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Rubber Production Projection in Riau Province using Autoregressive Integrated Moving Average (ARIMA) Approach

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Abstract
Rubber has long been become a mainstay of Indonesian exports along with oil palm, coffee and tea. As a commodity that has increasing world demand, rubber exports are given priority. This must be responded quickly by the government in order to increase national income from the export side. Riau as the third largest national rubber producer has great potential to increase rubber production. Therefore, it is necessary to make further analysis related the targets that need to be achieved, so the development of rubber production can be applied measuredly. Analysis using the ARIMA method is used to predict rubber production in the next five years (2021-2025). The results of the analysis showed that there will be an increase in rubber production by 2.38 percent with a maximum increase up to 3.05 percent. This increase is still at a low level, so efforts need to be made to increase rubber production.

Keywords: ARIMA, export, production, projection, rubber

Proyeksi Produksi Karet di Provinsi Riau dengan Pendekatan *Autoregressive Integrated Moving Average* (ARIMA)

Abstrak
Karet telah sejak lama menjadi produk andalan ekspor Indonesia bersama dengan kelapa sawit, kopi dan teh. Sebagai komoditas yang terus mengalami peningkatan permintaan di dunia menyebabkan ekspor karet menjadi sebuah keuntungan. Hal tersebut harus dapat direspon dengan cepat oleh pemerintah guna meningkatkan pendapatan nasional dari sisi ekspor sehingga dapat meningkatkan perekonomian dalam negeri. Provinsi Riau sebagai provinsi yang memiliki kontribusi terbesar ketiga sebagai produsen karet nasional memiliki potensi yang besar untuk dapat meningkatkan produksi karet. Oleh sebab itu, perlu adanya analisis lebih lanjut terkait dengan target yang perlu dicapai agar pengembangan produksi karet dapat diaplikasikan secara terukur. Analisis dengan metode ARIMA digunakan untuk memproyeksikan produksi karet lima tahun mendatang (2021-2025). Hasil analisis menunjukkan bahwa akan terjadi peningkatan produksi karet sebesar 2.38 persen dengan peningkatan maksimum mencapai 3.05 persen. Kenaikan tersebut masih berada pada taraf yang rendah sehingga perlu dilakukan upaya agar terjadi peningkatan produksi karet.

Kata kunci: ARIMA, karet, ekspor, produksi, proyeksi

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INTRODUCTION

Rubber has long been a plantation commodity with important role in the national economy due to contributing to a high export value with export destinations to various countries in the world (Daulika et al., 2020). This is illustrated by the volume of rubber exports which reached 2.4 million tons with a value of US$3.4 billion in 2019, an increase of 2.97 percent since 2012 (Central Bureau of Statistics, 2020a). In 2019, Indonesia was the second-largest rubber export in the world after Thailand with an export share of 26.50 percent, this achievement has a difference of 6.57 percent with Thailand of 33.07 percent (Trademap, 2020). In addition, the rapid progress in the industrial sector has changed the demand for rubber in the global market to increase. The establishment of various automotive companies in the world at the end of this decade has made the demand for rubber to increase rapidly because it is needed for the manufacture of tires. Although many of the rubber needs in the automotive industry focus on synthetic rubber, the need for natural rubber is still needed because of the natural properties of natural rubber that are not found in synthetic rubber (Damanik, 2012). Therefore, the increase in rubber production is very potential, given the existence of a clear market destination so that it is not difficult for farmers to sell their rubber crops. This indicates that Indonesia has a great opportunity to export rubber due to the availability of a potential market. However, the open rubber export market has made the competition in the world's rubber exports even tighter, thus, it is necessary to make efforts for the sustainability of Indonesia's rubber exports.

So far, rubber production in Indonesia is spread across almost all provinces in Indonesia and South Sumatra is the province with the largest contribution to total national rubber production in 2019 with a contribution of 27.39 percent, followed by North Sumatra and Riau with each contribution of 11.69 percent and 9.59 percent (Central Bureau of Statistics, 2020c). In the same year, South Sumatra had the largest area with an area of 861 thousand hectares, followed by North Sumatra and Riau with 409 thousand hectares and 330 thousand hectares respectively (Central Bureau of Statistics, 2020b).

