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STUDY ON INTER-RELATION OF ENERGY CONSUMPTION AND ECONOMIC PERFORMANCE IN INDONESIA

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Abstract

Energy utilization is known to affect economic performance. Energy consumption fosters economic growth. Better economies consume more energy. This article analyzes the fuel consumption and GDP of Indonesia. The evaluation of economic performance is based on the GDP in US dollars and energy consumption in British ounces. 1980–2019 time series data. In 1998, Indonesia experienced a severe economic crisis, and again in 2002 and 2008. The HEESI, Ministry of Energy and Mineral Resources, provided secondary data on energy consumption, while the World Bank website provided GDP data. A VAR analysis examined their relationship. The data reveal a significant correlation between fuel and GDP in Indonesia. The Granger test confirms. Due to the unidirectional causality between GDP and fuel, only GDP has a statistically significant impact on fuel with a probability of 0.0455 (rejects Ho). This investigation is essential for Indonesia's energy policy.

Keywords: energy consumption; energy policy; financial crisis; GDP

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1. Introduction

Energy consumption and economic performance are known to have a reciprocal relationship. Energy economics research is intriguing due to the positive correlation between energy demand and GDP per capita income (Abosedra et al., 2015). Robledo & Sarmiento (2013) examined energy consumption and GDP in 10 Latin American countries: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, and Venezuela. Energy has supported Latin American civilizations for decades.

China has produced additional proof of the link between energy consumption and economic performance. According to the U.S. EIA (2021), due to its rapidly expanding economy, China is the biggest known energy consumer as well as manufacturer (1,4 billion people in 2019) due to its swiftly expanding economy. China's influence on the global energy market has grown due to its increasing energy demand. China's energy demand is anticipated to rise despite recent structural economic changes, and government initiatives promote cleaner fuels and energy efficiency.

According to Hu et al. (2015), Energy is a crucial factor in the financial transaction process. Institute National de la Statistique defines economic activity as a process that, based on inputs, results in the production of a commodity or the provision of a service (Buell et al., 2021). By aggregation, economic activities are separated into various sectors, such as agriculture, industry, construction, and commerce, among others. The production output of these sectors determines the financial performance of the economy.

The manufacturing industry is a part of the economic process. According to the IEA and the World Bank (2015), this sector consumes one-third of the world's primary energy. Energy consumption is required in manufacturing, where it is generally proportional to output. Thus, energy efficiency through energy management has attracted a large number of researchers. Existing research publications on manufacturing energy utilization (May et al., 2017; Gahm et al., 2016; Peng & Xu, 2014: Olanrewaju & Jimoh, 2014; Lee, 2014; Shrouf et al., 2015; and Mostafa et al., 2014) support this notion. In the developing world and social sciences, energy issues and their respective research are vital (Sovacool, 2014).

Strong economic development in Indonesia has accelerated the increase in energy demand. From 1980 to 2010, the total production of main energy sources increased 2.80 times, while energy consumption increased nearly fivefold (Mujianto, 2018). Energy is indispensable for national development. Energy can achieve a balance of social, economic, and environmental sustainable development objectives. Moreover, energy is the primary catalyst for the development of other sectors, particularly the industrial sector. The increased economic development, social welfare, and population growth will be associated with rapid energy consumption (Budiarto, 2011).

However, the significant increase in energy consumption will also create new challenges, particularly in terms of energy efficiency. Thus, it questions the sufficiency of GDP as an indicator of economic growth when applied to the valuation of essential services such as health care, insurance, education, R&D, etc. (Jacobs & laus, 2010). Energy consumption might indicate a nation's development.

Energy is an absolute requirement for effective productivity at work. The accessibility of energy is a vital contributor to GDP. The global technological advancement has lead to tremendous economic and social development. At the moment, coal, oil, and natural gas have been the primary sources of energy generation substances. Energy is a requirement for carrying out tasks. Energy availability is an essential component of economic expansion. Significant social advancements and economic expansion have resulted from the global industrial revolution.

The COVID-19 pandemic has caused unprecedented societal disruptions, including the closure of schools and economies and the straining of healthcare systems. The energy sector is not exempt from concerns regarding the consequences of the transition to renewable energy (Akrofi & Antwi, 2020).

The US economy confronts two significant shocks: the sharp drop in crude prices and the spread of the novel COVID-19 pandemic. (Sharif et al., 2020). These two factors have the potential to cause an indefinite financial crisis and drive the U.S. economy into a subsequent crisis.

