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Priyadi, Unggul; Atmadji, Eko; Artiani, Listya Endang et al.

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## Kontakt/Contact

ZBW – Leibniz-Informationszentrum Wirtschaft/Leibniz Information Centre for Economics  
Düsternbrooker Weg 120  
24105 Kiel (Germany)  
E-Mail: [rights\[at\]zbw.eu](mailto:rights[at]zbw.eu)  
<https://www.zbw.eu/econis-archiv/>

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## Sustainable Energy Economic Policy: Population, Energy Consumption, and Macroeconomic Conditions

Unggul Priyadi<sup>1\*</sup>, Eko Atmadji<sup>1</sup>, Listya Endang Artiani<sup>1</sup>, Shahrina Md Nordin<sup>2</sup>, Muhammad Ridhuan Tony Lim Abdullah<sup>2</sup>, Mochamad Ali Imron<sup>2</sup>, Muhammad Alkirom Wildan<sup>3</sup>, Rohayu Che Omar<sup>4</sup>

<sup>1</sup>Department of Economics, Faculty of Business and Economics, Universitas Islam Indonesia, 55283 Yogyakarta, Indonesia,

<sup>2</sup>Department of Management and Humanities, Universiti Teknologi PETRONAS, Bandar Seri Iskandar 32610, Malaysia,

<sup>3</sup>Department of Management, Faculty of Economics and Business, University of Trunojoyo Madura, Bangkalan, 69162 Jawa

Timur, Indonesia, <sup>4</sup>Institute of Energy Infrastructure, Universiti Tenaga Nasional, 43000 Kajang, Malaysia. Indonesia;

\*Email: [unggul.priyadi@uii.ac.id](mailto:unggul.priyadi@uii.ac.id)

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### ABSTRACT

This study examines and analyzes the energy economic policy of Indonesia with population, energy consumption and its macroeconomic condition in the short-run and long-run. In the long run, this study found that the non-renewable energy will be replaced with renewable energy. One of Indonesia's imported energy commodities is fuel and engine oil consumer goods. Based on the unit root test results, the Autoregressive Distributed Lag (ARDL) Model is the most appropriate model used in this study. The coefficient of determination indicated by the R-squared is 0.967579, which means the model can explain 96.8% of the international trade and its macroeconomic factors on the volume of imported fuel and engine oil in Indonesia. This study uses independent variables like total population, vehicle volume, gross domestic product (GDP), exchange rates, and foreign exchange reserves. These variables were fruitful in explaining the critical factors in the imported volume of fuel and engine oil, which are essential public goods used in daily activities and have to meet the people's consumption. In addition, the result reveals that the interesting thing is in the long run, the total population negatively affects fuel and engine oil imports in Indonesia.

**Keywords:** Economic, Energy consumption, Population, Exchange rate, Autoregressive distributed lag

**JEL Classifications:** E20, F18, C15, F62

### 1. INTRODUCTION

International trade is one of the efforts to improve the growth and development of the economy. The condition of a country will be challenging to meet the needs of its people without the work together with other countries. International trade includes exports and imports. One of Indonesia's imported commodities is fuel and engine oil commodity (Chand et al., 2022; Long and Zhang, 2022). Fuel and engine oil was important to use in daily activities, and the price is essential to be controlled by the government, because it concerns the livelihood of million Indonesian people.

The phenomenon of fuel and engine oil imports raises pros and cons (Mao, 2016). Indonesia is an archipelagic country with

abundant natural resources, including petroleum (Friederich and van Leeuwen, 2017). The abundance of petroleum in Indonesia should be manageable to meet its people's engine oil consumption needs. However, petroleum production in Indonesia is decreasing while demand increases. One of the factors that triggered the increase in fuel and engine oil demand was the increase in motor vehicle volume.