Based on these data, Riau is one of the largest rubber producers in Indonesia, but compared to South Sumatra and North Sumatra, the production and area of rubber in Riau is still lower than the two provinces. Based on the potential of Riau as a province with the sixth largest area in Indonesia, Riau can be used as a center for plantation commodities in Indonesia. so that the expansion of land area for plantation commodities, especially rubber is needed to increase production.

Riau is a province on Sumatra Island with many plantation areas to be planted with various kinds of plantation commodities. Based on data from Ministry of Agriculture of the Republic of Indonesia (2020), there are at least seven plantation commodities cultivated in Riau such as oil palm, coconut, rubber, coffee, pepper, sugar cane, and cloves. From these seven commodities, oil palm is the leading commodity with the most dominant contribution to the economy of Riau. This data can be seen from the production and total area of oil palm and even becomes the largest in Indonesia. However, over a long period, oil palm has shown superiority as one of the main sources of income for the people in Riau, thus the cultivation of other plantation commodities seems not significant. The potential possessed by other commodities such as rubber commodities should be further developed, considering that rubber can be an alternative source of income for the people of Indonesia and specifically for the people of Riau.

Riau as a province with a potential land area can be optimized for its potential in increasing rubber production by intensifying productivity increases. So far, the Indonesian Ministry of Agriculture has carried out the BUN 50 program which is a rubber plant replanting program by preparing 500 million quality seeds in the next five years (Ministry of Agriculture of the Republic of Indonesia, 2020c). This is an effort by the government to maintain the productivity of rubber plants through replanting so that rubber that is no longer productive can be renewed with new and more productive rubber plants.

The end of the program launched by the Ministry of Agriculture is the increase in domestic rubber production. Riau which currently has a contribution of 9.59 percent of the national rubber production, is expected to increase its production which in turn can increase the national rubber stock both in the short and long term. Since 2012, the growth of rubber production in Riau has decreased by 2.24 percent (Ministry of Agriculture of the Republic of Indonesia, 2020b). This indicates that improvements to existing rubber production in Riau must be carried out immediately, either by replanting existing rubber land or by clearing new land to plant rubber.

Based on the description above, it is known that rubber is a strategic commodity that has the potential to be developed in Indonesia. In addition, the GRDP value of the agricultural sector in Riau is the second-largest sectoral GRDP value after the manufacturing sector in 2020 with a percentage of 26.16 percent, which reflects that the agricultural sector (including rubber) is the largest contributor to regional income. In addition, the large market demand for rubber in the global market makes rubber an important commodity that can be used as the mainstay of Indonesian exports, although so far it is still predominantly natural rubber, further development needs to be done to increase the added value of products through downstream activities. On this basis, this study aimed to project rubber production in Riau which can be achieved in the next five years (2021-2025). This target is a measurable increase in production so that what is planned by stakeholders can be achieved as expected. Moreover, it is also a response to the Medium-Term Development Plan (RPJMD) for 2019-2024 which targets that rubber production in Riau Province in 2024 will reach 408,961 tons.

METHOD

This study used time-series data for 43 years (1976-2018) collected from the Center for Agricultural Data and Information, Ministry of Agriculture. The data collected has been analyzed using the Autoregressive Integrated Moving Average (ARIMA) method to see short-term projections of rubber production that may be produced in Riau.

The ARIMA method was originally introduced by Box and Jenkins in the book entitled Time Series Analysis: Prediction and Control as the most suitable method for time series data and has the principle of simplicity (Nyoni, 2018; Stellwagen & Tashman, 2013). The ARIMA method is a model developed from the Autoregressive Moving Average (ARMA) model which consists of the Autoregressive (AR) and Moving Average (MA) models (Jia et al., 2015). The difference between the two models is the process used, where

ARIMA has a differentiation process where the primary data owned is replaced by the difference between the current data and the previous data, the ARIMA model can reduce the non-stationary time series data which causes the predictions to be more accurate (Zhang et al., 2017). ARIMA is a model that is often used in forecasting that is only based on observations of the behavior of data variables and completely ignores the independent variables in the model (Qonita et al., 2017).

