Evaluation of The Mandatory Biodiesel Policy On Diesel Imports Oil and Gas Trade Deficit and Energy Price Volatility In Indonesia

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Abstract.
This research aims to evaluate the effectiveness of the mandatory biodiesel policy in reducing diesel imports, reducing the oil and gas trade deficit, and mitigating energy price volatility in Indonesia. The study is driven by high dependence on energy imports, which leads to external vulnerability and macroeconomic instability. A quantitative approach was employed using multiple linear regression analysis on secondary annual data from 2005 to 2023. The results indicate that the mandatory biodiesel policy has a significant negative effect on diesel import volumes, where increasing renewable energy blends effectively substitute fossil fuel needs. Furthermore, the policy contributes significantly to reducing the oil and gas trade deficit through substantial foreign exchange savings. The findings also reveal that domestic energy price volatility due to global crude oil fluctuations can be dampened, indicating the effective role of biodiesel as a "strategic buffer" for national energy stabilization. In conclusion, the mandatory biodiesel policy is a vital instrument for maintaining economic and energy stability, particularly in supporting the upcoming B50 implementation. This research provides a comprehensive understanding of biodiesel's macroeconomic impact on national resilience.
Keywords: *Mandatory Biodiesel, Diesel Imports, Oil and Gas Trade Balance, Foreign Exchange Savings and Energy Security.*

I. INTRODUCTION

Indonesia's dependence on energy imports, particularly diesel fuel, remains a major challenge in maintaining macroeconomic stability and national energy security. According to data from the Ministry of Energy and Mineral Resources (ESDM), diesel imports reached a crucial 8.3 million tons in 2024. This dependence is further exacerbated by the volatility of global crude oil prices, fueled by geopolitical uncertainty. This fluctuation was clearly reflected in May 2026, when oil prices reached
$100.05 per barrel, a drastic jump compared to its low of $19.23 per barrel in April 2020. This unpredictable price fluctuation directly puts pressure on the trade balance and depletes the country's foreign exchange reserves. In this context, the biodiesel policy exists not merely as an alternative energy source, but as an economic defense strategy to reduce the oil and gas deficit through import substitution.

Historically, biodiesel development in Indonesia is not a new phenomenon, but rather the result of a long evolution that began with pioneering research in the 1990s by strategic institutions such as LEMIGAS, BPPT, ITB, and PPKS. Literature reviews show that the impact of this policy extends beyond the energy sector; it affects the macroeconomic landscape, including trade flows and national income. Since the initiation of the mandatory program through Presidential Decree No. 5 of 2006, this energy mix has grown rapidly, reaching the implementation of B30 in 2020. However, this development faces challenges; findings indicate that the use of a 30% biodiesel blend results in a 5% increase in fuel consumption due to its lower calorific value compared to pure diesel. This efficiency constraint is a critical variable that must be considered in assessing the overall effectiveness of the policy.

Amidst these dynamics, the scientific novelty of this article lies in its evaluation of the effectiveness of the mandatory biodiesel policy as a buffer against extreme global crude oil price volatility. Unlike previous research, which tends to focus on the technical aspects of engines or the general macroeconomic impact, this study specifically combines recent historical crude oil price data with the actual reduction in diesel imports.

Based on this background, this research is focused on answering three questions.
main:

Volume Effectiveness Analysis: To what extent is the mandatory biodiesel policy effective in

1. significantly reduce the volume of diesel imports in Indonesia?
2. **Monetary Contribution Analysis:**What is the direct impact of this policy on reducing the trade deficit in the oil and gas sector?
3. **Risk Mitigation Analysis:**Is the biodiesel policy capable of reducing the volatility of domestic energy prices due to the uncertain fluctuations in global crude oil prices?

Through this analysis, it is hoped that an overview of the biodiesel program's ability to reduce dependence on imports while providing added economic value from the domestic palm oil sector as a future energy pillar will be obtained.

II. METHOD

This study uses a quantitative approach with simple and multiple linear regression analysis to evaluate the effectiveness of the mandatory biodiesel policy on several economic variables. The data used were collected from official publications of the Ministry of Energy and Mineral Resources (ESDM) and historical global crude oil price data.

