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Analysis Time Series (ARIMA): To determine the Development of Oil Exports in Indonesia

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A B S T R A C T

Oil exports are the largest export in Indonesia. Indonesia's oil exports from year to year tend to fluctuate and in the end continue to decline, however in the last three years exports of oil products have continued to increase from the previous year. This research aims to analyze the development of oil exports in Indonesia. The data used in this research is doil export data from 1996 to 2023 obtained from data Indonesian Central Statistics Agency (BPS). The method used to analyze development of oil exports in Indonesia is Autoregressive Integrated Moving Average (ARIMA). The research results show that Indonesia's oil exports have experienced significant fluctuations from year to year, with a quite striking decline in export volume in recent years. The ARIMA model (2,2,2) was identified as the best model for predicting future behavior from oil export data. This model succeeds in describing the intrinsic patterns in the export data well. Using the ARIMA (2,2,2) model it is known that forecasting results development of oil exports in Indonesia (2024-2035) will experience an increase from the previous year.

Keywords: Time Series Analysis, ARIMA, Exports, Oil Results, Indonesia

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1. Introduction

Indonesia is a developing country that has diversity and abundance of natural resources consisting of many commodities and is a country that has enormous potential to carry out economic transactions with other countries or what is called international trade. Export is the release of goods from the customs area (including land, water and air space or certain places for the movement of goods) of Indonesia to be sent abroad by following the applicable provisions, especially regarding customs regulations [1]. Exports are one element that can increase economic growth. The export process in general is the action of removing goods/commodities from within the country to enter them into another country. Large exports of goods generally require customs intervention from sending and receiving countries [2]. One of the largest sources of exports is oil exports [3]. Oil exports are the largest export in Indonesia. This situation causes the Indonesian economy to be very sensitive to changes in oil and gas prices on the international market [4]. Based on data from the Pusan Statistics Agency, it is recorded that the amount of oil exports in 2021 will be 3,712,700 tons and in 2022 it will be 6,361,000 tons. Meanwhile, in 2023 this figure will again increase to 8,737,000 tons. From the number of oil exports in the last three years, it can be seen that oil exports continue to increase. The results of previous research conducted by Mustika et al., show that the value of crude oil exports has a significant positive effect on economic growth in Indonesia. The same results were also shown by Indonesian crude oil imports which also had a significant positive effect on economic growth in Indonesia [5]. In contrast to research conducted by Arsa F. Et al., The research results show that in the long term oil exports have a negative effect on economic growth. The existence of a negative influence shows that decreasing oil exports will increase Indonesia's economic growth [6].

1.1. Export of oil products

a Export
International trade is a medium that can increase the production capacity of a country in order to improve the quality of domestic economic development by looking at advantages from abroad [7]. Export is a trading system carried out by individuals or business entities and institutions which aims to carry out trade between countries. Exports are an important part of international trade, the influence of exports on international trade and the economic development of a country is very large [8]. Positive net exports illustrate the large demand from other countries for domestic goods, so that domestic productivity increases then has the effect of increasing domestic economic growth [9].

b Understanding Oil
Oils are carboxylate derivatives of glycerol esters called glycerides. Petroleum or in English it is called Petroleum, according to Latin it consists of two word fragments, namely Petrus which means coral and Oleum which means oil. Petroleum or petroleum is also known as black gold, which is a thick, dark brown or greenish liquid that is flammable, and is in the upper layer of several areas in the earth's crust. Petroleum consists of a complex mixture of various hydrocarbons, most of which consist of the alkane series but vary in appearance, composition and purity [10].

c Development of Oil Products Exports
Indonesia's oil exports from year to year tend to fluctuate and in the end continue to decline and ultimately force Indonesia to leave OPEC members. Even though the volume of Indonesian oil exports has decreased more than the increase, this decrease in exports has not been accompanied by a decrease in the value of exports, although the volume has decreased, the value produced has increased due to an increase in prices [5].

