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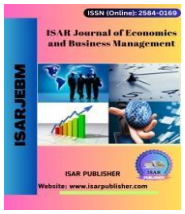

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Exchange Rate Depreciation, Oil Prices, and Energy Intensive Growth: Evidence of Inelastic Energy Import Demand in Indonesia

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Abstract: *Dependence on energy imports remains a crucial challenge for Indonesia as a net oil importer facing increasing energy demand, exchange rate volatility, and global oil price fluctuations. This study aims to analyze the effect of exchange rates, Brent crude oil prices, and economic growth on energy imports in Indonesia. This study uses a multiple linear regression approach with annual time series data (1990–2023). The research data was obtained from the World Development Indicators (World Bank) and the U.S. Energy Information Administration (EIA). Based on the regression results, it was found that exchange rate depreciation did not reduce energy imports, due to the inelastic nature of energy demand and the strategic role of energy as a fundamental input in the production process. Similarly, the increase in world oil prices also correlates positively with the increase in energy imports in Indonesia. This is due to domestic fuel price controls, limited international price transmission, and limited domestic production and refining capacity. Furthermore, based on the results of this research, it was found that economic growth emerged as the main driver of energy imports, indicating that Indonesia's economic expansion during the research period was still energy intensive and highly dependent on fossil fuels. The results of this study show that exchange rate mechanisms and oil price fluctuations alone are not sufficient to reduce energy imports in Indonesia. These results emphasize the importance of implementing structural energy policies, which include improving energy efficiency, expanding domestic production and refining capacity, and accelerating diversification towards alternative energy sources. Such interventions are crucial in order to reduce dependence on imports, mitigate vulnerability to external shocks, and strengthen national energy security in a sustainable manner.*

Keywords: *Exchange Rate, Brent Oil Price, Economic Growth, Oil Demand*

Introduction

Energy is a fundamental pillar that supports the performance of modern economies, both in developed and developing countries. Energy does not only function as an input for production and transportation, but also plays a strategic role in maintaining price stability, controlling inflation, and determining macroeconomic balance. Currently, Indonesia's domestic energy production continues to decline, while national energy consumption continues to increase in line with economic expansion, urbanization, and industrialization. The imbalance between domestic energy production capacity and national energy demand has prompted Indonesia to shift from being an energy exporter to an energy importer. This has led to increasing dependence on energy imports and made the national economy more vulnerable to external shocks, both from the global energy market and exchange rate dynamics. In this case, energy imports are no longer merely an international trade phenomenon, but have become a source of structural vulnerability in Indonesia's macroeconomic system.

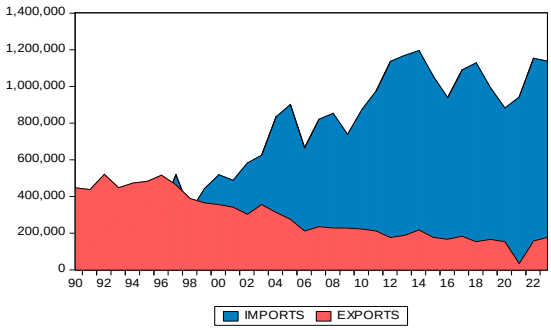

Figure 1. Perkembangan Export dan Import Energy Indonesia, 1990-2023
Source: Energy Information Administration (processed data)

Based on Figure 1, it can be seen that Indonesia's energy dependence has increased during the period 1990–2023. This can be seen from the trend of energy imports, which have increased continuously. Despite short-term fluctuations, the overall movement of energy imports is dominated by a structural upward trend. The increase in energy imports reflects short-term economic changes, but more importantly, it reflects structural conditions,

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namely the increasing domestic energy demand that is not matched by domestic energy production capacity.

This dependence on imported energy has an impact on the economy. Several studies have found that high dependence on energy imports puts significant pressure on the trade balance and foreign exchange reserves. According to the results of research İmzalı & Bayraktutan (2025) and Uysal et al. (2015), Energy import dependency can have a negative impact on the current account balance, especially when energy demand increases and global energy prices are high. In addition to putting pressure on the trade balance, this energy import dependency is also highly vulnerable to fluctuations in global energy prices, which will ultimately lead to high inflation and increased domestic production costs. As found in a study by Yadav & Mahalik (2024), energy price volatility exacerbates economic uncertainty and suppresses real sector growth. This situation is further complicated by the fact that domestic energy demand continues to increase, while domestic supply capacity is limited.