The data processing instrument uses the R programming language as the primary tool for statistical analysis, regression model estimation, and classical assumption testing. Microsoft Excel is used as a supporting tool in the initial data tabulation stage. The data processing process is carried out with a 95% confidence level (α= 0.05The research procedure begins with the data gathering stage, followed by data cleaning and tabulation to prepare it for estimation using a statistical model. The main analysis method used is multiple linear regression. Based on literature from Iba & Wardhana (2024), multiple linear regression is an analysis involving more than one independent variable to examine its influence on the dependent variable simultaneously. The econometric equation used in this study
is:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta n Xn + \varepsilon$$

Where:

- Y: Dependent variable (Volume of Diesel Imports or Value of Oil and Gas Balance Deficit).
- X_1: Independent variable 1 (Percentage of Mandatory Biodiesel Mix)
- X_2: Independent variable 2 (World Crude Oil Price)
- β_0: Intercept or constant.
- $\beta_{1,2}$: Regression coefficient for each independent variable.
- ε: Error term or random error.

To ensure the validity and reliability of the model (Blue: Best Linear Unbiased Estimator), this study conducted a series of Classical Assumption Tests including the normality test (Shapiro-Wilk), the heteroscedasticity test (Breusch-Pagan), and the autocorrelation test (Durbin-Watson). Hypothesis testing was carried out through the F-Test (simultaneous test) and the t-Test (partial test) as well as analysis of the coefficient of determination (R^2) to measure the extent to which biodiesel policies are effective in reducing imports and mitigating the risk of global price fluctuations.

III. RESULTS AND DISCUSSION

This analysis stems from Indonesia's long-standing efforts to build energy independence and reduce dependence on imported diesel. This policy did not occur overnight, but rather through a gradual, evolving process of mandated biodiesel use.

The formal journey of biodiesel policy in Indonesia began with the issuance of Presidential Instruction No. 1 of 2006, which was later reinforced by Minister of Energy and Mineral Resources Regulation No. 32 of 2008. This regulation was the first to mandate a 1% biodiesel blend (B1). However, over time, the increase in biodiesel blending levels has not only been driven by clean energy visions, but has often served as an emergency aid in response to pressing national economic dynamics.

Entering the 2013-2014 period, Indonesia faced serious economic challenges in the form of Twin

Deficits (trade balance and current account deficits). The Rupiah exchange rate weakened sharply against the US Dollar due to high foreign exchange spending on diesel imports. Responding to this, the government, through ESDM Ministerial Regulation No. 25 of 2013, accelerated the fuel mix to 7.5% to 10% (B10). This step was taken as a strategy to conserve foreign exchange reserves by replacing some imported diesel with domestic palm oil, as emphasized in the 2013 Ministry of Finance report regarding the mandatory acceleration to reduce the deficit.

A crucial turning point occurred in 2015 when global oil prices plummeted. This situation caused fossil diesel prices to become cheaper than biodiesel production costs, which risked killing the domestic biofuel industry. To ensure the program's continuity, the government issued Ministerial Regulation No. 12 of 2015, mandating B15 and establishing the Indonesian Palm Oil Plantation Fund Management Agency (BPDPKS). This institution plays a crucial role in providing incentives to maintain competitive biodiesel prices, ensuring the program's sustainability despite fluctuating global commodity prices.

Policy aggressiveness intensified in the 2018-2019 period. Facing a massive increase in fuel imports that were burdening the state budget, President Joko Widodo expanded the B20 mandate through Presidential Regulation 66/2018. Previously mandatory, it only applied to the subsidized (PSO) sector. As of September 1, 2018, non-PSO sectors, including heavy equipment and industry, were required to use B20. This policy marked the most significant moment in Indonesia's biodiesel history due to its "uncompromising" approach to reducing the national oil and gas deficit.

Entering the pandemic era and post-pandemic (2020-2023), the government's commitment remains steadfast by increasing the mix to 30% through ESDM Ministerial Decree No. 227 K/2019. Furthermore, geopolitical turmoil such as the Russia-Ukraine war that triggered a global energy crisis prompted the government to immediately implement B35 in February 2023 through ESDM Ministerial Decree No. 205.K/2022. This implementation aims to strengthen energy security and maintain

Price stability for domestic palm oil farmers. The entire series of regulations and their impact on diesel import volumes are summarized in Table 1 below:

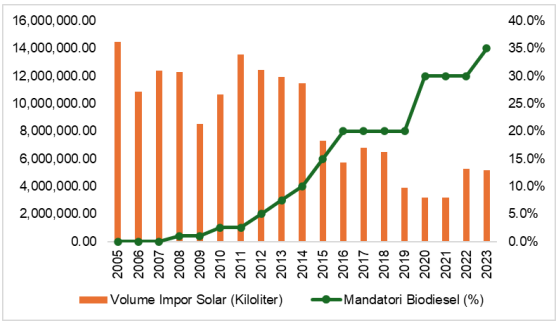
Table 1. Mandatory Biodiesel Data and Diesel Import Volume in Indonesia (2005-2023)