COVID-19 has a substantially bigger influence on global security than on financial instability in the United States. On both ends of the spectrum, the COVID-19 risk is assessed variously and may at first be viewed as an economic depression. (Sharif et al., 2020). The Covid-19 pandemic and subsequent quarantine exacerbated global energy destitution and insecurity. Numerous governments implemented extraordinary provisions to protect those who used electricity during the blackout. (Mastropietro et al., 2020).

During the lockdown, numerous governments in various nations enacted emergency measures to safeguard energy consumers/people. Norwegian policy was motivated by three distinct objectives: preventing the national proliferation of the disease, moderating the financial consequences, and dealing with the societal repercussions of the government's approach (Ursin et al., 2020). Norway's policy is driven by three distinct objectives: a) preventing the virus from spreading within the country; b) minimizing its influence on the economy; and c) taking care of the repercussions for society of the diplomatic reaction.

2. Literature Review

Beginning in the 1970s, the world became aware of the importance of energy to all aspects of existence. The events of the past two years have nearly convinced everyone that we are facing a potentially catastrophic energy crisis. The global impact of this crisis has caused almost instantaneous unrest in developed nations. Energy has become a tool for exerting international leverage (Edward A. Walters and Eugene M. Wewerka, 1975). The economic and social ramifications of the energy crisis now dominate international politics.

Four significant conflicts precipitated the 1973 crisis. The first was the 1948 conflict against Israeli control of portions of the region. The second was the Suez Canal Crisis of 1956, in which Israel sought to expand its territory into the Gaza Strip. Thirdly, in 1967's Six-Day War, Israel was able to thwart an impending Egyptian offensive and win the war within six days. They captured the West Bank, the Golem Highs, and the Sinai Peninsula. Fourth, during the 1973 Yom Kippur War – an Israeli holiday – the PLO, aided by Egypt, Jordan, and Syria, launched a surprise attack against Israel. A few days into the conflict, the United States decided to send Israel weapons, ammunition, and other supplies (Sara Lorenzini: author PavelPeek).

Energy may fulfill an essential role in the growth of every nation. The global population will have quadrupled by the close of the twenty-first decade. A significant positive correlation exists between energy production and economic expansion. Every aspect of contemporary existence is affected by energy. The exponential growth of the global population is driving an exponential increase in energy demand (Adam et al., 2015).

Energy is a prerequisite for accomplishing tasks. The availability of energy is essential to economic success. Considerable human and financial development has occurred through widespread technological advancement. For many years, petroleum, natural gas, and coal have been utilized as power sources. (NurIqtiyaniIlham et al., 2020). Energy is a prerequisite for accomplishing a mission. The availability of energy is a crucial factor in propelling economic expansion. The interrelationships and interdependencies between energy and other industries will influence economic activity at both the macro and micro levels. At the macro level, energy will influence the productivity of key economic sectors, especially the Gross Domestic Product (GDP) of the country.

This document examines the connection among Indonesia's consumption of energy and its financial performance. This paper investigates and resolves two primary concerns, namely, What is the connections among these two? Exists a delay in the connection? Considered are all forms of energy utilized by any activity in Indonesia. On the other hand, the gross national product of Indonesia represents economic performance. Vector autoregression (VAR) is one of the most efficient, flexible, and user-friendly models for analyzing the relationship within energy consumption and economic performance. Sims (1980) popularized the VAR model within economics. Natural expansion of the multivariate autoregressive model. The VAR framework contributes to the dynamic behavior description and forecasting of financial time series. Granger (1981), Engle & Granger (1987), MacDonald & Power (1995), and Barnhill et al. (2000) are instances of authors who have examined the interactions among economic factors using the VAR and Vector Error Correction Models (VECM).

Engle and Granger (1987) It was recognized that, for cointegrated structures, the VAR in the initial differences would be overestimated, and the power source VAR in levels would disregard substantial limitations on the value vectors. While these restrictions may be fulfilled asynchronously, it is likely that imposing them will culminate in increased effectiveness and improved estimates. Consider a time-series system with level-one variables and cointegration relations. Instead of a vector error rate (VAR), this system uses a vector error correction

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model (VECM). Thus, Ahn and Reinsel (1990) and Johansen (1991) provided several techniques for predicting co-integrating matrices in full-order The VECM method is applicable to systems with greater than zero coefficient matrix values. Full-order VECM algorithms can be used to analyze brief dynamics and future interwoven relationships. Due to the reality that full-order VECM models assume something other than zero parameter array elements, complications could happen. In theoretically over-parameterized designs, the number of components to estimate grows proportionally to the square of the number of variables, although the levels of freedom are significantly lowered.