The ARIMA model can be written as follows:

$$(1 - \emptyset_1 \beta) X_t = \mu' + (1 - \theta_1 \beta) \varepsilon_t$$

Where X_t is the t-period data, ∅_1 is the 1-st autoregressive parameter and ε_t is the error value at time t.

The ARIMA model has three stages namely the identification of the model structure, parameter estimation, and model calibration as well as model testing and validation (Sena & Nagwani, 2015). The following are the stages in forecasting with the ARIMA model:

1. **Stage of identification of the model structure**

   The structure identification stage is the stage of testing the data through the stationarity test. The data is categorized to be stationary if the average variance at each time interval (lag) is constant at all times (Hanurowati & Prahutama, 2016). The identification stage uses a simple principle by looking at the pattern of ACF (Autocorrelation Function) and PACF (Partial Autocorrelation Function). The observed data should meet the criteria as described in the Table 1.

Table 1. ACF and PACF behavior

Model	AR (p)	MA (q)	ARMA (p,q)
ACF	Decreases exponentially and forms a sine wave (*Dying down*)	*Cut off* after lag-q	Decreases exponentially and forms a sine wave (*Dying down*)
PACF	*Cut off* after lag-q	Decreases exponentially and forms a sine wave (*Dying down*)	Decreases exponentially and forms a sine wave (*Dying down*)

Source: Maulana (2018)

   Data without ACF and PACF as described in Table 1, can be categorized as non-stationary, which needs efforts to obtain stationary data through differencing. Differencing is a data transformation by performing a data reduction process at time t with time data t-1 and can be done more than once until the data becomes stationary. The differencing formula can be written as follows:

$$d = 1 \rightarrow W_t = \nabla Y_t = Y_t - Y_{t-1}$$

$$d = 2 \rightarrow W_t = \nabla^2 Y_t = \nabla(\nabla Y_t) = Y_t - 2Y_{t-1} + Y_{t-2}$$

2. **Stage of parameter estimation, and model calibration**

There are two basic methods that can be used at the parameter estimation and model calibration stages (Bangun, 2017):

a. Trial and error is a test performed on several data with different values and determine the value of the error (sum of squared residuals) obtained. The best model is determined by selecting the model with the lowest error value.
b. Make repairs by repetition; choose the initial estimated value with the help of a computer program to refine the estimated value.

3. Stage of Model Calibration and Validation

The calibration and model validation stages were carried out on the condition that the model obtained has a random error value (does not have a certain pattern). This stage uses a diagnostic test to determine the model with the lowest standard error value. The following is the equation used in carrying out the diagnostic test:

$$S = \left[\frac{SSE}{n - np}\right]^{1/2} = \left[\frac{\sum_t^n (Y_t - \hat{y}_t)^2}{n - np}\right]^{1/2}$$

Where SSE is the standard error, Y_t is the actual value of the t-th time and y _t is the estimated value of the t-th time and np is the p-th sample size.

FINDING AND DISCUSSION

Analysis of Autoregressive Integrated Moving Average (ARIMA)

a. Stage of identification of the model structure

The identification of the model structure has been used to test the stationary of the analyzed time-series data. The time-series data have been determined using plot analysis to determine the stationarity of the data. The results of the plot test carried out, shown in Figure 1, show that the data is not stationary so that it is necessary to do differencing on the data. The differencing results show that the data is stationary as shown in Figure 2.