Therefore, this research is important to analyze the main determinants of energy imports in Indonesia both theoretically and empirically, given the structural conditions of the economy that are vulnerable to external shocks, so that the results can be used as a basis for more anticipatory and sustainable energy, fiscal, and monetary policies. Based on several previous studies discussing the dynamics of Indonesia's imports, it was found that world oil prices, economic growth, and exchange rates are determinants of energy import demand (Yadav & Mahalik, 2024; Ilmanita & Aimon, 2019; Sultan & Putri, 2025; Mardiana et al., 2018; Mafruhah et al., 2024; Elinur et al., 2012; Purwoko & Wibowo, 2020). Based on data from the World Bank and the U.S. Energy Information Administration (EIA), from 1990 to 2023, economic growth trends, international crude oil prices (Brent), and the exchange rate of the rupiah against the U.S. dollar fluctuated from year to year.

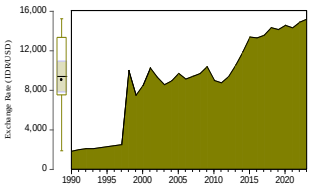

Figure 2. Trend Exchange Rate IDR/USD, 1990-2023
Source : World Bank(processed data)

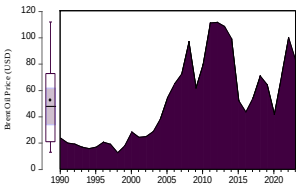

Figure 3. Trend Brent Oil Price (USD), 1990-2023
Source : U.S. Energy Information Administration (EIA) (processed data)

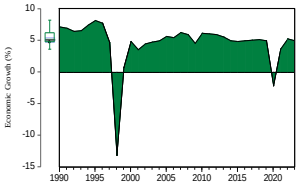

Figure 4. Trend Economic Growth of Indonesia (%), 1990-2023
Source : World Bank(processed data)

These three figures collectively illustrate the main mechanisms that shape Indonesia's energy import dynamics, particularly energy imports. Figure 4 shows that economic growth tends to increase in the long term, reflecting the expansion of production, consumption, and transportation activities. This economic growth reflects the expansion of energy-intensive industrial, transportation, and domestic consumption activities. Within the framework of energy demand theory, energy is viewed as an essential input in the production process and economic activities, so that sustainable economic growth directly drives an increase in energy demand (Ilmanita & Aimon, 2019; Sultan & Putri, 2025). When domestic oil production capacity and refining infrastructure cannot keep pace with this growth, energy imports become the main instrument for maintaining the sustainability of national economic activity (Elinur et al., 2012; Purwoko & Wibowo, 2020).

In addition to economic growth, energy imports are also greatly influenced by external conditions, as reflected in Figure 3 and Figure 2. Figure 3 shows the high volatility of global Brent crude oil prices, which determines the amount of energy imports that must be borne by the domestic economy. When Brent prices increase, the foreign exchange requirements to finance energy imports also increase, even when import volumes remain relatively constant. This indicates that surges in energy imports are not only triggered by increased demand, but also by international price increases that are beyond domestic control. A number of studies show that the positive response of oil imports in the short term to increases in world oil prices reflects strong domestic demand pressure and limited national production and refining capacity, although in the long term the effect of prices tends to be negative or insignificant (Azzahra & Kurniawan, 2023; Septriani, 2025; Ziramba, 2010; Ghosh, 2009; Ji et al., 2014; Seo, 2013; Shao et al., 2017). This phenomenon is explained by stock adjustment mechanisms, inventory behavior, institutional rigidity, and delays in price transmission to the domestic level (Fedoseeva & Zeidan, 2018).

Furthermore, Figure 2 confirms the strategic role of the rupiah exchange rate as a transmission variable. The long-term depreciation trend and exchange rate volatility have caused energy imports to become increasingly expensive in domestic currency. The depreciation of the rupiah amplifies the effect of Brent price increases on the value of energy imports, creating double pressure on the trade balance and macroeconomic stability. In other words, even when economic growth drives energy demand, the weakening of the exchange rate reinforces the impact of import costs arising from fluctuations in world oil prices.

Several previous studies have shown that in the long term, the effect of prices on oil imports tends to be negative or insignificant, while in the short term the price coefficient can be positive due to stock adjustment factors, inventory behavior, institutional rigidity, and delays in price transmission to the domestic level (Azzahra & Kurniawan, 2023; Ziramba, 2010; Ji et al., 2014; Seo, 2013; Shao et al., 2017; Fedoseeva & Zeidan, 2018). In addition, the majority of studies find that energy and oil imports are more responsive to income growth than to price changes, with long-term price elasticities generally negative or insignificant (Marbuah, 2018; Ghosh, 2009).