3. Research Methodology

Data and Graphical Representation

Considered were Indonesia's GDP and fuel consumption. The data on GDP (in billions of United States dollars (USD), current value) was obtained from the World Bank's website (Berg, 1999). And the data on energy consumption was gathered from the HEESI, KESDM (Ministry of National Development Planning/Bappenas, 2015), expressed in thousand barrels of oil equivalent (BOE). These periodic data span the years 1980 through 2019.

The data is displayed visually in Figure 1. The blue curve is the Indonesian GDP in billion USD. On the other hand, Indonesia's national energy consumption in BOE is the red curve. Indonesia's GDP increased steadily albeit slowly from 1980 to 1997. This is the period when Indonesia implements a five-year development plan (Repelita) in 6 stages, namely for 30 years. Repelita began in 1969 by Kansil (1970), so the period from 1980 to 1997 was the third to the sixth stage of Repelita. Rahmawati (2022), nevertheless from 1997 to 1998, there was a significant and drastic decline in GDP. This is due to the multi-dimensional crisis, the economic crisis that generally hit Asia (Berg, 1999), and in particular the political crisis of the end of the new order that has ruled Indonesia for about 30 years. After experiencing stagnant growth in 1999, Indonesia's GDP increased again from 2000 to 2012, even rapidly increasing in certain periods. From 2012 to 2015 the Indonesian economy contracted slightly.

Slowing investment growth, government consumption, and household consumption all contribute to and influence Indonesia's economic decline. In addition, the mining and quarrying industries contracted as a result of the decline in coal extraction. During the second quarter of 2015, the decline in economic growth was accompanied by an increase in inflation and a weakening trend in the Rupiah exchange rate. The exchange rate for the Rupiah at the end of the month in June 2015 was Rp 13,339/USD, according to the Ministry of National Development Planning/Bappenas (2015). Following that, the Indonesian economy grew swiftly again until 2019.

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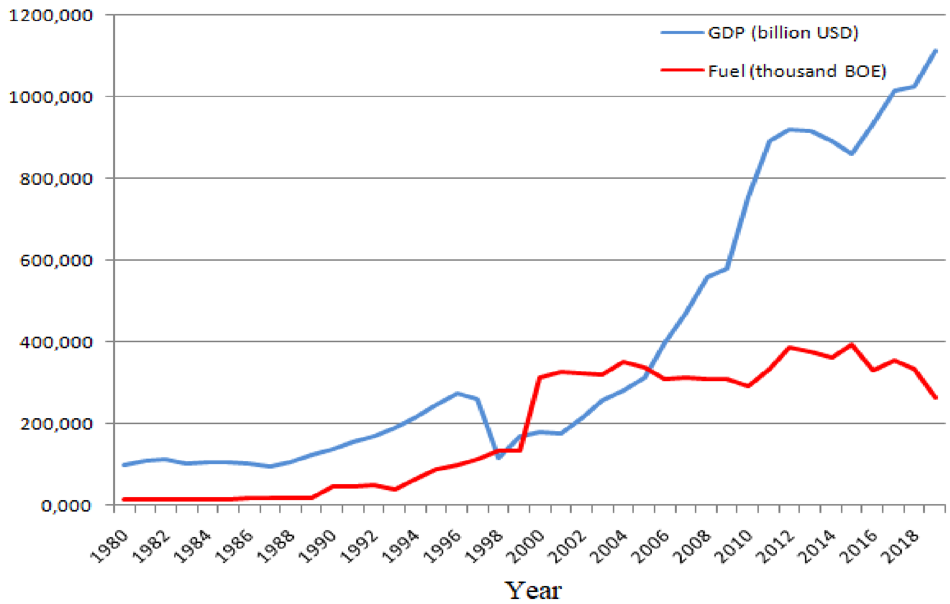

Fig. 1: Graphical representation of the GDP (blue) and fuel consumption data (red)

During the period between 1980 and 1997, however, the increase in energy consumption appeared to parallel the rise in GDP. Moreover, despite a significant decline in GDP between 1997 and 1998, energy consumption continued its upward trend from the previous period. In fact, in 2000, the increase in energy consumption was disproportionate to the expansion of the economy.