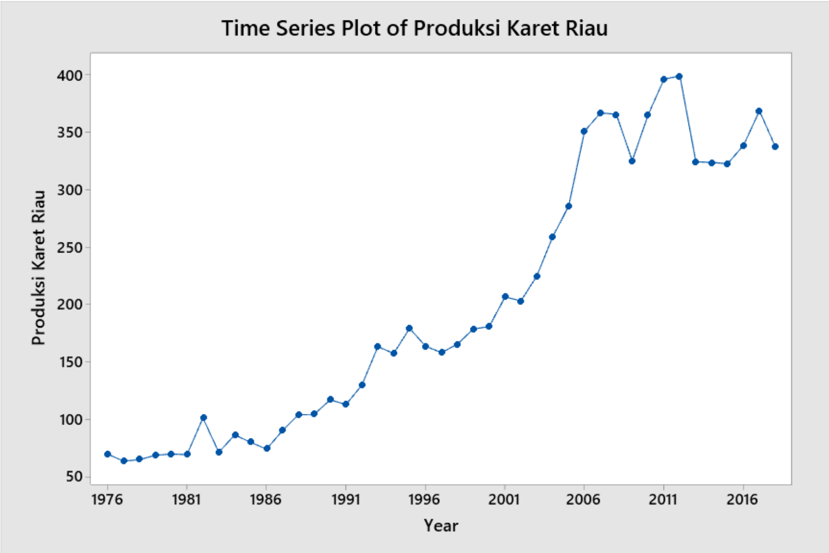

Figure 1. Time series plot of rubber production in Riau

Data that has been stationary at 1st differencing is then tested by looking at the behavior of ACF and PACF to determine the cut-off or dying down pattern of the data. Based on the results of the ACF and PACF tests, suggested that the pattern formed is a cut-off and is immediately significant in the initial lag, then in the 4th lag, the data reverses direction to be positive then followed by a dying down pattern. This indicates that the existing data may be in autoregressive or moving average models. Based on this, several models can be used as temporary models to choose the best model. The models that have been further estimated for rubber production projections in Riau Province are ARIMA (1,1,1), ARIMA (2,1,1) and ARIMA (1,1,2).

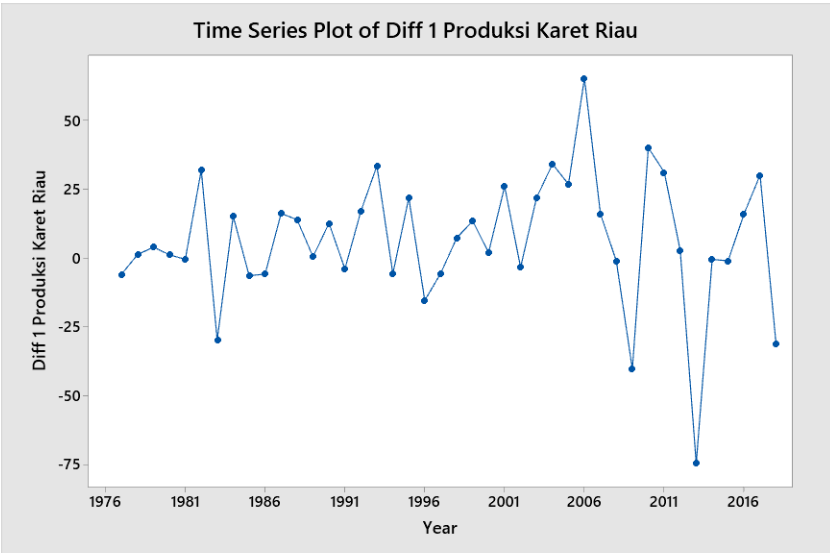

Figure 2. Time series plot of rubber production in Riau (1st differencing)

b. Stage of parameter estimation and model calibration

The second stage after identifying the structure of the model is the parameter estimation and model calibration stage. This stage was carried out to verify the most suitable ARIMA model for the analysis. The estimation and calibration of the model were done by comparing the p-value of each parameter coefficient with a tolerance level of 5 percent (0.05). The hypotheses made are as follows:

H_0 : Parameters are not significant to the model

H_1 : Parameters are significant to the model

The criteria used are; if the p-value is greater than 0.05 then accept H_0. If the p-value is less than 0.05 then accept H_1.

Based on the test results for each ARIMA model, it can be concluded that the best model for projecting rubber production in Riau is ARIMA (1,1,1). This is because these parameters have a high level of significance to the model as presented in Table 2.