Figures 2, 3, and 4 show that Indonesia's energy imports are shaped by the interaction between domestic demand factors and external shocks. Economic growth increases energy demand, while global oil price volatility and exchange rate movements determine the size of the import burden. The combination of sustained economic growth, dependence on imported energy, and vulnerability to fluctuations in oil prices and exchange rates confirms that energy imports are one of the main channels for

transmitting external shocks into the Indonesian economy. Therefore, based on these empirical dynamics and theoretical foundations, this research is very important and urgent. By analyzing the integrated effects of economic growth, Brent oil prices, and exchange rates on Indonesia's energy imports, this study is expected to provide a more comprehensive empirical understanding of the determinants of energy imports and serve as a strong basis for the formulation of more coordinated, adaptive, and sustainable energy, fiscal, and monetary policies.

Method

This study uses a quantitative approach with econometric methods to analyze the effect of exchange rate, brent oil price, economic growth on energi import in Indonesia. The empirical model is estimated by multiple linear regression based on annual time series data for the period 1990-2023. All variables are analyzed in first-differenced form to overcome potential non-stationarity and spurious regression problems, as recommended by Gujarati and Porter (2009) and Wooldridge (2016). Furthermore, the research data is obtained from various international sources including the U.S. Energy Information Administration (EIA), World Development Indicators (World Bank). The empirical model used is formulated as follows:

$$E\,\mathrm{Im}_t = \beta_0 + \beta_1 EXR_t + \beta_2 BOP_t + \beta_3 EG_t + \varepsilon_i$$

In this model, EIm_t is Indonesia's energy imports in the period t (1990–2023). The variable EXR_t is the exchange rate of the rupiah against the US dollar (IDR/USD) in the period t, while EG_t is Indonesia's economic growth in the same periodc, The variable BOP is Brent oil price in the period t. β_0 in this model describes the influence of fixed factors not included in the independent variables, thus providing a base value for energy imports when all independent variables are zero. The coefficients β_1, β_2 and β_3 indicate the magnitude of the influence of each independent variable on the variation in energy imports. Meanwhile, ε_t is the error term that captures the influence of other factors not included in the model, such as fluctuations in energy policy, domestic production capacity, or other external factors.

Furthermore, to ensure the reliability of the estimation results, this study conducted several classical assumption tests, namely normality, autocorrelation, heteroscedasticity, and multicollinearity. These tests were conducted following the methodological guidelines described in detail by Gujarati & Porter (2009) and Wooldridge (2016), which emphasize the importance of ensuring that classical assumptions are met so that coefficient estimates are unbiased, consistent, and efficient. Once these assumptions were met, the study then assessed the significance of the regression coefficients using t-tests, F-tests, and coefficient of determination (R^2) tests..

Results and Discussions

The normality test results show that the dataset used in this study is normally distributed. This is shown in Figure 3, where the Jarque-Bera probability is 0.559868, higher than the significance threshold of 5% (α = 0.05), so it can be concluded that the data meets the normality assumption..

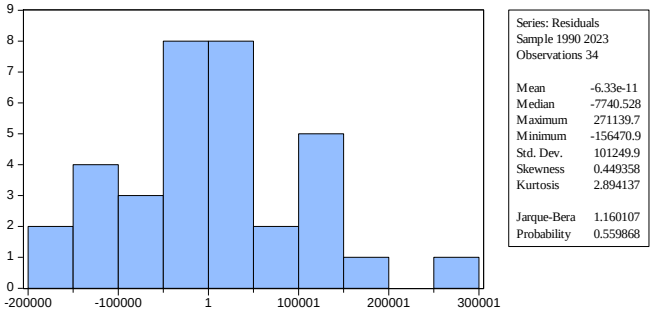

Figure 3. Normality Test Results
Source: Processed research data (2025)

The results shown in Figure 3 indicate that the data used are suitable for regression analysis. The autocorrelation test using the Breusch-Godfrey Serial Correlation LM Test shows a Chi-Square probability value of 0.0552, which is greater than the significance level of 5% (α = 0.05), indicating that the regression model does not have autocorrelation problems. Details of the test statistics are presented in Table 1.