The Indonesian Statistics (BPS) notes that the volume of vehicles each year continues to increase. The increased volume of motorized vehicles will undoubtedly increase the demand for fuel and engine oils. This situation will open up opportunities for domestic fuel and engine oil industry competition to develop innovations to seize market share. Based on data taken from BPS and the Ministry of Industry, the domestic engine oil industry can produce 1.8 million

kiloliters per year (Adyasari et al., 2021). Still, the production absorbed by the community is only about 47% of the engine oil produced. This means that as much as 53% or equivalent to 980-kilo liters of engine oil is not absorbed by the Indonesian market (Fan et al., 2020). This certainly causes Indonesian engine oil products to continue to experience a trade balance deficit.

The increase in population from year to year has made the government also have to be able to meet the needs of its population. The results of the population census conducted by BPS in 2018 show that Indonesia has a population of 267.7 million with a population growth rate of 1.1%. With increasing growth, Indonesia faces challenges in meeting the consumption needs of its people (Tritto, 2021). However, the Indonesian government must make new policies with limited production factors. International trade is one of the government's solutions to meet the consumption needs of the Indonesian people.

Concerning imports then closely related to the foreign exchange reserves, exchange rate, and the Gross Domestic Product (GDP). Foreign exchange reserves are a medium of exchange used in international trade transactions (Nafik et al., 2022). The Bank of Indonesia website article also states that Indonesia's foreign exchange reserves are safe if they can finance the country's needs for three months. Thus, foreign exchange reserves need to be considered in importing.

The exchange rate is also crucial when conducting an international trade payment transaction. If the IDR weakens, the price of the product to be imported will be higher and vice versa. The exchange rate plays an essential role in determining the volume of fuel and engine oil imports to Indonesia. Data taken from the World Bank states that the value of the IDR exchange rate against the dollar in 2020 weakened by IDR 14,105 compared to IDR 13,901 in 2019 (Utomo et al., 2021). GDP is also closely related to imports, one aspect of import financing. GDP growth plays an essential role in the country's growth. The amount of GDP will indicate how capable a country is of conducting international trade (Kurniawan and Managi, 2018).

## 2. LITERATURE REVIEW

### 2.1. International Trade on Energy Commodity

Trading internationally is a means to increase the welfare of the people in a country. According to (Wildan et al., 2021), a country making trade with other countries to gain an advantage for their respective countries, both countries are importers or country exporters. Importers do trade it to buy goods outside the country that are relatively inexpensive. Economists and others also argued that their trade internationally is caused due to the existence of a superiority comparative of each country. It makes each country speculate and earn a profit. Activity in international trading can be in the form of export and imports. Export is an activity to sell a commodity outside the country, while import is an activity to buy a commodity outside the country. Activity is not only done by the state forward, but countries developing also do it. There are several theories in international trade, including the Heckscher-Ohlin theory, the Leontief Paradox theory, and the Opportunity Cost theory. The

theory can help a country in analyzing the advantages that arise from international trade (Nafik et al., 2022; Wildan et al., 2021).

### 2.2. Consumption

Consumption is using goods or services to meet one's daily needs, such as primary and other goods. Consumer goods are goods (Long and Zhang, 2022; Utomo et al., 2021). Consumer goods are used in everyday life and are not used for productive activities. Consumer goods include all types of goods used for domestic purposes in the long, medium, and short term (Imron, 2021; Wildan et al., 2021; Nafik et al., 2021). Based on the function that indicates that the C symbolizes the total consumption of a household, a is the amount of consumption that does not impact revenue. At the same time, b is the desire of marginal communities to consume, and Y symbolizes the income of a home stair or state. When a country cannot meet its residents' needs for goods and services, then the way that a country does is by importing (Kurniawan and Managi, 2018).

### 2.3. Import

Import is a form of consumption of foreign commodities. Import is an activity of international transactions purchased in customs by complying with prevailing laws and regulations (Priyadi et al., 2021). This international trade activity occurs when a country cannot meet its people's needs, so it carries out import activities that are paid for using foreign currency (Ryandono et al., 2022).