Since then, Indonesia's energy consumption has remained relatively stable; there has been no significant increase, and in 2019 it has declined relative to the previous year. Moreover, Figure 2 illustrates the ratio of fuel consumption per million USD of GDP.

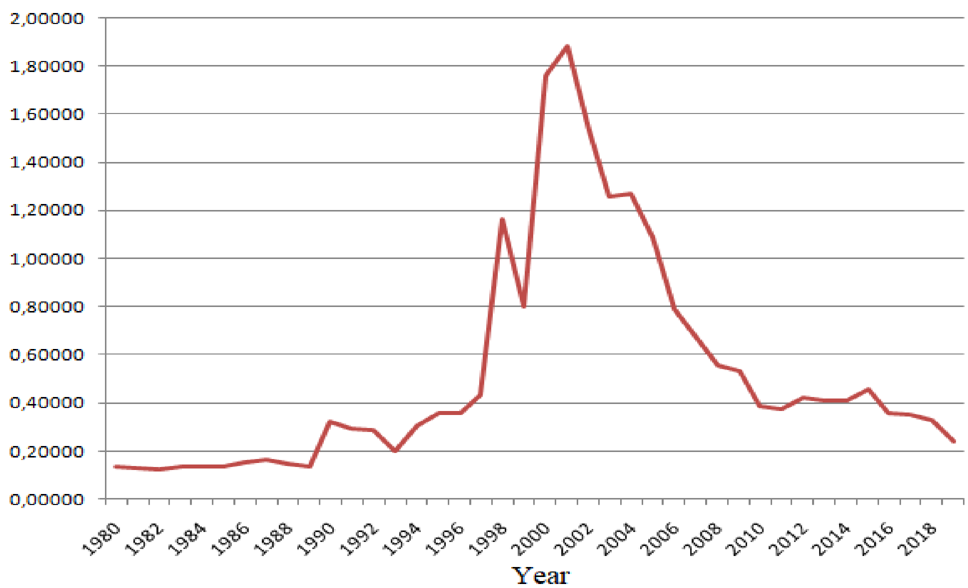

Fig. 2: BOE fuel consumption per million USD

Data Analysis Technique

The Agung (2009) proposed an LVAR (p, q) causal model, which was used as the basis for this study's methodology (Adam et al., 2015). Let $x = \ln X$, $y = \ln Y$, where X is the GDP in billion USD (current value) and Y is the fuel consumption in thousand BOE. The structure of the long-term trajectory of the connection among GDP and the use of energy is presented. consumption in thousands of BOE. The form shows a lengthy GDP-energy consumption link.

$$y_t = a_0 + \sum_{i=1}^{p} a_i y_{t-i} + \sum_{i=1}^{q} b_i x_{t-i} + \varepsilon_t$$

where p and q are time lag, and $\varepsilon_t$is an error term at time t.

According to *Heij et al.* (2004), in causative model (1), the coefficient (λ) of the parameter that is independent x to the associated variable y is given by

$$\lambda = \frac{\sum_{i=1}^{q} b_i}{1 - \sum_{i=1}^{p} a_i}$$

The value of (λ) reveals the nature of the dynamic association across the two data sets. $\lambda > 0$ represents a positive relationship and vice versa.

Use of the CON notation for fuel oil consumption, and GDI for gross domestic product.

$$Y_t = C + \sum_{i=1}^{p} \theta_i Y_{t-i} + \varepsilon_t$$

Where the coefficient $\theta_i (i = 1, 2, \dots, p)$ is the $n \times n$ matrix, C is the $n \times 1$ constant vector, and ε_t is the error (residual) $n \times 1$ which is identically distributed and independent with the mean vector 0, $\Omega. Y_t$ variances are the endogenous variable vectors with $Y_t = (GDI, CON)'$.

Equation (3) can be converted into the form of equation (4) which is called the error correction vector model (VECM).

$$D(Y_t) = C + \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i D(Y_{t-i}) + \varepsilon_t$$

Where the coefficient matrix Π is an error-correction matrix with $\Pi = \sum_{i=1}^{p} \theta_i - I, I$ identity matrix. Then the matrix Γ_i $(i = 1, 2, \dots, p-1)$ satisfies the equation $\Gamma_i = -\sum_{j=i+1}^{p} \theta_j, (i = 1, 2, \dots, p-1)$. The matrix Γ_i is called the short-term coefficient matrix, while Π is the long-term coefficient matrix.

