How Exchange Rate, Refinery Capacity, Consumption, and Petroleum Power Generation Respond to the Risk of Oil Import Shocks

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Abstract. Indonesia's oil reserves and oil availability currently show a dwindling supply while consumption of oil has increased continuously. As consequence Indonesia import a lot of petroleum that always fluctuated. This study aimed to analyses how exchange rate, refinery capacity, consumption, and petroleum power generation respond to Indonesia's crude oil import that is a risk of shock. The data were from British Petroleum and CEIC and used the Vector Autoregressive (VAR) method and a test of Impulse Response Function (IRF). The results show that the exchange rate and power generation variables petroleum give a fluctuating response when there is a shock of oil imports, and vice versa. In contrast, the variables of refinery capacity and oil consumption give a negative response on oil import when there is a shock of oil imports

Keywords: Import, petroleum, VAR, IRF.

1 Introduction

Petroleum is a natural resource that must be processed to be consumed. So, a refinery is needed to carry out the processing. However, reserves of oil production and consumption in Indonesia indicate that the availability of oil in the long term is running low. Indonesia's proven oil reserves from 1980 to 2019 amounted to 11.6 thousand million billion barrels and decreased to 2.5 thousand million billion barrels on Figure 1. In the same time span, in terms of oil production, it was 1,577 thousand barrels per day, down to 781 thousand barrels per day. This shows that Indonesia's oil production capacity is decreasing. In contrast to the world's consumption of crude oil, which consists of crude and fuel which showed an increase from 386 thousand barrels per day to 1,732 thousand barrels per day [1]. From this situation, Indonesia must import petroleum to meet consumption. Petroleum is a natural resource that is still being used for consumption and production purposes. The refined petroleum products consist of fuel oil (BBM) and non-fuel oil (BBBM). Fuel products consist of Avgas, Avtur, Gasoline, Kerosene, Diesel Oil, Diesel Oil, Fuel Oil and BBM products consist of Lube Base Oil, Asphalt, Ready Wax, Naphthan, and Low Sulfur Waxy Residue. In 2000-2015 refinery capacity in Indonesia experienced an insignificant increase from 2000 to 2015 [1] [2].

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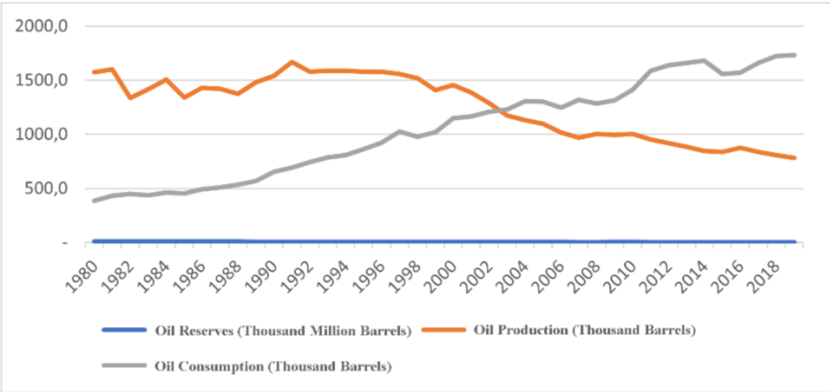

Fig 1. Petroleum reserves in Indonesia from 1980 to 2018 [1].

Indonesia uses petroleum as a raw material for power generation. Transmission-wise, power plants have a rotating engine that converts heat from combustion into energy through steam which is used to operate an electric generator. From 1985 to 1993, petroleum power plants contributed the most compared to gas and coal in generating electricity [1]. However, since then, the contribution of crude oil for power plants has decreased [1]. Under these conditions, Indonesia must import petroleum, with transactions using the United States Dollar/USD or foreign exchange rates. Based on **Figure 2**, the foreign exchange rate of the Rupiah against the Dollar from year to year tends to increase. This can mean that in the long term the Rupiah will depreciate by the US Dollar which will reduce the ability to import petroleum in units of output.