Table 1. Autocorrelation Test Results

Breusch-Godfrey Serial Correlation LM Test			
F-statistic	2.875667	Prob. F(2,28)	0.0731
Obs*R-squared	5.793707	Prob. Chi-Square(2)	0.0552

Source: Research data (Processed 2025)

Futhermore, the regression model was also tested to determine whether there was heteroscedasticity. The test results showed that there was no indication of heteroscedasticity, as indicated by the Chi-Square probability value at Obs*R-squared of 0.6233. A summary of the heteroscedasticity test results is presented in Table 2.

Table 2. Heteroskedasticity Test Results

Heteroskedasticity Test: Breusch-Pagan-Godfrey:			
F-statistic	0.546456	Prob. F(2,30)	0.6544
Obs*R-squared	1.761681	Prob. Chi-Square(2)	0.6233

Source: Research data (Processed 2025)

Finally, a multicollinearity test was conducted to assess the relationship between independent variables, and the results showed no indication of significant multicollinearity, so that all independent variables could be reliably used in the regression model. A summary of the test results is presented in Table 3.

Table 3. Multicollinearity Test Results

Variable	EXR	BOP	EG
EXR	1	0.52	-0.30
BOP	0.58	1	0.19
EG	0.30	0.19	1

Source : Research data (Processed, 2025)

Furthermore, the regression results of this study are presented in Table 4, which provides an overview of the partial and simultaneous effects of exchange rates, Brent oil prices, and economic growth on energy imports in Indonesia during the period 1990–2023.

Table 4. Multiple Linear Regression Results

Variable	*Coeff.*	*Std. Error*	*t-Statistic*	Prob.
C	-29542.11	56687.39	-0.521141	0.6061
EXR	49.74106	6.041921	8.232656	0.0000
BOP	4615.474	797.7192	5.785837	0.0000
EG	14331.74	6006.160	2.386174	0.0235

R^2 : 0.912
Adj.R^2 : 0.904
F-statistic : 104.22
Prob (F-Statistic) : 0.000000

Source : Research Data (processed, 2025)

Based on the test results in Table 4, the regression equation is obtained as follows:

$$E\,\mathrm{Im} = -29542.11 + 49.74 EXR_t + 4615.47 BOP_t + 14331.74 EG_t + \varepsilon_i$$

Hypothesis Test

Based on the regression estimation results in Table 4, the coefficient of determination (R^2) value obtained is 0.912. This indicates that approximately 91.2 percent of the variation in Indonesia's energy imports can be explained by the exchange rate against the dollar, Brent oil prices, and economic growth. Furthermore, this model yields an Adjusted R^2 value of 0.904, indicating that the model has very strong and stable explanatory power. Furthermore, the simultaneous test results show an F-statistic value of 104.22 with a probability of 0.0000, which means that the exchange rate, Brent oil price, and economic growth together have a significant effect on energy imports at α 5 percent. Therefore, the regression model used is declared feasible and valid to explain the dynamics of Indonesia's oil imports during the observation period.

Based on the partial test (t-test), it was found that the exchange rate has a positive and significant effect on energy imports, with a coefficient of 49.74, a t-statistic value of 8.23, and a probability of 0.0000. This finding shows that the depreciation of the rupiah against the USD is followed by an increase in the volume of energy imports. The Brent oil price variable also shows a positive and significant effect on energy imports, with a coefficient of 4,615.47, a t-statistic value of 5.79, and a probability of 0.0000. This means that every increase in world oil prices of USD 1 per barrel will increase energy imports by around 4.615 TJ. Meanwhile, economic growth has a positive and significant effect on energy imports with a coefficient of 14.331.74, a t-statistic value of 2.39, and a probability of 0.0235.

Discussion

Based on the regression results, it was found that the IDR/USD exchange rate had a coefficient of 49.74 with a t-statistic value of 8.23 and a probability of 0.0000. This indicates that the exchange rate has a positive and significant effect on Indonesia's energy imports at the α= 5% level. These results indicate that every 1 IDR increase in the exchange rate against the USD (depreciation of the rupiah) will be followed by an increase in energy imports of around 49.74 terajoules (TJ), assuming that other variables in the model remain constant. The results of this study indicate that Indonesia's energy imports are inelastic to exchange rate changes because oil is a strategic energy commodity and demand must still be met even when the domestic exchange rate weakens.

