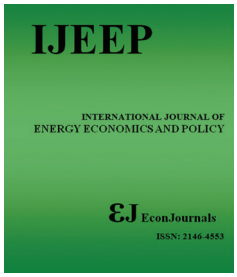

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The Effect of Crude Oil Price and Inflation on Algae Export in Indonesia

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ABSTRACT

The aim of this study is to test and analyze the long-term and short-term effects of crude oil prices and inflation on algae export in Indonesia. The effects were tested using multiple cointegration regression and error correction models. Furthermore, annual time series data from 2012 to 2021 was used in this study and the results of the analysis show that in the long term, crude oil price and inflation have a positive effect on algae export. While in the short term, only crude oil price positively influences its exportation.

Keywords: Crude Oil Price, Inflation, Algae Export, Cointegration Model, Error Correction Model
JEL Classifications: C32, E31, F410

1. INTRODUCTION

Algae is one type of chlorophyll-containing plant and it is classified as a low-level plant that does not have true roots, stems, or leaves but rather it has what resembles a stem, called a thallus. Algae can grow in shallow water with sandy, slightly muddy, or mixed bottom conditions. To grow, this plant usually attaches to a certain substrate, such as coral, mud, sand, stone, or other hard objects. Therefore, farmers in some countries use media made of hard objects to plant algae (Riyastini, 2022).

Economically, this plant has many benefits, including in the fields of pharmacy, agriculture, textiles, and food processing and coastal communities cultivate this commodity to improve their household economy. In connection with the improvement of welfare through algae cultivation, the government of algae-producing countries has also developed various cultivation methods, including in countries such as Latin America (Robledo and Hayashi, 2019), Indonesia (Riyastini, 2022), and Fiji (Lal and Vuk, 2010). The development of these cultivation methods is intended to increase production to meet both domestic and export needs.

Accordingly, the development of algae cultivation in Indonesia is carried out only in areas where the commodity can thrive, such as Aceh, North Sumatra, Jakarta, West Java, Central Java, East Java, Bali, East Nusa Tenggara, West Nusa Tenggara, North Sulawesi, Central Sulawesi, South Sulawesi, Maluku, and Papua regions (Reza et al., 2020). This development has contributed to the increase in production quantity and also exports. Statista (2021) reported that Indonesian algae production has shown an

increasing trend from 6.52 million metric tons in 2012 to 11.32 million metric tons in 2015 and then decreased to 9.66 million metric tons in 2019. Nonetheless, the quantity of 2012-2019 still shows an increasing trend. The increased production level in 2019 made Indonesia the second-highest algae-producing country in the world, with the highest being China. The export volume in Indonesia also shows a fluctuating and increasing trend from 110134.3 USD in 2012 to 222613.8 USD in 2021.

Although the quantity shows an increasing trend, it does not mean that farmers do not experience obstacles in the cultivation process. These obstacles include the scarce supply of materials used which in turn causes the commodity's price to increase (Reza et al., 2020; Saragi et al., 2021).

Study on the determinants of algae export is still limited in number. In Indonesia, this study has only been conducted by Denatika (2012) and Saragi et al. (2021). The focusing factors are the exchange rate and GDP, but the studies employed different methods of analysis. Furthermore, there has not been a study that reports the long-term and short-term effects of crude oil prices and inflation on algae export in Indonesia.

Therefore, the aim of this study is to examine the long-term and short-term effects of crude oil prices and inflation on algae export in Indonesia. To analyze the data, multiple regression cointegration models and an Error Correction Model (ECM) were used. The two models were intended to test for the long-term and short-term effects respectively.

2. LITERATURE REVIEW

As stated in the introduction, a study on the effect of crude oil prices and inflation has not been conducted. Therefore, in this literature review section, only theories related to the relationship between the price of crude oil and export, as well as the relationship between inflation and export will be discussed.

The Indonesian country region consists of islands with a total coast length of 99,093 km, and these coastal waters have the potential for algae cultivation, as various species of algae can be cultivated in this area. According to the Ministry of Marine and Fishery, 2019, the Indonesian coastal waters have 782 algae species consisting of 196 green algae (*Chlorophyceae*), 452 red algae (*Rhodophyceae*), and 134 brown algae (*Phaeophyceae*) (Kementerian Kelautan dan Perikanan, 2019). This is a potential for the development of algae cultivation and based on this potential, according to the theory of absolute advantage, Indonesia can produce enough of this commodity for exportation purposes (Salvatore, 2013).