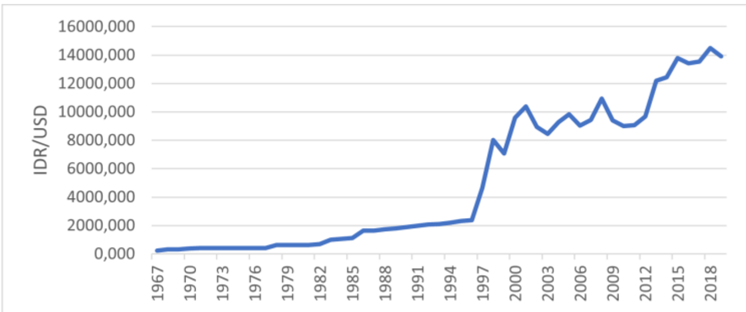

Fig 2. Foreign Exchange Rates IDR/USD exchange rate 1967 – 2019 [3]

Indonesia was one of the oil exporters until 2003 due to higher oil production than oil consumption. So that with excess production, Indonesia chooses to export petroleum. However, since 2004, oil production can no longer meet domestic needs [4]. Based on **Figure 3**, in 2003 and 2004, the trend of oil production and consumption of crude oil had an intersection where the rate of oil production could not keep up with the rate of consumption of petroleum. The increase in Indonesia's oil consumption is the impact of economic growth and population growth [5]. From 1980 to 2019, Indonesia's population had an increasing trend. This increase in population will result in increased consumption of petroleum. So that from 2004 to 2019, Indonesia has experienced dependence on imports of petroleum and fuel.

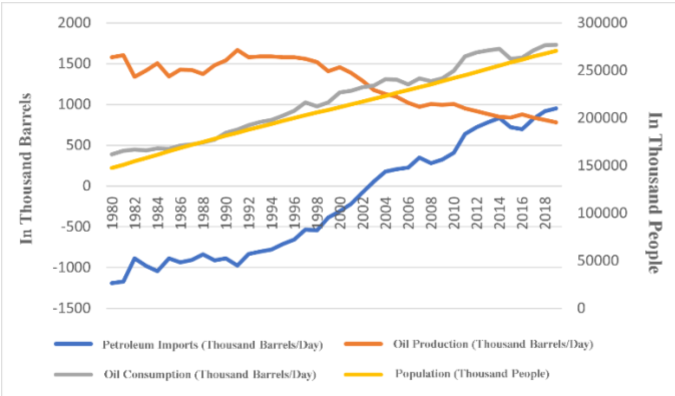

Fig 3. Comparison of Oil Production, Consumption, Imports of Petroleum, and Population in Indonesia 1980 – 2019 [1] [2].

In fulfilling its oil supply, Indonesia must import. In Indonesia, there are factors that influence dependence on imports of petroleum, including: imbalance between consumption and production of petroleum, oil production that is not yet equal to being able to meet refinery capacity, the continued use of petroleum in producing electricity at power plants, and the exchange rate. foreign exchange rates that can interfere with the amount of crude oil imports. Seeing these factors, this study aims to analyze how the exchange rate, refinery capacity, consumption, and petroleum power generation respond to Indonesian crude oil imports which are at risk of oil import shock.

2 Method

This research was conducted in Indonesia for a period of 44 (four) months and 15 days, from September 2020 to January 2021. The data used in this study is secondary data obtained from various valid sources. The data is time series data for the annual period from 1989 to 2019. The collection of data and information is carried out through a literature review through previous research and existing sources. The data comes from British Petroleum and CEIC and uses the Vector Autoregressive (VAR) method and the Impulse Response Function (IRF) test.

This research was conducted using StataMP 16.0 software using the Vector Autoregressive/Vector Error Correction Model (VAR/VECM) analysis method. The VAR model uses static and dynamic equation models and influences each other [6]. One of the objectives of this study is to analyze how the exchange rate, refinery capacity, consumption, and petroleum power generation respond to Indonesia's crude oil imports. Several tests were carried out in this study, namely stationarity test, determination of optimal lag, cointegration test, VAR/VECM, Granger Causality Test, Lagrange-Multiplier Testtest (LM Testtest), stability test, and Skewness-Kurtosis Testtest. The causal relationship can be done on the VAR/VECM model and can use the Granger Causality Testtest. Assumptions from Granger Causality Testtest with valid information and only obtained in time series.