### 2.4. Foreign Exchange Reserves

Foreign exchange is a tool of exchange that is used in trade internationally. Tool exchange that can be in the form of currency money has been recognized the world, gold, or letter worthwhile (Kumeka et al., 2022; Ryandono et al., 2022). In comparison, foreign exchange reserves are a whole tool exchange or assets that can be used by any who is in government power.

Reserves of foreign exchange have a role important in international trade. Reserves of foreign exchange are considered one of the indicators of a solid or weak country in the field of the economy (Chandrarin et al., 2022). Reserves of foreign exchange also determine the ability of a country can trade with other countries. So, reserve foreign exchange impacts positively on the import. Increasingly sizeable foreign exchange reserves can be interpreted as more great ability of countries to import goods from outside the country (Nafik et al., 2022).

### 2.5. Gross Domestic Product Per Capita

GDP per capita is divided by the population in a country. According to (Wildan et al., 2021) calculating GDP can use three approaches, namely, the approach to production, the approach to income, and the approach to spending.

GDP plays an essential role in international trade, especially imports. Increasingly large GDP then increasingly large also items which generated a state the goods can compete with goods from other countries (Ryandono et al., 2022). The GDP also determines the number of imports a country import. If the country has a GDP, that is an excellent means for the state with the ability to finance imports.

## 2.6. Exchange Rate

The exchange rate would be the value of a country's currency measured by the value of another country's currency if it were to trade with other countries (Jiang et al., 2022). Currency is the value of a country's currency expressed in another country's currency (Wang et al., 2022). When discussing international trade, it will not be separated from the exchange rate. Exchange rates are essential in international trade because they affect the purchase price from an exporting country to an importing country.

## 2.7. Total Population

The population is all people residing in a geographic area for at least 6 months. Increasing the population in a country will cause an increase in demand for consumer goods. Thus, increasing the population should be studied more to fulfill a country's needs (Kumeka et al., 2022).

## 3. RESEARCH METHODS

This study uses secondary data as a research source. Data is obtained through the Institute's official and reliable collection and uploading of data in a specified period via the internet. Software that is used to perform the processing of the data is the application Eviews 12. The data processing in the study is based on quantitative analysis with the method of Autoregressive Distributed lag (ARDL) in a test study of whether the variables independently affect the dependent variable. ARDL methods were used in the test study because testing stationery at the level does not give significant results, and the data used have lag or period several periods. The study uses a range of time, 30 years, from the year 1989 until the year 2020. The test is intended to determine and analyze the effect of a variable number of the population, the volume of vehicles, gross domestic products, the exchange rate value, and foreign exchange reserves to import fuels and engine oil in Indonesia.

Hence, the general ARDL model is

$$\Phi(L)yt = \varphi + \theta 1(L)x1t + \theta 2(L)x2t + \theta k(L)x3t + \theta k(L)x4t + \theta k(L)x5t + \mu t$$

Where: Y= Fuel and Engine Oil Consumption

X1 = Total Population

X2 = Vehicle Volume

X3 = Gross Domestic Product

X4 = Exchange Rate

X5 = Foreign Exchange Reserves

## 4. RESEARCH RESULTS AND ANALYSIS

### 4.1. Stationarity Test

The initial process of conducting this research is to perform a stationarity test. This test uses a Unit Root Test.

