected, the next step is to perform a model fit test with historical data that was not used during the estimation process. This involves checking the residuals to ensure that no patterns or structures remain in the data that has been modelled. The results of this analysis will guide the optimal ARIMA model that can be used to forecast rubber export values in West Kalimantan.

Model Significance Test

Table 3. Significance Test of ARIMA Model

ARIMA Model	Parameters	Coefficient	MS	p-value	Description
(1)	(2)	(3)	(4)	(5)	(6)
ARIMA (0,1,1)	MA (1)	0.285	1.53235E+14	0.051	Significant
ARIMA (1,1,0)	AR (1)	-0.364	1.79358E+13	0.012	Significant
ARIMA (1,1,1)	MA (1)	-0.282	1.81255E+13	0.459	Not Significant
	AR (1)	-0.610		0.062	

From the table above, it can be seen that the significant models are ARIMA (0,1,1) and ARIMA (1,1,0). Of the two ARIMA models, the ARIMA (1,1,0) model was chosen because it has the smallest MSE value. The next step is to test whether the selected model's parameters are significant or not. The significance test of the AR (1) parameter is 1=-0.385 from the ARIMA model (1,1,0)

Hypothesis:

$H_0 : \theta_1 = 0$ (parameter is not significant)

$H_1 : \theta_1 \neq 0$ (significant parameter)

Critical region: Reject H_0 if p-value$< \alpha = 0.05$

From Table 3 it can be seen that the AR (1) parameter has a p-value of 0.001 so reject H_0 which means $\theta_1 = -0.385$ significant in the model.

Based on parameter estimation, it is found that the significant parameters in the ARIMA (1,1,0) model have equation (1) as follows:

$$Z_t = (1 + \varphi_1)Z_{t-1} - \varphi_1 Z_{t-2} + \alpha_t$$

$$Z_t = \big(1 + (-0.364)\big)Z_{t-1} - (-0.364)Z_{t-2} + \alpha_t$$

$$Z_t = 0.636Z_{t-1} + 0.364Z_{t-2} + \alpha_t$$

The next stage is the diagnosis of the model made with the normality test and the Ljung-Box test.

1. Independence test

   This test is conducted to determine the independence of residuals between lags. Two lags are said to be uncorrelated if there is no significant correlation between them.

   Hypothesis

   $H_0 : p_1 = p_2 = p_i = 0$ (no correlation between lags)

   $H_1 : p_1 = p_2 = p_i \neq 0$ there is a correlation between lags)

   Critical region: Reject H_0 if p-value$< \alpha = 0.05$

The results of the Ljung-Box statistical test for the ARIMA(1,1,0) model can be seen in Table.

Table 4. Ljung-Box test results

Lag	Chi-Square Value	p-value	White Noise
(1)	(2)	(3)	(4)
12	5.63	0.897	Yes
24	9.87	0.992	Yes
36	18.25	0.991	Yes

From table 4, based on the p-value, the p-value> 0.05, which means it fails to reject H0 . This means that there is no correlation between lag 12 and lag 36. It can be concluded that the residuals have fulfilled the independent assumption.

2. Residual Normalization Test

This model fit test aims to demonstrate, using error analysis, that the specified temporal model is adequate to meet the assumption of model normality. The model normality test was conducted using the Kolmogorov-Smirnov test.

Hypothesis

H_0 : residuals are normally distributed

H_1 : residuals are not normally distributed

Critical region: Reject H_0 if p-value$< \alpha = 0.05$

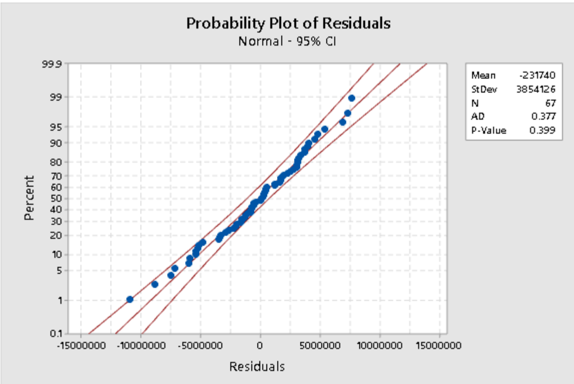

Figure 9. Residual Normality test results

Based on Figure 9, the p-value =0.399, greater than the significance level α=0.05. Then the ARIMA (1,1,0) model fulfills the assumption of residual normality. Because all assumptions are met, it can be concluded that the ARIMA model with AR(autoregressive) of 1, differencing degree of 1, and MA (moving average) of 0 can be used for forecasting the value of rubber exports in West Kalimantan.