Impulse Response Function (IRF) equation can provide information on the response of variable X to shocks to variable Y [7], so that it can see the response due to shocks to variable Y by one standard deviation of variable X.

$$F = (ń -) \frac{RSS_R - RSS_{UR}}{m(RSS_{UR})} \quad (1)$$

Description:

RSS_R : *Residual Sum of Squares* equation *restricted*
RSS_{UR} : *Residual Sum of Squares* equation *unrestricted*
ń : Number of observations
m : Number of *lags*
ķ : The number of estimation parameters in the equation unrestricted

3 Result and discussion

Value Exchange rate is a variable that has a positive correlation with imports of petroleum. However, Indonesia was also dragged into the crisis, so that the rupiah exchange rate depreciated against the USD. In tackling the crisis, the government carried out various policies. However, in the process, the current refinery capacity is unable to process petroleum supplies from the total domestic production and imports of petroleum. Refinery capacity is a variable that has a correlation with crude oil imports. Consumption of petroleum is used to produce goods that can be consumed such as fuel, causing Indonesia to be vulnerable to fluctuations in the exchange rate of the rupiah against the United States dollar [4]. Petroleum consumption is a variable that has a positive correlation with imports of petroleum to meet the needs of petroleum power plants. Thus, Indonesia must continue to consider the supply of petroleum needs for petroleum power plants.

3.1 The Stationary Test

This test is conducted to ensure that the variables used are stationary in the first difference. The following are the results of the stationarity test. **Table 1** shows that at the level, all variables have an absolute value of the ADF test statistic that is smaller than the critical value of 5% or is not stationary at the 5% level. So that these results produce spurious regression which causes the data to have no relationship between variables.

Table 1. Stationarity Test Results

Level	***First***		***Difference***	
	Critical Value (5%)	ADF *Test Statistical*	*Critical Value (5%)*	ADF *Test Statistic*
er	-2,986	-0.904	-2,986	-5.454*
refcap	-2,986	-1,856	-2,986	-5,166*
consoil	- 2,986	-1,241	-2,986	-5.055*
egfo	-2,986	-1,826	-2,986	-5,550*
coi	-2,986	-0.277	-2,986	-5.067*

*Stationary at 5% level

Due to this condition, the researcher conducted a stationarity test at the first difference level. The results of the stationarity test at the first difference level show that all variables have an absolute value of the ADF test statistic that is greater than the critical value of 5% or stationary. So that the test produces the mean, variance, and autocovariance that remain the same at various lags or are constant.

3.2 The Lag Optimum Test

optimal lag is determined based on the Akaike Information Criterion (AIC), Hannah Quin Information (HQIC), Schwartz Bayesian Information (SBIC) minimum and maximum Likelihood Ratio (LR) marked with an asterisk (*). **Figure 4** shows that based on the interpretation (*), the optimal lag for the variables consoil, refcap, egfo, er, and coi is at lag 1.

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-855.223				4.0e+19	59.3257	59.3995	59.5615
1	-742.218	226.01*	25	0.000	9.5e+16*	53.2564*	53.6994*	54.6709*
2	-725.443	33.551	25	0.118	2.0e+17	53.8236	54.6358	56.4168

Endogenous: consoil refcap egfo er coi
Exogenous: _cons

Fig 4. Optimal Lag Determination Results

3.3 Cointegration Test

Cointegration test is used to determine the stability of the variables in the long term. Cointegration is a long-term relationship between variables, although partially it is not stationary, but can be stationary when the variables move simultaneously [8].

Table 2. Cointegration Test Results

Variable	Maximum Rank	***Trace Statistic***	***Critical Value*** **5%**	Information
er and coi	*rank* (0)	5,8512*	15,41	There is no cointegration
	rank (1)	0.1010	3.76	
refcap and coi	*rank* (0)	7.0740*	15.41	There is no cointegration
	rank (1)	1.2721	3.76	
consoil and coi	*rank* (0)	15.4032*	15.41	There is no cointegration
	rank (1)	0.6266	3.76	
egfo and coi	*rank* (0)	11.6894*	15.41	There is no cointegration
	rank (1)	0.0174	3.76	

Based on the results **Table 2** shows that the variables er, refcap, consoil, egfo have no cointegration with respect to coi. Based on the cointegration test and stationarity test, this study uses the first difference VAR analysis method.

3. 4 Stability Test

test was carried out to ensure that the VAR first difference lag-1 model was stable. The stability test results show that the first difference lag-1 VAR model has a modulus less than 1 (one) and the roots of characteristic polynomial are in the unit circle. Thus, the model in this study has been stable.

3.5 Granger Causality Test in the Relationship between Variables and Imports of Petroleum

Based on **Table 3** shows that the variables of consumption, refinery capacity, and petroleum power generation have a relationship with petroleum imports because the value of Prob > chi2 is greater than 5%. However, the exchange rate variable has no relationship with crude oil imports. The results of this study are in line with the research of [4] that the exchange rate has no negative and significant effect on imports of petroleum.