Tables 1 and 2 shows the results of testing Augmented Dickey-Fuller (ADF) of each variable. Known only one variable is significant at the different first level under the alpha value of

**Table 1: Stationarity test result**

Variabel	Augmented Dickey-Fuller		Information
	P-value	$\alpha=10\%$	
Y	0.7253	0.1	Not Stationary
X1	0.0017	0.1	Stationary
X2	0.9841	0.1	Not Stationary
X3	0.6412	0.1	Not Stationary
X4	0.3086	0.1	Not Stationary
X5	0.5975	0.1	Not Stationary

**Table 2: Stationarity test result at first different**

Variabel	Augmented Dickey-Fuller		Information
	P-value	$\alpha=10\%$	
Y	0.001	0.1	Stationary
X1	0.1672	0.1	Not Stationary
X2	0.0710	0.1	Stationary
X3	0.0341	0.1	Stationary
X4	0.0001	0.1	Stationary
X5	0.0040	0.1	Stationary

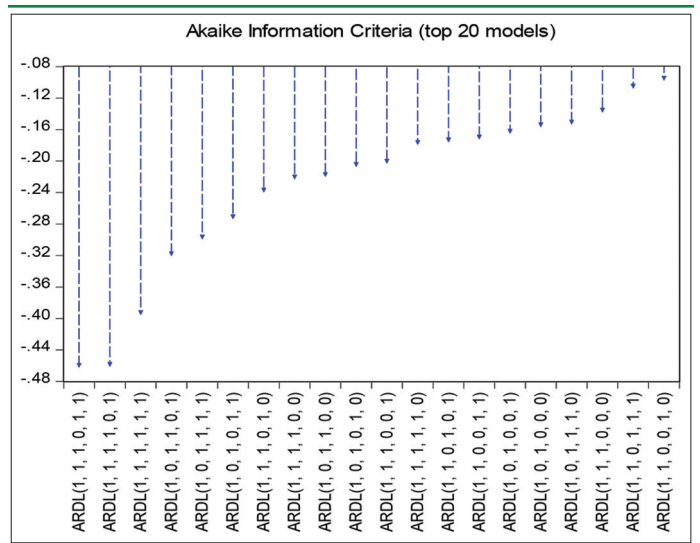
**Table 3: Autocorrelation test result**

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.914858	Prob. F (2,16)	0.4205
Obs*R-squared	2.976031	Prob. Chi-Square (2)	0.2258

**Table 4: Cointegration test result**

F-bounds test	Value	Null Hypothesis: No levels relationship		
		Signif. Asymptotic	I (0) n=1000	I (1)
F-statistic	8.470535	10%	2.08	3
k	5	5%	2.39	3.38
		2.5%	2.7	3.73
		1%	3.06	4.15

**Table 5: ARDL result**



10%. It can be concluded from the results of the test stationary at the top that the testing regression in research uses the method of ARDL.



**Table 6: Short run model test**

Variable	Coefficient	Prob.
DLOG (TP)	-290.0310	0.0000
DLOG (VV)	1.569015	0.0246
DLOG (EXR)	1.009291	0.0000
DLOG (FEXR)	0.079637	0.7103

**Table 7: Long-run model test**

Variabel	Coefficient	Prob.
C	222.7377	0.1044
LOG (IM(-1))	-0.860830	0.0001
LOG (TP(-1))	-12.30038	0.1131
LOG (VV(-1))	-1.291894	0.1601
LOG (GDP)	1.365684	0.1574
LOG (EXR(-1))	1.470752	0.0518
LOG (FEXR(-1))	0.938894	0.0687
DLOG (TP)	-290.0309	0.0348
DLOG (VV)	1.569015	0.1732
DLOG (EXR)	1.009292	0.2130
DLOG (FEXR)	0.079637	0.8484

**Table 8: F-test result**

Prob (F-statistic)	Critical Value $\alpha=10\%$	Information
0.00000	0.1	Significant

**Table 9: t-test result**

Variable	Coefficient	Prob.*
LOG (IM(-1))	0.13917	0.4127
LOG (TP(-1))	277.7306	0.0336
LOG (VV(-1))	-2.860909	0.0121
LOG (GDP)	1.365684	0.1574
LOG (EXR(-1))	0.461461	0.0165
LOG (FEXR(-1))	0.859257	0.0238
C	222.7378	0.1044

## 4.2. Autocorrelation Test

Table 3 Autocorrelation test result shows detection of this autocorrelation test uses the Breusch-Godfrey Serial Correlation LM Test method. The autocorrelation test results obtained probability value Chi-square of 0.2258 is more significant than  $\alpha$  of 10% that failed to reject  $H_0$ . It can be concluded that the data does not have autocorrelation.