Oil plays an important role in the world economy, as an input in production. In manufacturing industries, oil is used to run production machines that process raw materials into finished products. Likewise, in the algae industry, crude oil is used to run production machines that process raw algae into food and pharmaceuticals. In algae cultivation, farmers use crude oil to run their marine vehicles when they travel to the cultivation site. In such conditions, the rise in the price of crude oil will burden the production costs of both the manufacturing and the algae industry.

Economically, oil is a production factor not only in the manufacturing industry but also in the algae industry. In the context of crude oil as a production factor, Faria et al. (2009) developed a mathematical model to explain the relationship between crude oil price and export using the Douglas production function:

$$Y=(\Omega N)^{\alpha} O^{\beta}$$

where Ω is technology, N represents workforce, and O is the price of crude oil, while α and β are constants. The model development shows that the price of crude oil and export have a positive relationship. To prove the correctness of the model development conclusions, Faria et al. (2009) used China's export data and the monthly West Texas Intermediate (WTI) crude oil price for the period from 1992.1 to 2005.12. The analysis, which was conducted using the Autoregressive Distributed Lag (ARDL) model, shows that crude oil prices have a positive effect on export.

The effects of oil prices on exports can also be explained using the wealth effect theory as follows. Indonesia is a crude oil-producing country and some of its products are exported abroad, but this country is no longer a member of the Organization of Petroleum Exporting Countries (OPEC) since 2008. According to the wealth effect theory, when Indonesia exports oil to other countries, the country receives a wealth transfer from the importing country. With this wealth transfer, consumption expenditure will increase, which will in turn increase the GDP and economic growth (Cologni and Manera, 2008; Abel et al. 2020). The relationship between economic growth and export can be bidirectional and positive. According to the export-led growth hypothesis, exports can drive economic growth, and vice versa, and based on the theory of comparative advantage, economic growth can positively affect exports (Dodaro, 1993).

Furthermore, inflation can significantly impact exports through domestic interest rates and the domestic currency exchange rate against foreign currencies. As a result of monetary policy, the Indonesian government through the central bank has set an inflation threshold. Therefore, if inflation rises above the threshold, the central bank will raise interest rates to curb inflation. This increase in interest rates can affect exports, especially algae export, because of the exchange rate. Based on the interest rate parity theory, domestic interest rates (r) are equal to the sum of international interest rates (r*) and the change in the domestic currency exchange rate against foreign currency. Then, if the foreign currency is the US Dollar (USD) and the domestic currency is IDR, mathematically the interest rate parity theory is expressed by the equation:

$$r = r^{*} + \Delta\left(\frac{IDR}{USD}\right)$$

Where $\Delta\left(\frac{IDR}{USD}\right)$ changes in the IDR/USD exchange rate. Therefore, if the increase in domestic interest rates is greater than the increase in international interest rates or $(r–r^{*}) > 0$, then the

domestic interest rates will increase the $\Delta\left(\frac{IDR}{USD}\right)$ value or the IDR domestic currency exchange rate will depreciate (Pilbeam, 2006). In international trade theory, when the domestic currency depreciates, domestic goods will become cheap and can be sold abroad, and this can increase exports (Ali et al., 2014).

3. DATA AND METHODOLOGY

3.1. Data

Three variables were used in this study, namely: The crude oil price and inflation as the independent variables, and export as the dependent variable. The time series data for WTI crude oil price was collected, while inflation was used to collect consumer price index time series data (the base year 2010), and the export variable was used to collect the algae export time series data. The time series data spans from 2012 to 2021 and the unit price for crude oil was USD per barrel, while the unit for algae export was USD. Furthermore, the crude oil price data, consumer price index data, and algae export data were obtained from the Energy Information Administration (EIA) website, the World Bank website, and the Indonesian Central Bureau of Statistics website respectively.

3.2. Methodology

The natural logarithm of crude oil price, inflation, and algae exports were represented by OIL, INF, and EXI respectively. To test the long-term effect of crude oil price and inflation on algae export, the cointegration model (Asteriou and Hall, 2021) was used with the equation:

$$EXI_t = \alpha_0 + \alpha_1 OIL_t + \alpha INF_t + u_t \quad (1)$$

Equation (1) is a multiple regression equation where α_0, α_1, and α_2 are the parameters of the regression equation, and u_t is an error. Error u_t has assumptions, such as no autocorrelation, homoscedastic, and normally distributed. Another assumption is that the variables OIL and INF are not multicollinear, and are exogenous to EXI.