Year	Import Volume (Kiloliters)	ry Biodiesel (%)
2005	14,469,201.46	0.0%
2006	10,845,813.48	0.0%
2007	12,366,057.37	0.0%
2008	12,282,006.20	1.0%
2009	8,504,565.39	1.0%
2010	10,636,547.52	2.5%
2011	13,572,549.76	2.5%
2012	12,455,008.59	5.0%
2013	11,946,708.18	7.5%
2014	11,474,699.78	10.0%
2015	7,318,129.00	15.0%
2016	5,707,622.00	20.0%
2017	6,793,996.00	20.0%
2018	6,498,799.00	20.0%
2019	3,872,804.00	20.0%
2020	3,181,936.00	30.0%
2021	3,189,951.00	30.0%
2022	5,270,481.00	30.0%
2023	5,145,275.00	35.0%

Source: Ministry of Energy and Mineral Resources

To facilitate understanding of the policy evolution trends and correlations between these variables, the data in Table 1 are visualized in Figure 1 as follows:

Fig. 1. Trends in Mandatory Biodiesel Development and Realized Diesel Import Volume in Indonesia 2005-2023.



Source: Ministry of Energy and Mineral Resources (Data processed using Microsoft Excel, 2026).

Based on the visualization in Figure 1, a significant relationship pattern is seen between the mandatory biodiesel policy and the realization of the volume of diesel imports in Indonesia during the period 2005-2023. In the initiation phase (2005–2012), where the mandatory policy was still at a low level below 5%, the volume of diesel imports tended to fluctuate at high figures, namely ranging from 8 million to 14 million Kiloliters (KL). This condition indicates that in the initial stage, the mix policy did not have a large substitution power for dependence on fossil diesel from abroad.

The turning point in the policy's effectiveness began to emerge during the acceleration phase of the 2013–2018 period. Following the increase in the biodiesel mix to B15 in 2015, accompanied by the establishment of BPDPKS as an incentive provider, diesel imports showed a consistent downward trend. This peaked during the implementation of B30 in 2020, when diesel imports reached their lowest point in two decades, reaching 3.1 million kiloliters. Despite the impact of reduced mobility due to the COVID-19 pandemic during this period, imports remained at a significantly lower level than before 2015. Overall, Figure 1 provides visual evidence of a strong negative correlation, with each increase in the mandatory biodiesel percentage being followed by a decrease in national diesel imports.

To strengthen the visual analysis, a statistical test was carried out using the Pearson correlation coefficient (r) to measure the degree of relationship between the biodiesel mandate level and the volume of diesel imports. Based on the results of calculations using Excel software, a correlation coefficient value of -0.88926 was obtained. This value indicates a very strong negative correlation, indicating that each increase in the percentage of biodiesel mandate is significantly followed by a decrease in the volume of diesel imports. This large correlation value provides a strong statistical basis for continuing the analysis to the linear regression stage to see the magnitude of the influence between variables more specifically.

Based on the strong negative correlation found, this study conducted an analysis by constructing two linear regression models to analyze the effectiveness of the policy. Model 1 was constructed as a simple linear regression to measure the net impact of the mandatory biodiesel policy on diesel import substitution. Meanwhile, Model 2 was developed into a multiple linear regression model by including global crude oil prices to evaluate the policy's resilience to global economic fluctuations (risk mitigation). The following analysis stage begins with testing the classical assumptions of the models to ensure the validity of the resulting statistical parameters.

VOLUME EFFECTIVENESS ANALYSIS

Model Analysis Requirements Test 1

Before estimating the parameters in Model 1, a series of classical assumption tests were conducted to ensure that the model met the Best Linear Unbiased Estimator (BLUE) criteria. This test was conducted by establishing the following statistical hypothesis:

- Normality Test (Shapiro-Wilk):

  H_0: The residuals of the model are normally distributed ($p > 0.05$).

  Ha: The residuals of the model are not normally distributed ($p \leq 0.05$).
- Heteroscedasticity Test (Breusch-Pagan):

  H_0: The residual variance is constant/Homoscedastic ($p > 0.05$).