The results of this study show that oil and other energy products as strategic energy commodities have relatively inelastic demand in the short term, so that a weakening of the domestic exchange rate does not significantly reduce imports. During the 1990–2023 period, energy demand in Indonesia continued to increase, in line with population growth, expansion of the industrial and transportation sectors, and limited domestic production capacity. This condition necessitates continued energy imports to maintain national energy security, even though the depreciation of the Rupiah increases import costs. In this case, currency depreciation does not automatically reduce energy imports when demand is inelastic, as seen in other developing countries where exchange rate fluctuations and global oil prices result in complex import behavior. Similarly, in Indonesia, the depreciation of the Rupiah tends to increase the value of energy imports due to the increase in Rupiah costs and not because of a decrease in import volume. Therefore, the government must emphasize the need for more comprehensive energy policies, including strengthening domestic production and diversifying energy sources, to strengthen national energy security.

In theory, countries that are highly dependent on energy imports do not see a direct decline in import volumes when their domestic currency weakens, because energy is a fundamental input for economic activity. Unlike non-essential consumer goods, energy demand tends to be price inelastic, so that relative price changes due to exchange rate fluctuations are not responded to with a significant decline in import quantities. In addition, the limitations of energy substitution in the short term also reinforce dependence on energy imports even though import costs increase.

The results of this study reinforce previous findings that exchange rates are not always effective in reducing energy imports in net energy-importing countries, because energy demand tends to be inelastic to exchange rate and price fluctuations. Exchange rate changes are often associated with an increase in the cost or value of energy imports when domestic demand is high. Previous studies also confirm that demand for oil and energy as strategic commodities must still be met, so currency depreciation does not always reduce import volumes even though it increases costs (Adi et al., 2022). Beckmann et al. (2020) adding that the long-term relationship between energy prices and exchange rates is strong and mutually influential, with the intensity depending on the economic structure and characteristics of each importing country.

In addition, several other research results also show that exchange rate depreciation tends to encourage an increase in oil and energy imports in importing countries, although the effects are heterogeneous and most prominent in strategic sectors. According to Saqib et al. (2021), currency depreciation significantly increases imports of crude oil and electricity, both in the short and long term, while appreciation has no significant effect. Similarly, research by (De Schryder & Peersman, 2015) found that domestic currency depreciation against the US dollar correlates with increased demand for oil and energy, which in turn drives import demand. Although depreciation can reduce aggregate energy consumption in some situations (Shahbaz et al., 2018), oil imports remain sensitive to depreciation because they serve as essential inputs in the industrial, transportation, and power generation sectors, with limited substitution. Methodological approaches such as ARDL/NARDL and dynamic panels allow for the identification of short- and long-term effects, asymmetry differences between

depreciation and appreciation, and the role of exchange rate volatility (Saqib et al., 2021; De Schryder & Peersman, 2015; Shahbaz et al., 2018), thus theoretically supporting the claim that exchange rate movements can have a positive impact on oil imports, differing from the general trend in aggregate imports.

Meanwhile, based on the regression results, it was found that Brent Oil Price had a coefficient of 4,615.47 with a t-statistic value of 5.79 and a probability of 0.0000. This shows that world oil prices have a positive and significant effect on Indonesia's energy imports. This means that every increase in the Brent oil price of USD 1 per barrel will be followed by an increase in energy imports of around 4.615 TJ, assuming other variables remain constant. Theoretically, these research results can be explained by the law of inelastic demand. In this case, energy is a strategic commodity whose demand is relatively unresponsive to price changes, especially in the short term.

Based on research data, it is known that during the 1990-2023 research period, domestic fuel prices were always controlled administratively through subsidies and government pricing mechanisms. This condition caused the transmission of global oil price increases to domestic retail prices to be partial and delayed, making final demand relatively inelastic to international prices. In addition, stagnant crude oil and energy production capacity and limited domestic refining infrastructure meant that increasing energy demand could not be met from domestic supplies. Therefore, under these conditions, the government and state-owned enterprises tended to maintain or even increase energy imports, despite relatively high prices, in order to avoid supply shortages and disruption to economic activity. According to Azzahra & Kurniawan (2023); Septriani (2025), this short-term positive response reflects strong domestic demand pressure and limited national production and refining capacity. Although in the long term, world oil prices have a negative impact on import volumes.

Although in previous studies conducted by (Azzahra & Kurniawan, 2023; Ziramba 2010; Ghosh, 2009; Ji et al., 2014; Seo, 2013; Shao et al., 2017) shows that although the long-term effect of prices is generally negative or insignificant, in the short term, the coefficient can be positive due to stock adjustment factors, inventory behavior, institutional rigidity, and delays in price transmission to the domestic level (Fedoseeva & Zeidan, 2018).