1.2. Auto Regressive Integrated Moving Average (ARIMA)

a Understanding ARIMA
Auto Regressive Integrated Moving Average (ARIMA) or Box-Jenkins is a method developed by George Box and Gwilym Jenkins in 1970 [11]. Model Autoregressive Integrated Moving Average (ARIMA) is a model that completely ignores independent variables in making forecasts. The values used by ARIMA for forecasting are using the past and present values of the dependent variable to produce accurate forecasts [12].

b Stationary
Stationarity Stationary means that there are no drastic changes in the data. Testing the stationarity of a time series data can be done with a unit root test, by observing whether the time

series data contains a unit root, that is, whether there is a trend component in the form of a random walk in the data [13]. Stationarity is divided into 2, namely:

1) Stationarity in the mean Stationary in the average is that data fluctuations are around a constant average value, independent of time and the variance of these fluctuations. From the form of the data plot it can often be seen whether the data is stationary or not stationary. If you look at the ACF plot, the autocorrelation values of stationary data will decrease to zero after the fifth or sixth time lag.
2) Stationarity in variance A time series data is said to be stationary in terms of variance if the structure over time has data fluctuations that are fixed or constant and do not change. Visually, you can see this by using a time series plot, namely by looking at data fluctuations from time to time.

c ARIMA models

1) AR (Autoregressive) order p states that observations at time t are linearly related to observations at previous times $t-1, t-2, \ldots, t-p$ [14]. The equation form of the AR model can be written as follows:

$$\dot{Z}_t = \phi_1 Z_{t-1} + \phi_2 Z_{t-2} + \cdots + \phi_p Z_{t-p} + a_t \tag{1}$$

2) The MA (Moving Average) model is used to explain an event where an observation at time t is expressed as a linear combination of a number of residuals [14]. The equation form of the MA model can be written as follows:

$$\dot{Z}_t = a_t - \theta_1 a_{t-1} - \theta_2 a_{t-2} - \cdots - \theta_q \tag{2}$$

3) The ARMA model is a combination of the AR and MA models which can be written with the notation ARMA (p,q) [14]. The equation form of the ARMA model at order p and q can be written as follows:

$$\dot{Z}_t = \phi_1 Z_{t-1} + \cdots + \phi_p Z_{t-p} + a_t - \theta_1 a_{t-1} - \cdots - \theta_q \tag{3}$$

4) ARIMA model as a function of p, d, q, where p is the operator order of AR, d is the differencing order, and q is the operator order of MA [14]. The general ARIMA model can be written as follows:

$$\emptyset_p(B)(1-B)^d \dot{Z}_t = \theta_q(B) a_t \tag{4}$$

1.3. Autocorrelation Function and Partial Autocorrelation Function

In the time series method, the main tool for identifying models from the data to be predicted is to use the autocorrelation function Autocorrelation Function (ACF) and the partial autocorrelation function Partial Autocorrelation Function (PACF).

a) Autocorrelation Function (ACF)
Autocorrelation Function (ACF) or autocorrelation function is a representation of the relationship between z_t and z_{t+k} from the same process and separated by k time lags [15]. By taking a sample from the population, the ACF can be calculated using Equation (5)

$$r_k = \frac{\sum_{t=k+1}^{T} (z_t - \bar{z})(z_{t-k} - \bar{z})}{\sum_{t=k+1}^{T} (z_t - \bar{z})^2} \tag{5}$$

with:

r_k = autocorrelation coefficient at lag k
z_t = observation data at time t
$\bar{z}$ = average and observations

b) Partial Autocorrelation Function (PACF)
Partial autocorrelation function (PACF) is a tool to measure the closeness of the relationship between $YYii$ and $YYii+kk$ if the lag effect is $i+1, i+2, \ldots, i+k-1$ is considered separately [15]. The following PACF equation can be written.

$$\phi_{kk} = \frac{\rho_k - \sum_{j=1}^{k=1} \phi_{k-1,j}\rho_{k-j}}{1 - \sum_{j=1}^{k=1} \phi_{k-1,j}\rho_{k-j}} \tag{6}$$

with:

ϕ_{kj} $= \phi_{k-1,j} - \phi_{kk}\phi_{k-1,j}\phi_{k-j}$ for $j = 1, 2, \ldots, k-1$, where
ϕ_{kk} = Autocorrelation coefficient at lag k
ρ_k = Autocorrelation coefficient on the k estimated with nr_k
ρ_j = Autocorrelation coefficient at lag j which is estimated by r_j
ρ_{k-j} = Autocorrelation coefficient at lag k-j which is estimated by:

$$r_{k-j} = \frac{\sum_{t=(k-j)+1}^{T}(z_t - \bar{z})(z_{t-(k-j)} - \bar{z})}{\sum_{t=1}^{T}(z_t - \bar{z})^2} \tag{7}$$

2. Research Methods

2.1. Types of research

The type of research used is quantitative research. Quantitative research is a research method using numbers and statistics in the collection and analysis of measurable data.

2.2. Data Source

The data used in this research is secondary data, namely data on the volume of exports of oil products in Indonesia from 1996 to 2023. The data source used was obtained from data from the Indonesian Central Statistics Agency (BPS) (Badan Pusat Statistik Indonesia (bps.go.id)).

2.3. Research Variables

in this research we use the variable Exports of Oil Products.

2.4. Research Stages

Data were analyzed using the ARIMA method. The analysis stages in ARIMA are as follows:

a) Perform data input

b) Carrying out descriptive statistical tests on research data

c) Model identification

d) The ARIMA model can only be used for stationary time series. Therefore, the first thing to do is investigate whether the time series data is stationary or not.

e) Identify ACF and PACF In addition to determining the d value, at this stage it is also determined how many residual lag values (q) and dependent lag values (p) are used in the model. The main tools used to identify q and p are ACF and PACF (Partial Auto Correlation Function/Partial Autocorrelation Coefficient). Identification of the ARIMA model can be done by looking at the ACF plot and PACF plot which refer to theory as in the following table.

Table 1. Identify the ARIMA model by looking at the ACF plot and PACF plot

Model	ACF	PACF
$AR(p)$	decreases exponentially (dies down)	cut off after $lagp$ (cut off after $lagp$)
MA(q)	cut off after $lagq$ (cut off after $lagq$)	decreases exponentially (dies down)
ARMA(p,q)	decreases exponentially (dies down)	decreases exponentially (dies down)

f) Selection of the best ARIMA Model

g) Diagnostic checking

h) Forecasting

3. Result and Discussion

3.1. Descriptive Analysis

Explaining the results of research on an object can be done using descriptive analysis. Descriptive statistics consist of the average value (mean), the smallest value (minimum), the highest value (maximum) and deviation values as indicators that explain the distribution of data in research.

Table 2. Statistics Descriptive

Variables	Minimum	Maximum	Mean	Std. Deviation
export oil results	2868.10	10689.30	6381.1571	1983.92046

Based on Table 2 it is known that the oil export variable has a minimum data value of 2868.10, a maximum data value of 10689.30, an average data value of 6381.1571, and a standard deviation value of 1983.92046.

3.2. Model Identification

To see an initial estimate of the appropriate model form, you can see the results time series data plot of oil export data in Indonesia in 1996-2023 to see the data pattern from the graph which is marked by an increase or decrease in changes over time.

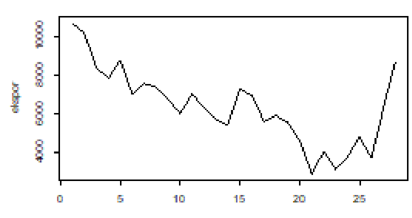

Figure 1. Time series plot of export data of oil products in Indonesia

Based on Figure 1, it can be seen that there is a pattern of decrease and increase in the data pattern so it can be concluded that the data is not stationary in the mean. So, the next step is to carry out a stationary test on the data using the Dickey-Fuller Test (ADF).