Following this, to test the short-term effect of crude oil price and inflation on algae export, the model used is the ECM model (Asteriou and Hall, 2021) with the equation:

$$D\,(EXI_t) = \beta_0 + \beta_1\, D\,(OIL_t) + \beta_2\, D\,(INF_t) + \pi\, EC_t + u_t \quad (2)$$

Where β_0, β_1, and β_2 are the parameters of the regression equation. Variable $D\,(EXI_t)$ is the first differentiable variable of EXI_t with $EXI_t = EXI(0) - EXI(1)$. Coefficient π is negative and is called the error correction coefficient, meanwhile, EC_t is called the ECM model error correction variable.

Accordingly, in order to examine the long-term and short-term effects of crude oil prices and inflation on algae exports, several testing steps were carried out. The first step was to test the stationarity of the three variables of crude oil price, inflation, and algae export. The stationary test used was the Phillips-Perron test or simply the PP test (Phillips and Perron, 1998).

The second step involves testing the cointegration between the crude oil price, inflation, and algae export. In this test, the Engle-Granger cointegration test (Engle and Granger, 1987) was employed and this test can only be used if the three variables, which are the crude oil price, inflation, and export, are stationary at the first difference. The steps for the Engle-Granger cointegration test are (i) estimate the regression equation (1) and suppose the result is:

$$Y = \hat{\alpha}_0 + \hat{\alpha}_1 OIL + \hat{\alpha}_2 INF \quad (3)$$

(ii) Generate time series EC_t using equation (3), where EC_t fulfilled equation (4) as follows.

$$EC_t = Y_t - \hat{\alpha}_0 - \hat{\alpha}_1 OIL_t + \hat{\alpha}_2 INF_t \quad (4)$$

Furthermore, the stationarity test EC_t was performed with the PP test. If EC_t is stationary at the level or integrated at order 0, I(0) then it can be concluded that the crude oil price, inflation, and algae export are cointegrated or have a long-term relationship.

The third step is to test the residual (error) assumptions u_t, the multicollinearity assumption, and the exogeneity of the OIL and INF variables. Meanwhile, the autocorrelation, heteroskedasticity, and error normality were tested using the Breusch-Godfrey Serial Correlation LM (BGSLM), Arch, and Jarque Bera (JB) tests respectively. The variance inflation factor (VIF) test was used to test the multicollinearity between OIL and INF. The two independent variables in the model (1) do not have multicollinearity if the VIF value is <10 (Rawlings et al., 1998: Cohen et al., 2003; Doane and Seward, 2011). Following this, the exogeneity of the OIL and INF variables was tested using the Durbin-Wu-Hausman (DWH) test, also known as the J-statistic test. The DWH test was distributed as a Chi-Square with degrees of freedom df=2 (number of independent variables). The hypotheses of the DWH test are:

H_0: OIL and INF are exogenous against EXI but the alternative hypothesis indicated that:
H_1: OIL and INF are endogenous against EXI (Davidson and Mackkinon, 1993; IHS-Markit, 2020).

4. RESULTS AND DISCUSSION

4.1. Results

The first step in examining the long-term and short-term effects of crude oil price and inflation on algae export is to test the stationarity of all the variables using the PP test as presented in Table 1. Based on the data, the three variables are stationary at the first difference.

Table 1: Results of the PP test

Variables	Level		First difference	
	Intercept	Intercept and trend	Intercept	Intercept and trend
OIL	−2.103300	−0.446651	−1.866325	−3.683547**
INF	−21.89444*	−1.153438	−0.091908	−3.904522**
EXI	−1.944209	−2.570089	−3.158795**	−2.466065

*, ** significant at 1%, 10%

The second step is to test the co-integration between crude oil price, inflation, and algae export by testing the stationarity of the EC variable using the PP test, as shown in Table 2. The EC error correction variable was found to be stationary at the level, indicating that crude oil price and inflation are co-integrated with algae export. In other words, crude oil price and inflation have a long-term relationship with algae export.