Ha: The residual variance is not constant/Heteroscedastic ($p \leq 0.05$).

- Autocorrelation Test (Durbin-Watson):

H_0: There is no autocorrelation in the residuals ($p > 0.05$).

Ha: There is autocorrelation in the residuals ($p \leq 0.05$).

A summary of the results of the classical assumption tests for Model 1 is presented in Table 2 below:

Table 2. Summary of Classical Assumption Test Results for Model 1

Test Type	Method	Test Statistics	P-Value	Information
Normality	Shapiro-Wilk	W = 0.93882	0.2511	Normal
Autocorrelation	Durbin-Watson	DW = 1.3498	0.03882	Detected*
Heteroscedasticity	Breusch-Pagan	BP = 0.29112	0.5895	Homoscedastic

Source: Data processed using RStudio (2026)

Based on Table 2, the following is an analysis of the validity of Model 1:

- Normality Test:

Obtained value$p$= 0.2511. Because of the value$p$> 0.05, soH_0 accepted, which means the residuals of the model are normally distributed. This indicates that the model can be used to perform statistical inference.

- Heteroscedasticity Test:

Value obtained$p$= 0.5895. Because of the value$p$> 0.05, soH_0 accepted, which indicates that the model is homoscedastic and there are no symptoms of heteroscedasticity that interfere with the accuracy of the standard error.

- Autocorrelation Test:

The test results show the value$p$= 0.038. Because of the value$p$> 0.05, soH_0 is rejected, which indicates the presence of positive autocorrelation symptoms. However, in the context of public policy time series data, this is still tolerable considering the very strong significance of the main variables and the valueR^2 high, so that the model remains worthy of further interpretation.

Parameter Estimation and Simple Linear Analysis of Model 1

After the model was declared statistically valid through the classical assumption test, parameter estimation was performed using the Ordinary Least Squares (OLS) method. This test aims to prove the main research hypothesis (H_1), that is:

- H_0: The mandatory biodiesel policy does not have a significant impact on the volume of diesel imports (β_1= 0).
- Ha: The mandatory biodiesel policy has a significant impact on reducing the volume of diesel imports ($\beta_1 \neq$ 0).

The results of data processing for Model 1 are summarized in Table 3 below: Table 3. Estimation Results Simple Linear Regression Parameters (Model 1)

Table 3. Results of Simple Linear Regression Parameter Estimation Model 1

Variables	Coefficient (Estimate)	*t-Statistic*	*P-Value*
Constant (β_0)	12,299,220	20,403	<0.001
Mandatory (β1)	-27,315,841	-8,061	<0.001
R-Squared	0.7908	F-Statistic	64.25

Parameter Substitution into the Regression Model Model 1

Substitution of parameter values from Table 3 into the regression equation produces the model as following:Y= 12,299,220 − 27,315,841X+ε

Where:

- Y: Diesel Import Volume (kiloliters)
- X: Mandatory Biodiesel (blend percentage)
- ε: Error term (other factors outside the model)

Based on this model, several important analysis points can be taken:

- Significance of Influence:

The mandatory variable of biodiesel has a value$p$< 0.001, which means far below the level of significanceα= 0.05. Thus,$_0$ rejected andH_1 accepted, which proves that the biodiesel blend policy has a statistically significant effect on reducing the volume of diesel imports. Effectiveness of Substitution: Coefficient valueβ_1The figure of -27,315,841 indicates that every 1% increase in the biodiesel mix (for example, from B30 to B31) is predicted to reduce diesel imports by 273,158 kiloliters. This confirms biodiesel's role as a highly effective fossil fuel substitute. Model Accuracy (R-Squared):

An R-squared value of 0.7908 indicates that the mandatory policy explains 79.08% of the variation in the decline in national diesel import volume from 2005 to 2023. This figure is very high for a public policy model, indicating that the mandatory policy is a major determinant in controlling diesel imports in Indonesia.

MONETARY CONTRIBUTION ANALYSIS

Having statistically demonstrated in Model 1 that the mandatory biodiesel policy significantly reduced diesel imports, this section evaluates the financial impact of this reduction. The primary focus of this analysis is to determine the extent to which physical substitution of domestic biodiesel improves the national volume balance (net imports).

Estimation of Import Cost Reduction through Substitution Value

Based on the regression coefficientβ_1With a value of -27,315,841, every 1% increase in the biodiesel mix theoretically reduces the need for diesel imports by 273,158 kiloliters. This volume reduction represents a tangible foreign exchange saving, as every liter of domestically produced biodiesel directly replaces the fossil diesel component that would otherwise be purchased using foreign currency.