Table 3. Test Dickey-Fuller Test (ADF)

Data	Dickey-Fuller	Lag orders	p-value
export oil results	-0,20582	3	0,9879

Based on Table 3, it is known that oil export data in Indonesia for 1996-2023 is at a non-stationary level. It is known that the probability value ($p-value$) is greater than the 5% significance level, namely 0.9879. Because the data is not stationary, differencing is carried out. After first differencing the probability value of oil exports is 0.6076. This value is greater than the 5% significance level, which means the data is not stationary. Therefore, second differencing was carried out and a probability value was obtained that was greater than the 5% significance level, namely 0.01. So it can be concluded that the oil export data is stationary at second differencing. Next, model formation was carried out in the Least Square Method ARIMA analysis by observing the ACF and PACF plots.

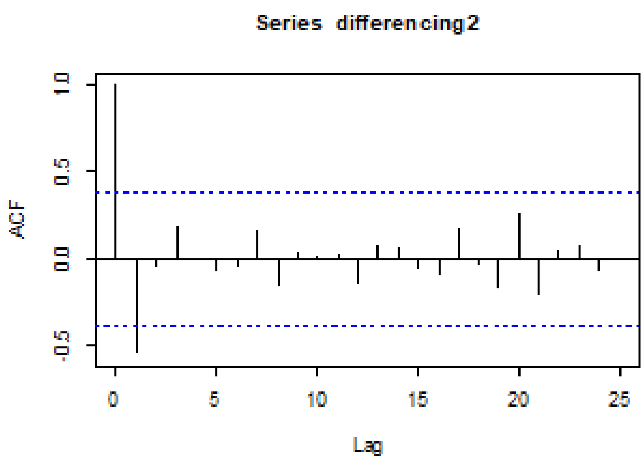

Figure 2. Plot ACF

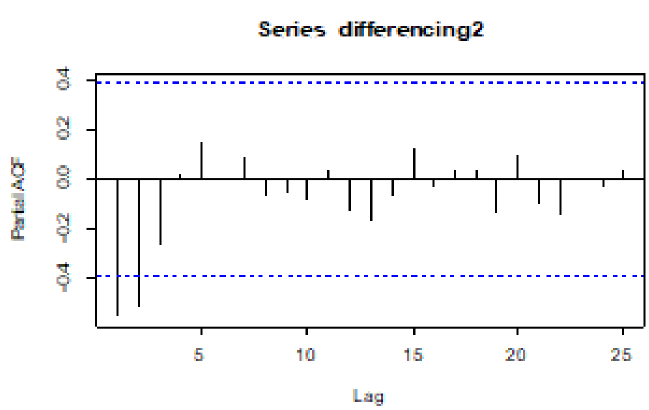

Figure 3. Plot PACF

Based on Figure 2, it can be seen that the ACF plot shows that the ACF values are truncated after $lag2$ (cut off after $lag2$) and in Figure 3, the PACF plot shows that the PACF values are truncated after $lag2$ (cut off after $lag2$). The ARIMA model consists of orders (p, d, q). In determining the ARIMA model, the PACF value is used to determine the AR order (p) and the ACF value is used to determine the MA order (q). Meanwhile, order (d) is the level of difference when the data has been declared stationary, in this study the data is stationary at the second difference, so order (d) has a value of 2. So the ARIMA model may be used for forecasting on oil export data There are three, namely: model 1 is (2,2,2), model 2 is (0,2,2), and model 3 is (2,2,0).

3.3. Selection of the Best ARIMA Model

After knowing the alternative models, estimation is then carried out. The following are summary results of alternative models that have been tested. The component to be considered related to the results of the regression analysis in this research is the value of Akaike Info Criterion (AIC).

Table 4. Observations of the Akaike Info Criterion (AIC) values for each model

Data	Model	AIC	AICC	BIC
	Model 1	438.36	441.52	444.46
export oil results	Model 2	438.8	439.95	442.46
	Model 3	450.21	452.35	453.87

Based on Table 4, it can be seen that the best model for oil export data is the 1 model, namely ARIMA (2,2,2) with the smallest AIC value, namely 438.36.