## 4.3. Cointegration Test

Table 4. Cointegration Test Result, the cointegration test results show that the value of  $f$  calculated for the bound test is  $8.715159 > I(1)$  at 10%, which is three so that  $H_0$  rejects so that there is cointegration in the model.

## 4.4. ARDL Estimation Results

This study uses an Autoregressive Distributed Lag (ARDL) with Eviews 12 software for analyzing and testing the best model with Akaike Information Criterion (AIC).

## 4.5. Determination of the Optimum Lag

Based on Table 5. ARDL Result shows the determination of lag optimum, the aim of their determination of lag optimum is to determine the amount of lag or lapse of time contained in the

variable research. The lag best on a test model of ARDL is ADRL (1, 1, 1, 0, 1, 1) because it has the results of error most small when compared with the other models.

## 4.6. ARDL Estimation Results

This research tests an ARDL using lag in testing. This test uses the Eviews 12 software application when analyzing and testing with Akaike Information Criterion (AIC).

## 4.7. Conditional ECM

Testing Conditional ECM is used to test the results of the estimation in term length and in term short. Long-term testing of the ARDL regression results is used to see the dynamic relationship between variables.

Based on Table 6. Short-Run Model Test Result, it can be concluded that in the short run, the total population variable has a negative effect on the variable volume of fuel and engine oil imports in Indonesia. The volume of vehicle impacts positively on the import volume of fuel and engine oil in Indonesia. The exchange rate positively affects import volume variable material fuel and engine oil in Indonesia in the run short. In addition, in the short run, the foreign exchange reserve variable has no effect on the variable volume of fuel and engine oil imports in Indonesia.

Based on the result shown by Table 7. Long Run Model Test Result, it can be concluded that in the long term, the variable fuel and engine oil imports in Indonesia in the previous year will have a negative effect on the imports of fuel and engine oil in Indonesia in the current year. In the long run, the total population has a negative effect on fuel and engine oil imports in Indonesia, because in the future, the public transportation is cheaper and the vehicle company will produce only electrical vehicle without with uses more fuel and engine oil (Chand et al., 2022; Topalović et al., 2022).

## 4.8. Simultaneous Test (F-test)

The F-test aims to determine the effect of the independent variable on the dependent variable in a study. Based on the Table 8. F-test result, it is concluded that the probability obtained is 0.00 less than alpha 10%. This means that simultaneously the independent variable affects the dependent variable.

## 4.9. Partial Test (t-Test)

A partial test is a test that intends to test the effect of each independent variable on the dependent variable.

Based on table 9. t-Test result, it can be concluded that the variable fuel and engine oil imports in Indonesia in the previous year and the GDP variable did not have a positive effect on fuel and engine oil imports in Indonesia. Because in the current energy will be more to renewable energy like electric based energy (Chand et al., 2022). The Vehicle volume variable has a negative effect on the dependent variable because the current vehicle company uses electric energy (Topalović et al., 2022). While the variable of total population, exchange rate and foreign exchange reserve in one year earlier are influence positively on the dependent variable.

#### 4.10. Coefficient of Determination

The coefficient of determination is a test to determine how much influence the independent variable has on the dependent variable. The coefficient of determination indicated by the R-squared in this test results in 0.967579, or it can be explained that 96.7579% of the variable volume of fuel and engine oil imports in Indonesia is influenced by independent variables, namely the variable population, vehicle volume, gross domestic product, exchange rate, and foreign exchange reserves.