Table 3. Granger Causality Test Results

Relationship	Prob > chi2
There is a relationship between consoil and coi	0.801*
There is a relationship between refcap and coi	0.405*
There is a relationship between egfo and coi	0.082*
There is a relationship between er and coi	0.010

3.6 Lagrange-Multiplier Test

Model VAR first difference is a model that uses time series data. The decision making in this study is if the value of Prob > chi2 is greater than 5%, then it does not reject H0 which means it does not contain autocorrelation at lag 1. **Figure 5** shows that the first difference lag-1 VAR model does not contain autocorrelation because the value of Prob > chi2 is greater than 5%.

Lagrange-multiplier test

lag	chi2	df	Prob > chi2
1	13.3093	25	0.97248

H0: no autocorrelation at lag order

Fig 5. The results of the Lagrange-Multiplier

3.7 The Skewness-Kurtosis Test

BLUE test is a regression assumption that should not be violated in the time series, one of which is the normality test [9]. Decision making in this study is if the joint Prob value > chi2 is greater than 5%, then accept H0 which means the residuals in the data are normally distributed. **Figure 6** shows that the residuals in the data are normally distributed because the joint Prob > chi2 value is greater than 5%.

Skewness/Kurtosis tests for Normality

				joint	
Variable	Obs	Pr(Skewness)	Pr(Kurtosis)	adj chi2(2)	Prob>chi2
res	30	0.0969	0.1207	5.06	0.0796

Fig 6. Skewness-Kurtosis Test Results

3.8 Impulse Response Function

IRF is an analytical tool used to see the response due to the shock of a variable in each period to other variables. The variables used to see the response due to shocks are exchange rates with imports of petroleum (er-coi), consumption of oil with imports of petroleum (consoil-coi), refinery capacity with imports of petroleum (refcap-coi), and power plants. petroleum by importing petroleum (egfo-coi).

Figure 7 shows the response given by er when a shock occurs in coi and the response given by coi when a shock occurs in er. When a shock occurs in coi, er gives a positive response in the 1st, 2nd, 5th, and 6th periods and a negative response in the 3rd, 4th, 7th, and 8th periods. Meanwhile, when there is a shock to er, coi gives a positive response to the 3rd, 4th, 7th, and 8th periods and a negative response in the 1st, 2nd, 5th, 6th periods. In these conditions, when a shock occurs in the COI, er gives the largest positive response in the 1st period (6,60504) and the largest negative response in the 3rd period (0.409444). Meanwhile, when there was a shock in er, coi gave the largest positive response in the 3rd period (0.00062) and gave the largest negative response in the 1st period (0.010001). The er-coi condition indicates that the er-coi and coi-er IRF results give a fluctuating response.

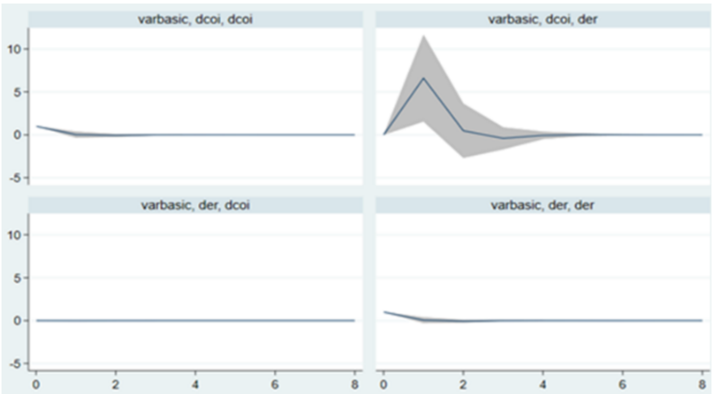

Fig 7. IRF Exchange Rate with Imported Crude Oil

Refinery capacity with imported crude oil (refcap-coi), based on **Figure 8**, these results show the response given by refcap when there is a shock to coi, and the response given by coi to refcap. When a shock occurs in the COI, refcap always gives a negative response from the 1st to the 8th period. Meanwhile, when a shock occurs in the refcap, COI always gives a negative response from the 1st to the 8th period. Under these conditions, when there was a shock to the COI, refcap gave the largest negative response in the 1st period (0.065039). Meanwhile, when there was a shock to the refcap, COI gave the largest negative response in the 1st period (0.552831). The condition of refcap-coi shows that the results of IRF refcap-coi and coi-refcap always give a negative response.