To illustrate the economic value, the potential savings can be estimated by multiplying the volume reduction by the assumed average price of imported diesel fuel. Although market prices fluctuate, the effectiveness of this policy in terms of physical quantity remains constant in reducing the volume deficit.

Solar Volume Balance Analysis (Export-Import)

To see the impact of the policy in a real context, here is the data on the realization of diesel imports and exports based on the publication of the Ministry of Energy and Mineral Resources:

Table 4. Realization of Indonesian Solar Imports and Exports (2021-2023)

Year	Diesel Import Volume (Kiloliters)	Export Volume Diesel (Kiloliters)	Import (Deficit)
2005	14,469,201.46	18,263.15	14,450,938.31
2006	10,845,813.48	12,465.85	10,833,347.63
2007	12,366,057.37	157,107.27	12,208,950.10
2008	12,282,006.20	10,189.52	12,271,816.68
2009	8,504,565.39	48,263.81	8,271,816.68
2010	10,636,547.52	241,472.17	10,395,075.35
2011	13,572,549.76	17,974.59	13,554,575.17
2012	12,455,008.59	14,667.80	12,554,575.17
2013	11,946,708.18	0	11,946,708.18
2014	11,474,699.78	23,510.12	11,451,189.66
2015	7,318,129.00	0	7,318,129.00
2016	5,707,622.00	96	5,707,526.00
2017	6,793,996.00	1,278	6,793,223.00
2018	6,498,799.00	576	6,498,223.00
2019	3,872,804.00	0	3,872,804.00
2020	3,181,936.00	0	3,181,936.00
2021	3,189,951.00	0	3,189,951.00
2022	5,270,481.00	0	5,270,481.00
2023	5,145,275.00	0	5,145,275.00

Source: Data processed using Microsoft Excel (2026)

A comparison of the Model 1 estimation results with the actual data in Table 4 demonstrates strong consistency in terms of long-term trends. Although annual data exhibits fluctuations, such as an increase in imports in 2022 due to the post-pandemic economic recovery, the mandatory biodiesel policy has significantly reduced diesel import volumes to tens of millions of kiloliters, similar to the 2005-2014 period.

Theoretically, if we refer to the valueβ_1Without increasing the biodiesel blend to B35, Indonesia's diesel import burden is predicted to be significantly heavier, both physically and financially. This emphasizes that the mandatory policy is not merely a complement, but a crucial substitute for national energy security. However, import volumes are not only
influenced by domestic policies. The dynamics of the global energy market, particularly fluctuations in global crude oil prices, are thought to influence import decisions and the economic effectiveness of biodiesel itself. Therefore, to obtain a clearer picture, the analysis will continue in
Model 2 involves the world oil price variable as a control factor.

RISK MITIGATION ANALYSIS

After demonstrating the effectiveness of mandatory biodiesel in a simple model (Model 1), the next step was to conduct a more in-depth evaluation involving global energy market dynamics. In accordance with the research methodology, a multiple linear regression analysis was conducted to test the policy's resilience to fluctuations in international commodity prices. The variables analyzed in Model 2 were:

- Y: Diesel Import Volume (Kiloliters).
- X_1: Mandatory Percentage of Biodiesel (%).
- X_2: World Crude Oil Prices (USD/Barrel).

Model Analysis Requirements Test 2

As a multiple regression model, in addition to meeting the assumptions of normality, heteroscedasticity, and autocorrelation, Model 2 must also meet the assumption of multicollinearity. This aims to ensure there is no excessively strong linear relationship between the independent variables.X_1AndX_2 which can cause bias in parameter estimates. The following are the classical assumption hypothesis testing criteria for Model 2:

- Normality Test (Shapiro-Wilk):
  H_0: The residuals of the model are normally distributed ($p > 0.05$).
  Ha: The residuals of the model are not normally distributed ($p \leq 0.05$).
- Heteroscedasticity Test (Breusch-Pagan):
  H_0: The residual variance is constant/Homoscedastic ($p > 0.05$).
  Ha: The residual variance is not constant/Heteroscedastic ($p \leq 0.05$).
- Autocorrelation Test (Durbin-Watson):
  H_0: There is no autocorrelation in the residuals ($p > 0.05$).
  Ha: There is autocorrelation in the residuals ($p \leq 0.05$).
- Multicollinearity Test (VIF):
  H_0: There is no multicollinearity between independent variables ($r < 0.80$).
  Ha: There is multicollinearity between independent variables ($r \geq 0.80$).