### 5. DISCUSSION

#### 5.1. Total Population and Imported Fuel and Engine Oil

The results of the study showed that in the short run, the number of the population impact positively on the variable volume of imports of fuels and engine oil in Indonesia. If the population increases, fuel, and engine oil imports will also increase to meet the people consumption. In contrast, for the long run, the total population has a negative effect on fuel and engine oil imports in Indonesia, because in the future, the public transportation is cheaper and the vehicle company will produce only electrical vehicle without with uses more fuel and engine oil (Chand et al., 2022; Topalović et al., 2022).

#### 5.2. Vehicle Volume and Imported Fuel and Engine Oil

The results of the study showed that the volume of vehicle impact negatively on the variable volume of imports of fuels and engine oil in Indonesia. The Vehicle volume variable has a negative effect on the dependent variable because the current vehicle company uses electric energy (Topalović et al., 2022).

#### 5.3. Gross Domestic Product and Imported Fuel and Engine Oil

The study's results showed that partial GDP does not affect imported fuel, and engine oil in Indonesia. Because the government decided to conduct imports considering their needs are urged by the national needs. So, the government should meet the needs by importing fuel and engine oil despite the Gross Domestic Product of Indonesia increasing or decreasing. This is correlate with the research carried out by (Ryandono et al., 2022; Utomo et al., 2021).

#### 5.4. Exchange Rate and Imported Fuel and Engine Oil

The study results indicate that the Exchange rate effect is positive toward the variable volume of imports of fuels and engine oil in Indonesia. The finding is in accordance with the research carried out by (Priyadi et al., 2021; Ryandono et al., 2022) that the exchange rate of the IDR against the US dollar affects positively. This means that if the value of the IDR exchange rate against the dollar increases, imports will also increase.

#### 5.5. Foreign Exchange Reserves and Imported Fuel and Engine Oil

The study showed that foreign exchange reserves positively impact the volume of fuels and engine oil imports. According to (Chen et al., 2022; Tarjo et al., 2021) when Indonesia's foreign exchange reserves increase, the volume of imports will also increase. It is

happened because Indonesia will be able to finance imports a lot when it has many foreign exchange reserves.

### 6. CONCLUSIONS AND SUGGESTIONS

#### 6.1. Conclusion

The variable volume of fuel and engine oil imports in Indonesia is influenced by independent variables, namely the variable total population, vehicle volume, gross domestic product, exchange rate, and foreign exchange reserves. Discussion Total Population and Imported Fuel and Engine Oil The results of the study showed that in the short run, the number of the population impact positively on the variable volume of imports of fuels and engine oil in Indonesia. In contrast, for the long run, the total population has a negative effect on fuel and engine oil imports in Indonesia, because in the future, the public transportation is cheaper and the vehicle company will produce only electrical vehicle without with uses more fuel and engine oil (Chand et al., 2022; Topalović et al., 2022). Vehicle Volume and Imported Fuel and Engine Oil The results of the study showed that the volume of vehicle impact negatively on the variable volume of imports of fuels and engine oil in Indonesia. Exchange Rate and Imported Fuel and Engine Oil The study results indicate that the Exchange rate effect is positive toward the variable volume of imports of fuels and engine oil in Indonesia. Foreign Exchange Reserves and Imported Fuel and Engine Oil The study showed that foreign exchange reserves positively impact the volume of fuels and engine oil imports. According to (Chen et al., 2022; Tarjo et al., 2021) when Indonesia's foreign exchange reserves increase, the volume of imports will also increase.

#### 6.2. Suggestions

Based on the research results, the suggestions proposed for the efficiency of fuel and engine oil imports in Indonesia are that national consumption is facing the challenges of an increasing population. Thus, the government is expected to develop renewable energy and pursue the domestic fuel and engine oil industry and should be able to meet national needs and also expected to be able to the stability of the IDR exchange rate through its fiscal and monetary policies.

### 7. COMPETING INTERESTS

The authors declare no conflict of interest and the funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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