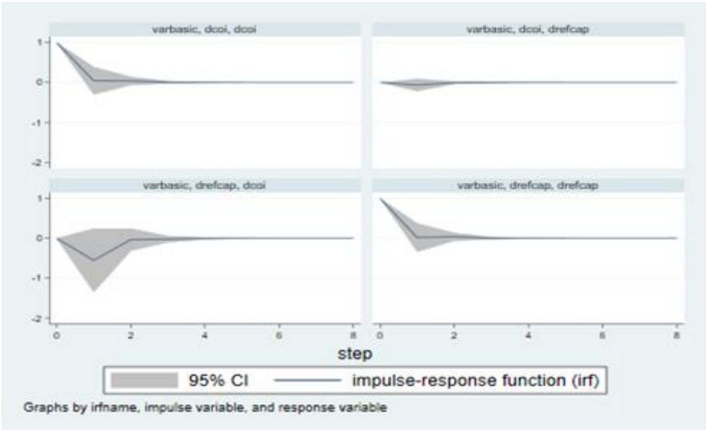

Fig 8. Refinery Capacity IRF with Crude Oil Imports

Based on **Figure 9**, when a shock occurs in the COI, the consoil always gives a negative response from the 1st to the 8th period. Meanwhile, when there is a shock to the consoil, COI always gives a negative response from the 1st to the 8th period. Under these conditions, when there was a shock to the COI, the consoil gave the largest negative response in the 1st period (0.050036). Meanwhile, when there was a shock to the consoil, COI gave the largest negative response in the 1st period (0.016896). The consoil-coi condition shows that both consoil-coi and coi-consoil IRF always give a negative response. This is in line with the research of [10] that the consumption of petroleum has a negative effect on imports of petroleum.

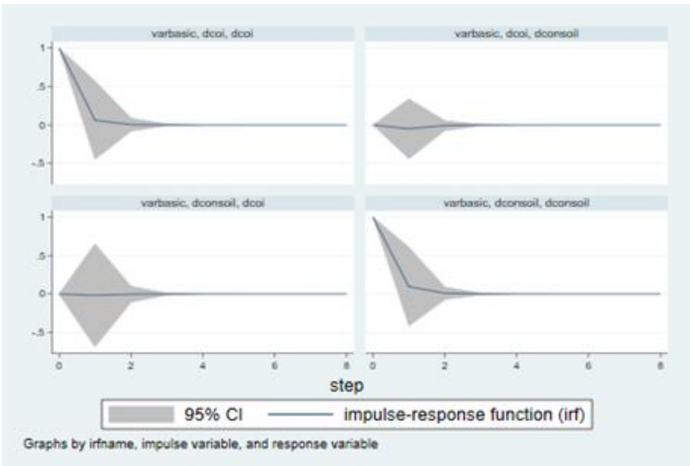

Fig 9. IRF Consumption with Imports of Petroleum

Based on **Figure 10**, these results will show the response given by egfo when there is a shock to the coi, and the response given by coi when there is a shock to the egfo. When a shock occurs in COI, egfo gives a positive response in the 1st, 2nd, 5th, and 6th periods and a negative response in the 3rd, 4th, 7th, and 8th periods. Meanwhile, when there is a shock to EGFO, COI gives a positive response to the 3rd, 4th, 7th, and 8th periods as well as negative responses in the 1st, 2nd, 5th, 6th periods.

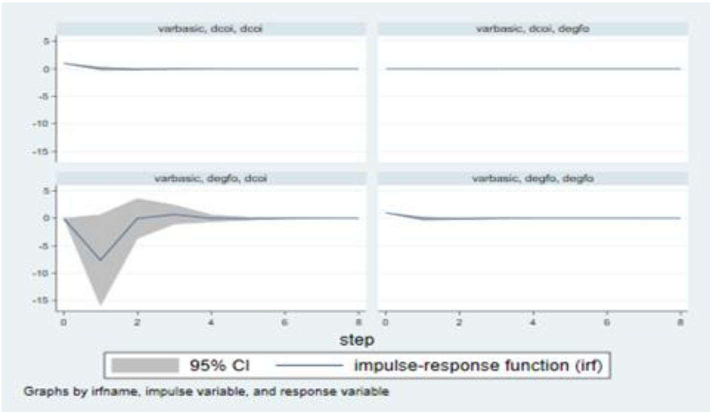

Fig 10. IRF of Petroleum Power Plants with Petroleum Imports

This condition occurs when shocks in coi, egfo give the largest positive response was in the 1st period (0.012278) and the largest negative response was in the 3rd period (0.001122). Meanwhile, when there was a shock to egfo, COI gave the largest positive response in the 3rd period (0.695403) and the largest negative response in the 1st period (7.61239). The condition of egfo-coi showed that the results of IRF egfo-coi and coi-egfo gave a fluctuating response.