A summary of the results of the classical assumption tests for Model 1 is presented in Table 2 below:

Table 5. Summary of Classical Assumption Test Results for Model 2

Test Type	Method	Test Statistics	P-Value	Information
Normality	Shapiro-Wilk	$W = 0.95352$	*0,*4526	Normal
Autocorrelation	Durbin-Watson	$DW = 1.5224$	0.0651	Autocorrelation free
Heteroscedasticity	Breusch-Pagan	$BP = 3,183$	0.2036	Homoscedastic
Multicollinearity	VIF	-	−0.3236783	Multicollinearity Free

Source: Data processed using RStudio (2026)

Based on the test results presented in Table 5, Model 2 has fulfilled all the classical assumption requirements of multiple linear regression as follows:

- Normality Test:

The p-value of 0.4526 (> 0.05) indicates thatH_0 accepted, which means that the residuals from the model are normally distributed. This ensures that the parameter estimates are unbiased.

- Heteroscedasticity Test:

The results of the Breusch-Pagan test show a p-value of 0.2036 (> 0.05), so it can be concluded thatH_0 accepted, there are no symptoms of heteroscedasticity in the model (residual variance is constant or homoscedastic).

- Autocorrelation Test:

The Durbin-Watson statistical value of 1.5224 with a p-value of 0.0651 (> 0.05) indicates that the model is free from autocorrelation interference at a 95% confidence level.

- Multicollinearity Test:

The correlation coefficient value between the mandatory biodiesel variables (X_1) and global crude oil prices (X_2) is -0.3237. Considering that this value is far below the threshold of 0.80, it can be confirmed that there is no multicollinearity problem between the independent variables in this model.

By fulfilling all the classical assumptions above, Model 2 is declared valid and suitable for use in analyzing the influence of variables partially and simultaneously on the volume of national diesel imports.

Parameter Estimation and Multiple Linear Analysis of Model 2

After ensuring the model meets all classical assumptions, the analysis continues with a more in-depth interpretation of the variables' influences. Unlike Model 1, which only looked at domestic policies, Model 2 attempts to capture a more complex reality by incorporating Global Crude Oil Prices (X_2) as a control variable.

This step is crucial to ensure that the decline in diesel imports is truly driven by the effectiveness of domestic policies, and not solely by the influence of energy price fluctuations on the international market. The data processing results for Model 2 are summarized in the following table:

Table 6. Results of Multiple Linear Regression Parameter Estimation Model 2

Variables	**Coefficient (β)**	***Std. Error***	***t-Statistic***	***P-Value***
Constant	7,955,533	1,548,763	5,137	0.0000994
MandatoryBiodiesel (X_1)	-24,454,952	2,983,200	-8,198	0.000000404
Global Crude Oil Prices (X_2)	55,138	18,610	2,963	0.00916
R-Squared	0.8649	-	-	-
Adj. R-Square	0.8480	-	-	-
F-Statistic	51.22	-	-	0.000000111

Source: Data processed using RStudio (2026)

Before examining the influence of each variable, first note the Adjusted R-Square value in Table 6, which is 0.8480. This figure provides an initial indication that the model we built is very robust, with 84.8% of the change in diesel imports being significantly influenced by biodiesel policy and global oil prices.

Furthermore, if we dissect the influence of variables partially, the Mandatory Biodiesel variable(X_1)shows results consistent with our hypothesis. With a value of (p< 0.001), this policy has been empirically proven to be a major factor suppressing diesel imports. Mathematically, the negative coefficient of -24,454,952 explains that every time the government's commitment to the biodiesel mix increases, our dependence on foreign diesel will immediately decline significantly.

On the other hand, this study also captures the influence of external factors, namely Global Crude Oil Prices (X_2). Although world oil prices have a significant positive influence (p= 0.009), its strength is unable to offset the dominance of biodiesel policy in suppressing imports. This provides a positive signal that Indonesia's energy sovereignty is beginning to be established through domestic policies, so that we are no longer completely 'driven' by fluctuations in global energy prices. In short, Model 2 demonstrates that despite uncertain global market conditions (oil prices), the Mandatory Biodiesel policy remains an effective

'shield' for Indonesia in keeping diesel import volumes under control.