Most studies conducted by various countries also show that oil/energy imports are more sensitive to income growth than to prices, while long-term price elasticity is generally negative or insignificant (Marbuah, 2018; Ghosh, 2009; Ziramba, 2010). Other factors that also influence energy imports are income, supply structure, and energy policy. Based on this study, it can be concluded that Indonesia is an energy-importing country with subsidized fuel prices, rigid energy demand, and limited domestic production and refining capacity. In this case, the increase in Brent oil prices can lead to an increase in energy imports in the short term, not as an empirical anomaly, but as a rational result of the interaction between domestic pricing policies, demand rigidity, and supply constraints.

Furthermore, based on the regression results, it was found that economic growth had a coefficient of 14,331.74 with a t-statistic value of 2.39 and a probability of 0.0235. This shows that economic growth has a positive and significant effect on Indonesia's energy imports. This means that every 1 percent increase in economic growth will be followed by an increase in energy imports of around 14,332 TJ, assuming other variables remain constant.

Theoretically, the relationship between economic growth and energy imports can be explained through energy demand theory, which states that energy is a major input in the production process and economic activity. When the economy grows, industrial activity, transportation, and public consumption also increase. This then drives an increase in energy demand. On the other hand, Indonesia's domestic energy production capacity is very limited, so to meet these needs, Indonesia must import from other countries. This is due to the downward trend in domestic production and limited oil/energy processing capacity (Elinur et al., 2012; Purwoko & Wibowo, 2020). In addition, energy substitution in Indonesia is still limited and the transition to renewable energy has not been optimal. Therefore, economic growth tends to increase dependence on energy imports. The results of this study indicate that Indonesia's economic growth during the 1990-2023 period was still energy intensive, where economic expansion went hand in hand with an increase in fossil energy demand. The results of this study are in line with various previous studies, which have also consistently shown that economic growth or GDP has a positive effect on the consumption of crude oil, fuel oil, and energy, both in the short and long term. (Ilmanita & Aimon, 2019;Sultan & Putri, 2025; Ilmanita & Aimon, 2019; Azzahra & Kurniawan, 2023; Priyadi et al., 2022; Aimon et al., 2020).

According to various previous studies, the cause of this positive relationship is the increase in industrialization and expansion of the manufacturing sector, which also significantly increases the demand for energy and oil (Sultan & Putri, 2025; Mardiana et al., 2018; Rezki, 2011). Similarly, the growth of the transportation sector and the increase in motor vehicle ownership also drive up demand for oil, particularly for transportation fuel (Mardiana et al., 2018; Priyadi et al., 2022; Elinur et al., 2012; Jaiswal et al., 2024). Then, when viewed from the policy side, subsidy policies, price regulations, and energy policies make energy demand relatively inelastic to price, but still elastic to income, so that economic growth becomes the main driver of demand (Ilmanita & Aimon, 2019; Sultan & Putri, 2025; Mardiana et al., 2018; Mafruhah et al., 2024; Elinur et al., 2012; Purwoko & Wibowo, 2020).

Meanwhile, the results of this study are also in line with the results of studies from various countries in Southeast Asia, Thailand, India, and China, which also found that at income levels and stages of structural transformation comparable to Indonesia, GDP growth strongly increases demand for energy and oil. In this case, oil is often a marginal fuel, especially in the transportation sector and some industrial uses (Rezki, 2011; Adams et al., 2000; Jaiswal et al., 2024; Guo, 2018). Therefore, based on the results of this study, without improvements in energy efficiency and accelerated diversification of energy sources, economic growth has the potential to increase energy imports, which in turn could increase vulnerability to global energy price volatility and trade balance pressures.

Conclusion

Based on the regression results, it shows that the depreciation of the rupiah exchange rate did not suppress energy imports, but

rather increased the value of imports, because energy is a strategic commodity with limited substitution in the short term. Furthermore, Brent oil prices also had a positive effect on energy imports in the short term. These results indicate that the weak transmission of international prices to domestic prices was due to subsidy and price control policies, as well as limited national production and refining capacity. Furthermore, economic growth also has a positive effect on energy imports. In this case, economic growth acts as the main driver of energy imports, confirming that Indonesia's economic expansion during the study period was still energy-intensive. Increased industrial and transportation activities were not matched by domestic energy production capacity or adequate alternative energy substitutes. Based on the results of this study, it is known that Indonesia's energy imports are more determined by structural factors and domestic demand pressures than by price and exchange rate mechanisms. Therefore, energy import control policies need to focus on long-term strategies, including increasing energy efficiency, strengthening domestic production and refining capacity, and accelerating energy source diversification, in order to strengthen national energy security and reduce vulnerability to external shocks.

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