Several categories of experiments are conducted to determine the link of causation between fuel and GDP. Determining the stationary nature of every variable is the first step. Utilizing the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1981). The initial assumption for this test is Ho: the time series is not stationary or has no unit root. The test requirement for this assumption is to dismiss Ho: if the likelihood value of the ADF number is less than the 1%, 5%, or 10% importance degree.

In the second step, we analyze the co-integration between oil consumption and GDP. If all variables are stationary in the first differential, we proceed in this manner. We use Johansen's test (Johansen, 1988) to examine the co-integration of these variables. Two tests comprise the Johansen co-integration test: the Max-eigen test and the Trace test. We use Max-eigen. The max- Eigen test statistic.

$$\lambda_{\max}(r, r+1) = -T\log(1 - \lambda_{r+1}),$$
$$r = 0, 1, \dots, k-1$$

with the formulation of the hypothesis H_0: There are r co-integration vectors, versus H_1: There are r+1 cointegration vectors (Brooks, 2014).

In the final stage, we estimate the parameters of the causal connection between oil consumption and GDP in order to verify its causality. As there are only two variables that originate, the VAR(p) model represents the Granger causality model between the two endogenous variables. At the level, the following equation represents the VAR(p) model:

$$GDP_t = C_1 + \sum_{i=1}^{q} \theta_{1i} GDP_{t-i} + \sum_{j=1}^{q} \vartheta_{1j} CON_{t-j} + \varepsilon_{1t}$$

$$CON_t = C_2 + \sum_{i=1}^{q} \theta_{2i} CON_{t-i} + \sum_{j=1}^{q} \vartheta_{2j} GDP_{t-j} + \varepsilon_{2t}$$

The formulation of the hypothesis testing the connected interactions throughout fuel to GDP in equation (Abosedra et al., 2015) is $H_0 : \vartheta_{11} = \vartheta_{12} = \cdots = \vartheta_{1p} = 0$ (there is no linked association regarding fuel to GDP) versus H_1: there is at least one$j$ $(j = 1, 2, \dots, q)$ with $\vartheta_{1j} \neq 0$ (there is at least one relational intimacy impact of fuel to GDP). Similar to verifying the unidirectional causal link between GDP and fuel in equation.

In the final phase, we examined the classical assumptions (autocorrelation, homoscedasticity, and residual normality). In this phase, we also examine the variance decomposition (VD) and the impulse response function (IRF).

4. Result

Using the ADF test, we first examined the stationarity of oil consumption and GDP. Table 1 displays the results of this test. Oil consumption and GDP are stationary at the first difference, but not at the level.

Table 1: ADF test statistics

Variable	Level	Difference
FUEL	-1.142706	-5.733476*
GDP	1.702967	-4.218910*

*Note: * means significant at 1% significance level*

Then, we conduct a cointegration test between oil consumption and GDP. Table 2 exhibits Johansen co-integration test statistics. At 5% significance, the Max-eigen test has less statistical significance than critical values. Oil consumption and GDP are not interdependent.

Table 2: Johansen cointegration test

Null hypothesis (H_o)	Max-eigen test	
	Statistical value	Critical value 5%
$r = 0$	13.832	14.265
$r \leq 1$	3.660	3.841

We estimate the model in the first differential in the third phase. We first ascertain the time lag's duration. Tabulated in Table 3 are the statistical values of the information criteria: Akaike information criterion (AIC), Schwarz information criterion (SC), and Hannan-Quinn information criterion (HQ).

Table 3: statistical values of the information criterion

Lag p	AIC	SC	HQ
0	21.084	21.175*	21.114
1	21.044	21.316	21.13588
2	20.812*	21.265	20.964*
3	21.005	21.640	21.218
4	21.120	21.936	21.395
5	21.343	22.341	21.679
6	21.350	22.529	21.747

*Note: * means the smallest value of the information criteria.*

Based on the information criteria of AIC and HQ, p=2 represents the shortest time latency. Next, we estimate the VAR (2) model for the first differential. Table 4 displays the VAR (2) estimation results.

The historical GDP coefficients for lag 1 and lag 2 were both 1 %, whereas the oil consumption coefficients were not. GDP has an effect on energy consumption. Simply stated, the GDP affects the consumption of oil. The Granger causality test utilizing the F test yields a value of 0.0455, which is below 5%, confirming this conclusion.