Parameter Substitution into Model 2

Based on the estimation results in Table 6, the coefficient values obtained can be substituted into the multiple linear regression equation as follows:

$Y = 7{,}955{,}533 - 27{,}315{,}841X_1 + 55{,}138X_2 + \varepsilon$

Where:

- Y: Diesel Import Volume (kiloliters)
- X_1: Mandatory Percentage of Biodiesel (%).
- X_2: World Crude Oil Prices (USD/Barrel).
- ε: Error term (other factors outside the model).

Mathematically, the equation above can be developed to explain how these two variables "work together" to influence import volume. Assuming the Mandatory Biodiesel variable (X_1) and World Oil Prices (X_2) is zero, then the estimated volume of diesel imports is 7,955,533 kiloliters. This figure represents Indonesia's basic diesel import needs before the biodiesel policy intervention.

CoefficientX_1 A value of -24,454,952 indicates a very strong negative relationship. Every 1% (or 0.01 decimal) increase in the mandatory biodiesel mix is predicted to reduce diesel import volume by 244,549 kiloliters. It is important to note that the value$p < 0.001$(obtained from the value of 0.000000404 in Table 6) shows that this effect is not a statistical coincidence, but rather a real impact of the substitution of fossil diesel with biofuels domestically.

CoefficientX_2 The value of 55,138 indicates a positive relationship. This means that for every USD 1 per barrel increase in global oil prices, import volume tends to increase by 55,138 kiloliters. This figure suggests that despite Indonesia's efforts to reduce imports through biodiesel, global price dynamics continue to exert pressure on procurement volume. However, with a value of$p = 0.009$(still below 0.05), this variable remains statistically significant as a control factor in this model.

When these two variables are combined, it is clear that the negative coefficient of the Mandatory Biodiesel Policy is significantly larger than the positive effect of oil prices. This indicates that the import-reducing effect of the biodiesel policy is far more dominant than the import-increasing effect of rising global oil prices. This means that Indonesia's domestic policies have a stronger bargaining power in controlling import volumes than the influence of the international energy market.

MODEL DEVELOPMENT AND INTERPRETATION

Testing Model Robustness

The multiple linear regression model described in the previous section is capable of simulating the impact of future energy policies. Referring to the obtained estimation equation:

$Y = 7{,}955{,}533 - 27{,}315{,}841X_1 + 55{,}138X_2 + \varepsilon$

This section outlines the interpretation to measure the extent to which domestic intervention variables can be a solution in mitigating uncertain external risks.

The above equation reveals a contrasting influence structure between domestic policies and global market conditions. The very negative coefficient on the Mandatory Biodiesel variable (X_1) of -24,454,952 indicates that each unit increase in the government's commitment to the bioenergy mix will linearly reduce the volume of national diesel imports. Theoretically, this figure reflects an effective energy substitution mechanism; where every drop of domestically produced biofuel directly replaces the need for fossil fuels from abroad. The significance of the value$p$ very small$p < 0.001$emphasized that this mandatory policy is not only a supporting factor, but also a major determinant (prime mover) in controlling the volume of Indonesian diesel imports over the past two decades.

To demonstrate the robustness of this model as a projection tool, a sensitivity analysis was conducted to variable fluctuations. Through mathematical simulations, we can see how domestic variables work to neutralize external shocks. For example, if the government increases the mandatory biodiesel target by 5% (e.g., from B35 to B40), the model predicts a decrease in import volume of:

$5\% \times 24{,}454{,}952 = 1{,}222{,}747 kiloliter$

The robustness of this model is demonstrated when we include "disturbances" from global markets. If, at the same time, the Global Crude Oil Price (X_2) surged by USD 10 per barrel, mathematically, this would only trigger an increase in imports of 551,380 kiloliters. On a net basis, the combination of the two events still resulted in a decrease in imports of 671,367 kiloliters. This phenomenon, from an economic perspective, can be called the Compensation Effect. This means that the mandatory biodiesel policy acts as a very strong buffer; even significant shocks in global oil prices cannot undo the effectiveness of the import reductions generated by domestic policies. This provides empirical evidence that Indonesia's energy sovereignty can be achieved as long as the consistent increase in the renewable energy mix is maintained.