3.4. Diagnosis Checking

After selecting the best model, the next stage is diagnosis checking to find out whether the residuals from the model show a significant pattern and have a distribution that is close to normal. At this stage, there are three tests that will be carried out, namely:

a) Parameter significance test (t test)

Table 5. t test

	Estimate	Std. Error	z value	$Pr(>\|z\|)$
ar1	-0.61356	0.23589	-26.011	0.009294
ar2	-0.49783	0.21704	-22.937	0.021809
ma1	-127.890	0.22684	-56.379	1.72E-05
ma2	0.49380	0.22505	21.942	0.028224

Based on Table 5, the t test results show that the p-value for each variable is smaller than the 5% significance level. This shows that all parameters in the ARIMA model ($ar1, ar2, ma1, ma2$) are significantly different from zero. This shows that the ARIMA model shows a good fit to the data.

b) Residual test white noise (test box.test) Based on the test results Box.Test the $p-value$ was 0.6577. This value is greater than 5%, which means that the residual data does not contain white noise elements.

c) Residual normality test Based on the results of the Shapiro-Francia Normality Test, a $p-value$ of 0.4461 was obtained. This value is greater than 5%, which means the residual of the data is normally distributed.

3.5. Forecasting

The best model for oil export data is ARIMA (2,2,2) with the smallest AIC value among all possible models, namely of 438,36. And after carrying out diagnostic checking on the model, it is known that the residuals from the model show a significant pattern and have a distribution that is close to normal, indicating the consistency of the model in explains variability in oil output export data.

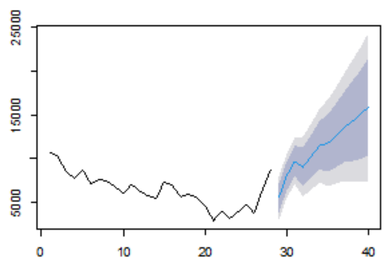

Figure 4. Forecasting Results

Based on the selection of the best model for ARIMA oil export data (2,2,2), the results obtained are forecasting for the next 12-year period, namely 2024-2035. It can be seen in Figure 4 that the predicted condition of oil exports in Indonesia will continue to increase until 2035.

Table 6. t test

Year	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
2024	5507,853	3882,435	7133,271	3021,991	7993,715
2025	7958,146	6323,358	9592,935	5457,953	10458,34
2026	9714,147	7971,013	11457,28	7048,254	12380,04
2027	9068,754	6825,175	11312,33	5637,496	12500,01
2028	10242,405	7764,359	12720,45	6452,561	14032,25
2029	11495,44	8733,115	14257,76	7270,829	15720,05
2030	11794,196	8578,69	15009,7	6876,504	16711,89
2031	12638,943	9.025	16253,26	7111,316	18166,57
2032	13623,757	9592,6	17654,91	7458,635	19788,88
2033	14250,822	9728,552	18773,09	7334,607	21167,04
2034	15027,659	10011,894	20043,42	7356,708	22698,61
2035	15890,699	10367,045	21414,35	7442,999	24338,4

Based on Table 6, it can be seen that the forecasting results for oil exports in 2024 are estimated at 5507,853 (thousand tons) until 2035 at 15,890,699 (thousand tons). With an 80% confidence level, the actual export value of oil products in 2024 will be between 3882,435 (thousand tons) and 7133,271 (thousand tons) as well as for the following years. Meanwhile, with a 95% confidence level, the actual export value of oil products in 2024 will be between 3021,991 and 7993,715. From this value it can be concluded that the forecasting results for oil exports in Indonesia will continue to increase every year.

4. Conclusions

From the results of the analysis using the ARIMA model on oil export data in Indonesia from 1996 to 2023, we can draw several important conclusions. First, it appears that there is a significant fluctuating pattern in the development of oil exports from year to year, with a quite striking decline in export volume, especially in recent years. However, through the ARIMA model approach, we can identify these patterns and provide a clearer picture of the dynamics of oil exports in Indonesia. The

ARIMA model (2,2,2) was identified as the best model that was able to explain data patterns well. The relatively low AIC value shows the ability of this model to predict future behavior from oil export data.

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