GDP is unaffected by energy consumption over the long term. Valid are the VAR-(2) coefficients for oil consumption and GDP. The probability values for the Breusch-Godfrey Serial Correlation LM, Breusch-Pagan-Godfrey, and Jarque Bera tests are greater than 1% based on autocorrelation, homoscedasticity, and normality.

Table 4: Model VAR-(2) in the first difference

Independent variable	Dependent variable	
	D(FUEL)	D(GDP)
D (FUEL (-1))	0.254**	-0.343
D (FUEL (-2))	0.0340	0.037
D (GDP (-1))	0.393*	0.255
D (GDP (-2))	-0.477*	0.108
C	6.409	20.664

*Note: ** significant at the 1% or 5% level of importance. The probability values of test statistics based on Chi-square statistics: Breusch-Godfrey Serial Correlation LM, Breusch-Pagan-Godfrey, and Jarque Bera are 0.751, 0.858, and 0.016*

We evaluate VD and IRF migration. Table 5 displays VD's contribution to GDP shock consumption for ten periods. The contribution of GDP ranged from 28.078% in the second period to 38.422% in the tenth.

Table 5: Variant Decomposition (VD)

Period	D(FUEL)	D(GOP)
2	71.922	28.078
6	61.695	38.305
8	61.591	38.409
10	61.578	38.422

To determine the behavior of the GDP shock to oil consumption and the oil consumption shock to GDP, we present in Figure 3 an IRF graph.

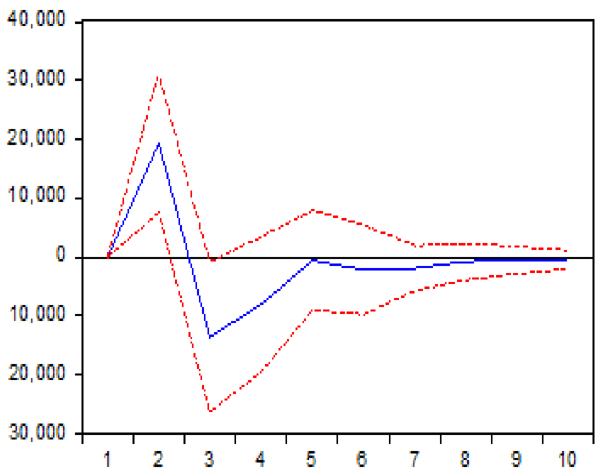

Figure 3: Response GDP to oil

The correlation between oil consumption and GDP is positive until the third period, after which it becomes negative until the tenth period. Oil consumption has a negative impact on GDP from the first period to the end of the tenth period. (Figure 4).

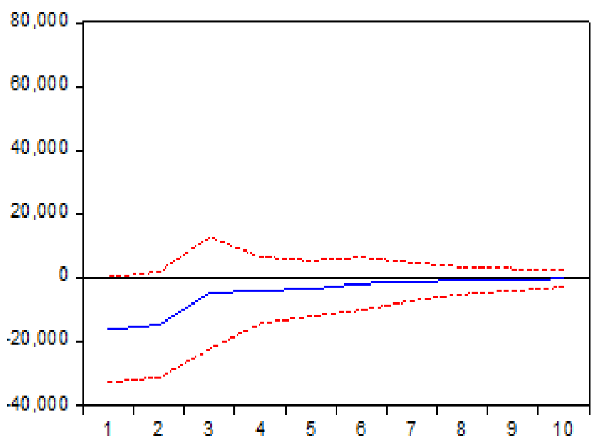

Figure 4: Response oil to GDP

5. Conclusion

Production requires energy. Thus, all nations, including Indonesia, require oil. Annually, Indonesia's oil consumption increases. The GDP also rises. This study examines the correlation in Indonesia's GDP and fuel consumption. The VAR model analyzes this causal relationship utilizing data from 1980 to 2019.

The gross domestic product and energy consumption are unrelated. Oil consumption has minimal effect on GDP over time. Granger causality and short-run VAR reveal the unidirectional relationship between GDP and oil consumption.

Weaknesses and Future Studies

This study is limited to presenting data on the magnitude of the relationship or links between variables in order to provide a thorough explanation of the causal relationship. Future analysis must disclose and explain thoroughly in order to make predictions/forecasts of future energy consumption trends and to serve as a guide for the government in determining the direction of national energy policy.

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