4 Conclusion

This study has estimated the relationship of exchange rate, refinery capacity, consumption, and petroleum power generation to Indonesia's petroleum imports. The method used in this study is VAR first difference with several testing stages including: stationarity test, determination of optimal lag, cointegration test, stability test, Granger Causality test, Lagrange-Multiplier test, Skewness-Kurtosis test, Impulse Response Function, Forecast Error Variance Decomposition, and trend prediction.

The results of the causality test are that the exchange rate has no relationship to imports of petroleum. On the other hand, refinery capacity, oil consumption, and petroleum power generation have a relationship with oil imports. The results of the IRF estimation show that the exchange rate variable and the petroleum power plant provide a fluctuating response when there is a shock to oil imports, and vice versa. In contrast to the variables of refinery capacity and oil consumption, which always give a negative response when there is a shock to oil imports.

Based on the research that has been done, there is a need for synergy between the government, Bank Indonesia, and industries engaged in the oil sector. As described from the results of this study, Indonesia's oil consumption has a relationship with oil imports, contributes 51% to changes in petroleum imports, always gives a negative response when there is a shock to oil imports and a downward trend in the initial period. Therefore, to overcome the shock of oil imports, Indonesia must reduce dependence on petroleum consumption by massively diversifying energy consumption both in terms of consumption activities and production activities such as the use of Gas Fuel (BBG), D-100 and electricity.

Based on the results of the study, the exchange rate of the rupiah has no relationship with imports of petroleum. However, the exchange rate contributed 22% to changes in petroleum imports and gave a fluctuating response when there was a shock to oil imports. Therefore, to overcome this, the government and Bank Indonesia must enter into cooperation or agreements with petroleum exporting countries in terms of using the exchange rates of each country to carry out exports and imports of petroleum. After that, the government requires importers and exporters of Indonesian petroleum to diversify the exchange rate according to the exporting country and Bank Indonesia must also supervise these transactions.

Refinery capacity also has a relationship with petroleum imports. As described from the results of this study, refinery capacity contributes 2% to crude oil imports, always gives a negative response when there is a shock to oil imports, and Indonesian refinery products in the form of fuel and fuel have decreased. Therefore, to overcome this, stakeholders must accelerate refinery optimization through the refinery development master plan (RDMP) program to increase refinery yields in the form of fuel and fuel production.

Petroleum power plants also have links to petroleum imports. As described from the research results, petroleum power plants contribute 8.5% and provide a fluctuating response when there is a shock to oil imports. Therefore, to overcome this, stakeholders must diversify fuels through the conversion of petroleum power plants into gas fuel, biodiesel, and other fuels in accordance with the minimum price and maximum production.

The results showed that the exchange rate variable and petroleum power generation gave a fluctuating response when there was an oil import shock, and vice versa. On the other hand, the variables of refinery capacity and oil consumption give a negative response to oil imports when an oil import shock occurs.

References

[1] British Petroleum. Statistical review of world energy. London: British Petroleum; 2020.

[2] Central Bureau of Statistics. Production of several oil and gas refineries by type of refinery (000 barrels), 2000-2018. Jakarta: Central Bureau of Statistics; 2020.

[3] Chief Executive in Council. Indonesia exchange rate against USD. Hong Kong: CEIC data; 2020.

[4] Dewi MJ, Sudirman IW. Analisis Faktor-Faktor Yang Mempengaruhi Impor Minyak Bumi Di Indonesia Tahun 1996-2015. E-Jurnal EP Unud. 2017;6(7):1364-1394.

[5] Cabinet Secretariat RI. Presidential Regulation number 22 of 2017: General national energy plan. Jakarta: Secretariat of the Cabinet of the Republic of Indonesia; 2017.

[6] Juanda B, Junaidi J. Time series econometrics: theory and application. Bogor: IPB Press; 2012.

[7] Gujarati. DN Basic econometrics. 4th Edition. New York: McGraw Hill; 2003.

[8] Widarjono A. Ekonometrika: Teori dan aplikasi untuk ekonomi dan bisnis. Yogyakarta: Ekonisia: 2007.

[9] Firdaus M. Aplikasi ekonometrika untuk data panel dan time series. Bogor: IPB Press; 2011.

[10] Utama ER. Analysis of the factors affecting imports of crude oil in Indonesia. Journal of Economics and Policy. 2014;7(1):85-91.