Table 2. Estimated projection of rubber production in Riau

Model/Parameter	Variable	Coef	SE Coef	t-Value	p-Value	MSE
ARIMA (1,1,1)	AR (1)	0.821	0.190	4.33	0.000	571.834
	MA (1)	0.943	0.159	5.94	0.000	
	Constant	1.330	0.309	4.30	0.000	
ARIMA (2,1,1)	AR (1)	-0.63	3.24	-0.19	0.847	606.478
	AR (2)	0.031	0.188	0.16	0.870	
	MA (1)	-.063	3.26	-0.19	0.847	
	Constant	10.15	6.21	1.63	0.110	
ARIMA (1,1,2)	AR (1)	0.780	0.223	3.50	0.001	56.908
	MA (1)	0.826	0.290	2.84	0.007	
	MA (2)	0.129	0.196	0.66	0.515	
	Constant	1.670	0.237	7.04	0.000	

c. Stage of Model Calibration and Validation

The ARIMA model (1,1,1) has been determined as the best model used to project rubber production in Riau Province. The next step is to verify the model by performing a residual normality test and a residual independence test (white noise). The normality test was carried out by the Kolmogorov-Smirnov test, namely by comparing the value of the test results and the predetermined tolerance level. The hypotheses used are as follows:

H_0 : Residues are normally distributed

H_1 : Residues are not normally distributed

The criteria used are; if the p-value is greater than 0.05, then H_0 is accepted, and if the p-value is less than 0.05, then H_1 is accepted.

Residual independence test was carried out by using the Ljung-Box test with the following hypothesis:

H_0 : There is no residual correlation between lags

H_1 : There is residual correlation between lags

The criteria used are; if the p-value is greater than 0.05 then accept H_0 and if the p-value is less than 0.05 then accept H_1.

Based on the results of the Kolmogorov-Smirnov test, the ARIMA model residue (1,1,1) is normally distributed because the p-value is greater than 0.05, which means that the values in the data are valid because they are along the normal line. The results of the Kolmogorov-Smirnov test is presented in Figure 3.

Testing of residual independence using the Ljung-Box test, it can be concluded that the processed data residues are homogeneous or have no residual correlation between lags. This is reflected in the results of the Ljung-Box test where the p-value is greater than 0.05, then the hypothesis H_0 is accepted. The following table are the results of the Ljung-Box.

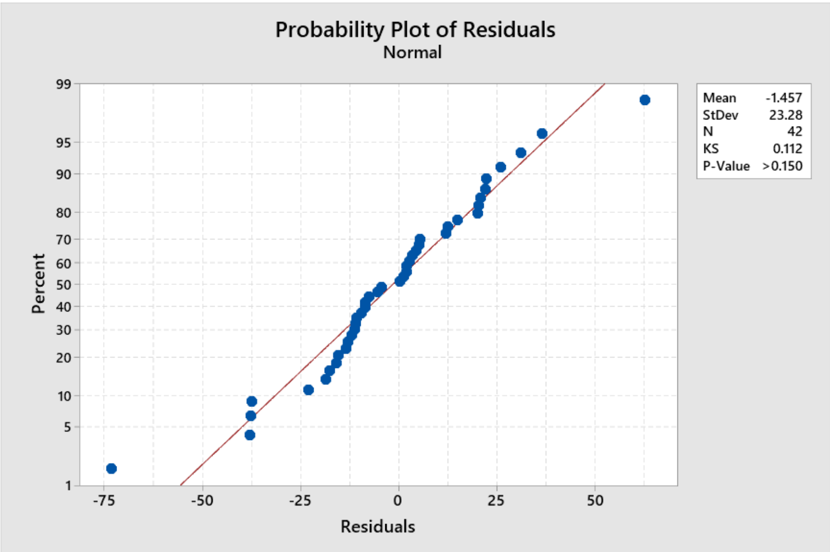

Figure 3. Kolmogorov-Smirnov test on the ARIMA model (1,1,1)

Table 3. Ljung-Box test on the ARIMA model (1,1,1)