Forecasting

The data modelling results are significant and meet the required assumptions. The ARIMA (1,1,0) model is the best model for forecasting the value of rubber exports in West Kalimantan in the next period. The following table shows the forecasting results from the minitab output.

Table 5. Forecasting results

Period	Forecast
(1)	(2)
49	8620172
50	9335399
51	9075188

Period	Forecast
(1)	(2)
52	9169857
53	9135415
54	9147946
55	9143387
56	9145045
57	9144442
58	9144661
59	9144582
60	9144611
61	9144600
62	9144604
63	9144603
64	9144603
65	9144603
66	9144603
67	9144603
68	9144603

Table 6. Error value of forecasting results

ARIMA Model	MSE	MAPE (%)
(1)	(2)	(3)
ARIMA (1,1,0)	1.44703E+13	0.20697

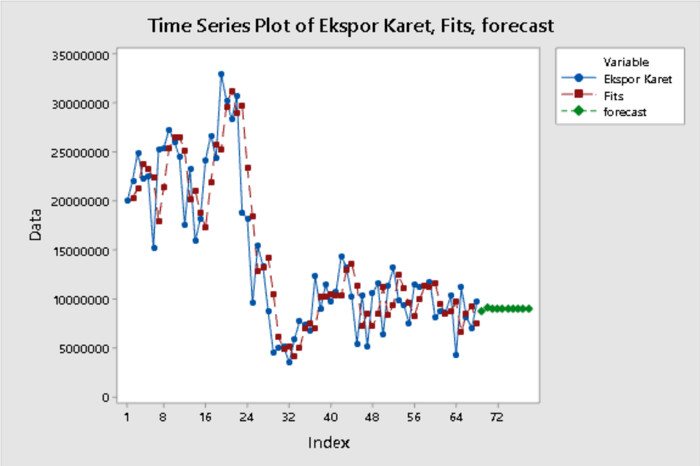

Figure 10. Plot of actual data, estimated data and forecasting results

From the forecasting results above, the value of rubber exports in West Kalimantan can be forecasted for the next 12 months. It can be seen that there is an increase and decrease in the value of rubber exports in the next year, or the value of rubber exports fluctuates. With the ARIMA (1,1,0) model, the forecasting results are obtained with a MAPE of 0.20697 or 20.7% where these results fall into the category of feasible forecasting. The value of rubber exports that experience fluctuating changes can be caused by low rubber prices so that farmers do not have a high spirit to produce rubber.

From Figure 10, it can also be seen that the plot of the estimated value and the actual value have a similar shape, so from the plot it can be judged that the forecast value is good.

CONCLUSIONS AND SUGGESTIONS

Based on the results of the analysis discussed above, it can be concluded that using the help of minitab software there are 2 ARIMA models that are feasible to use to predict the value of rubber in West Kalimantan from January 2018 to August 2023, the best model is the ARIMA model with an AR (autoregressive) degree of 1, a differencing degree of 1, and an MA (moving average) degree of 0 because it has the smallest p-value of 0.012. The best ARIMA model used for forecasting the value of rubber exports in West Kalimantan in the next 12 months is as follows:

$$Z_t = (1 + \varphi_1)Z_{t-1} - \varphi_1 Z_{t-2} + \alpha_t$$

$$Z_t = \left(1 + (-0.364)\right)Z_{t-1} - (-0.364)Z_{t-2} + \alpha_t$$

$$Z_t = 0.636Z_{t-1} + 0.364Z_{t-2} + \alpha_t$$

With the percentage error of the estimation results is 20.7% The value of rubber exports for the next 12 months based on the 49th period forecasting in September 2023 the value of rubber exports was IDR8,620,172 until the 80th period forecasting stated in August 2024 the value of rubber exports was IDR9,144,603. The results of forecasting for the next 12 months state that the value of rubber exports continues to fluctuate.

If accompanied by direct policies such as forming and developing microfinance institutions that provide rubber transportation services, as well as educating the public on the importance of re-developing natural rubber-based industries, increasing the added value of rubber products that can be stored for a long time so that rubber has a quality that can compete at the world level, and providing rubber rejuvenation assistance through superior rubber seeds can restore rubber to become a superior strategic commodity in West Kalimantan.

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