Furthermore, the third step is to estimate the long-term co-integration model parameters in Equation (1), and the ECM model in equation (2) using the ordinary least squares method, the estimation results are presented in Table 3. In panel A, the long-term coefficient of crude oil price and inflation is positive and significant at a 1% significance level. This means that both the crude oil price and inflation have a positive impact on algae export in the long term. In panel B, the short-term coefficient of inflation is positive, but only the coefficient of crude oil price is significant. In other words, the crude oil price affects algae export in the short term but inflation does not.

The final step is to test the model assumptions. From the p-value of the BGSCLM, Arch, and JB tests listed in Table 3, it was found that the error model does not have autocorrelation, is homoscedastic, and is normally distributed. Following this, the VIF calculation results are shown in Table 4. The VIF values of the two variables, OIL, and INF, are less than 10, indicating that there is no multicollinearity in the multiple regression model between crude oil price, inflation, and algae export. Furthermore, the DWH test statistic (J-statistic) is 0, which is less than its critical value at a 5% significance level of 5,991. This shows that variables OIL and INF are exogenous to EXI.

Table 2: PP test results for cointegration

Variables	Level	
	Intercept	Intercept and trend
EC	−3.784231*	−2.868480

*significant at 1%

Table 3: Estimating long and short-term coefficients model (1) and model (2)

Intercept and variable independent	Coefficient	t-statistics	P-value
A. Long-term effect, dependent variable: EXI			
C	−3.551804	−1.145882	0.2895
OIL	0.658244	3.546385	0.0094
INF	2.612401	5.087683	0.0014
F-statistic			0.004446
B. The short-term effect, dependent variable: D (EXI)			
EC (−1)	−1.232028	−3.230522	0.0232
D (OIL)	0.440840	3.110576	0.0265
D (INF)	4.086888	1.680641	0.1537
C	−0.051015	−0.502901	0.6364

The P values of the test statistics based on the Chi-square of BGSCLM, Arch, and JB are 0.0966, 0.4271, and 0.734081, respectively

Table 4: VIF values

Variable	Coefficient variance	VIF
OIL	0.034451	1.878596
INF	0.263657	1.878596

VIF: Variance inflation factor

4.2. Discussion

The data analysis shows that, partially, the crude oil price has a positive and significant effect on algae export in both the long and short terms. The long-term coefficient of the crude oil price variable is 0.658244, which means that for every 1 USD increase in crude oil price, algae export increases by 0.658244 USD. This result is in line with the theory presented by Faria et al. (2009). The result is also consistent with the combination of the wealth effect theory (Cologni and Manera, 2008; Abel et al., 2020) and the comparative advantage theory (Dodaro, 1993) where it was stated that an increase in crude oil price leads to an increase in export.

Partially, inflation also affects algae export in the long term and the coefficient of the inflation variable is 2.612401. Therefore, the effect of inflation on economic growth is positive, where for every 1 unit increase in the consumer price index (inflation), algae export increases by 2.612401 USD. This finding is in accordance with the combination of the interest rate parity theory presented by Pilbeam (2006) and the trade theory presented by Ali et al. (2014), where it was concluded that inflation drives export.

Lastly, according to the results, this study recommends that the Indonesian government pay more attention to changes in crude oil prices and inflation when exporting algae. An increase in crude oil price and inflation indicates that algae export activities can be carried out. This is also aimed at increasing foreign exchange.

5. CONCLUSION

Algae is a type of chlorophyll-containing plant that grows in coastal waters. This plant is found in almost all coastal waters of the islands in Indonesia since Indonesians use coastal areas for algae cultivation. Due to its economic benefits, the government has been developing different cultivation methods for this plant with the aim of increasing production, as an export commodity.

Two previous studies have examined the effect of economic growth on algae export in Indonesia. This study is a continuation of those studies, with its focus on the factors of crude oil price and inflation, which theoretically have a positive correlation with export.

Furthermore, in this study, the analysis models used are the multiple cointegration regression and the ECM models, each of which is useful for testing long-term and short-term effects. First, the model requirements were tested, which involves testing the stationarity of variables, crude oil price, inflation, and algae export, and the results showed that the variables were stationary in the first difference. A cointegration test was also performed, where the crude oil price and inflation were cointegrated with algae export.

Additionally, parameter estimation, which was carried out using the least squares method, showed that in the long and short term, crude oil price positively affects algae export. This means that an increase in crude oil price proportionally increases algae export. In the long term, inflation also positively affects algae export, meaning that an increase in inflation drives export. However, in the short term, only crude oil price positively affects algae export.

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