Residue	Lag	*Chi-Square*	*P-Value*	Note
	12	15.65	0.075	White Noise
Rubber production in Riau	24	24.13	0.287	White Noise
	36	32.92	0.471	White Noise

d. Projection of rubber production in Riau

The projection of rubber production in Riau is then carried out using the ARIMA (1,1,1) model by forecasting the optimum value, lower limit value, and final limit of rubber production in the upcoming five years (2021-2025). The ARIMA (1,1,1) model can be written with the following equation:

$$Zt = 1.330 + Z_{t-1} + 0.821\mathrm{a}_{t-1} + Z_{t-2} + 0.943\mathrm{a}_{t-2} + \mathrm{a}_t$$

Based on the forecasting results, rubber production in Riau for the next five years (2021-2025) has an average increase of 2.38 percent and has a potential increase of up to 3.05 percent (Table 4). This increase is still not in line with expectations because the

Table 4. The projected value of rubber production in Riau Province with the ARIMA model (1,1,1)

Year	Projection (ton)	Growth (%)	Lower limit (ton)	Optimum limit (ton)	Potential growth (%)
2021	369,538		297,261	441,816	
2022	379,191	2.61	299,888	458,495	3.78
2023	388,451	2.44	303,847	473,054	3.18
2024	397,386	2.30	308,617	486,156	2.77
2025	406,506	2.18	313,903	498,209	2.48
Average		2.38			3.05

potential increase that might be achieved in 2025 is only 498,209 tons or still low at 70.956 tons compared to rubber production in South Sumatra in 2012. Meanwhile, compared to the 2024's rubber production target written in the RPJMD, the projection of rubber production achieved is still deficit at 11,576 tons, but the rubber production can potentially exceed the RPJMD target of 498,209 ton or a surplus of 89,248 tons in 2024. This indicates that the growth of rubber production in Riau is very slow; several factors are possible as the cause. One of the causes is the low productivity of rubber in Riau as stated by Riadi et al. (2011) and Junaidi (2020) because most rubber plantations are owned by the local people with poor plantation management and lack of technology absorption.

Several factors are suspected as the cause of the low growth of rubber production in Riau; The low productivity of rubber plants is due to damaged old plantation increase and many land-use changes. This is reflected on declined rubber land area by 4.8 percent from 2014 to 2018 (Ministry of Agriculture of the Republic of Indonesia, 2021). In addition, in the Riau RPJMD for 2019-2024, it is written that other factors that cause rubber plant productivity are cultivation patterns and techniques that are not as recommended. Based on this condition, it is necessary to make efforts to increase the productivity of rubber plants in Riau in several ways, such as the use of uniform planting materials and in accordance with the agro-ecosystem (location-specific), applying appropriate cultivation techniques comprehensively from pre-planting, planting to maintenance and rejuvenating plants for non-productive plants (Boerhendhy & Amypalupy, 2010).

CONCLUSION

The projection of rubber production in Riau using the ARIMA (1,1,1) model showed that in the next five years (2021-2025), there may be an increase in rubber production, but at a low level, special efforts are needed to increase rubber production in Riau. One of the causes of low rubber production in Riau is low productivity. Ownership of rubber plantations is still dominated by people who still carry out traditional and modest management and lack of use of technology. Several steps needed to increase the productivity of rubber plants besides technical factors are by making regulations, policies and monitoring the planting and maintenance of rubber plants. The government needs to make regulations related to rubber planting to ensure that farmers using high-yielding seeds as well as introduce rubber seedlings which lead farmers to produce superior rubber seeds independently. In addition, the government needs to disseminate technology to farmers. This Dissemination to increase farmers' knowledge about effective ways to produce high quality rubber and control pests and diseases that occur during the planting and maintenance period. Monitoring of rubber planting also needs to be carried out by the local Agriculture Service to ensure that farmers have made planting recommendations so that problems during planting and maintenance can be immediately addressed. Therefore, regulations, policies, dissemination and monitoring of the planting and maintenance of rubber plants, followed by the use of appropriate technology need to be initiated and applied as soon as possible to help farmers cultivate rubber more easily and achieve optimal rubber production.

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