Model Validity against Future Mandatory Policy Projections

The urgency of this model's predictive power becomes even more apparent in response to recent news (CNBC Indonesia, May 2026) stating that the Indonesian government will officially implement the Mandatory B50 policy on July 1, 2026. This policy is an aggressive step to increase the Fatty Acid Methyl Ester (FAME) mix by 50% in every liter of diesel fuel to strengthen the country's fiscal position amidst global geopolitical risks that trigger energy price fluctuations. Based on the parameters generated in this study, the transition to B50, which represents a 15% increase in the mix from the B35 database, provides a projected reduction

huge volume of diesel imports:

$\Delta\ Y$ = 15% × 24,454,952 = 3,668,242$kiloliter$

Although the country's total foreign exchange savings (projected to reach IDR 157.28 trillion in 2026) encompass a broader range of fiscal variables, the model's estimation results provide a volume basis that reinforces this optimism. The reduction in diesel imports of 3.67 million kiloliters is a major contributor to the structure of these foreign exchange savings. The alignment between the direction of the volume reduction in Model 2 and the government's fiscal savings target indicates that the mandatory biodiesel variable has high external validity. This model demonstrates that the success of the B50 policy in maintaining foreign exchange stability is highly dependent on the consistent reduction in diesel import volume, as indicated by the significant negative coefficient in this study.

As a conclusion of the model development, this analysis confirms that Indonesia's dependence on foreign diesel supplies is no longer absolute, but can be precisely controlled through mandatory bioenergy mix instruments. Despite the dynamics of global oil prices (X_2) remains a significant external factor, the Mandatory Biodiesel policy (X_1) is present as an intervening variable with a much more dominant influence. With a model accuracy rate (Adjusted R-Square) of 84.8%, this study provides academic confidence that the move towards B50 implementation in July 2026 will be a major catalyst in stabilizing the national energy balance and minimizing economic vulnerability to international market shocks.

IV. CONCLUSION

Indonesia's mandatory biodiesel policy has proven effective in suppressing diesel imports, reducing the oil and gas trade deficit, and strengthening national energy security during the 2005–2023 period. Simple and multiple linear regression results indicate that increasing the biodiesel blend percentage has a negative and significant impact on diesel imports, with the model's ability to explain import variation reaching 84.8%. This finding confirms that the biodiesel policy functions not only as a substitute for fossil fuels but also as a strategic instrument in maintaining national economic stability by saving foreign exchange and reducing dependence on imported energy. Furthermore, although global crude oil prices have been shown to influence diesel imports, the mandatory biodiesel policy has a far more dominant influence, providing a cushion against volatility in the international energy market. The practical implications of this study indicate that implementing and increasing the biodiesel blend to B50 has the potential to be a strategic step for the government in strengthening energy independence and maintaining Indonesia's fiscal stability amidst global geopolitical uncertainty.

However, this study still has several limitations. The model only includes mandatory biodiesel variables and global crude oil prices, leaving other factors unaccommodated, such as the rupiah exchange rate, domestic refinery capacity, industrial sector energy consumption, and the dynamics of national

transportation demand. Furthermore, the use of annual data means the model is unable to capture short-term fluctuations that may impact policy effectiveness. Therefore, future research is recommended to develop a more complex econometric model by adding macroeconomic variables and using monthly or quarterly data to achieve more accurate and comprehensive estimation results. Future research could also examine environmental impacts, energy efficiency, and the sustainability of palm oil feedstock supplies to ensure that biodiesel policy implementation is not only economically sound but also ecologically and socially sustainable.

REFERENCE

[1]. Indonesian Palm Oil Plantation Fund Management Agency. (2024). Mandatory biodiesel in Indonesia.
[2]. https://www.bpdp.or.id/mandatori-biodiesel-untungkan-rakyat-indonesia
[3]. Bloomberg Technoz (2024). History mandatory biodiesel in Indonesia. https://www.bloombergtechnoz.com/detail-news/58988/b40-meluncur-besok-begini-sejarah- mandatory-biodiesel-in-ri
[4]. CNBC Indonesia. (2026, May 4). Indonesia will have new B50 fuel in July 2026. How much will it cost?https://www.cnbcindonesia.com/news/20260504103848-4-731938/ri-bakal-punya-bbm-baru- b50-in-july-2026-how-much-does-it-cost
[5]. Directorate General of Oil and Gas, Ministry of Energy and Mineral Resources. (2015).
[6]. Oil and gas statistics 2014. Ministry of Energy and Mineral Resources
[7]. Directorate General of Oil and Gas, Ministry of Energy and Mineral Resources. (2019). Oil and gas statistics 2018. Ministry of Energy and Mineral Resources.
[8]. Directorate General of Oil and Gas, Ministry of Energy and Mineral Resources. (2024). Oil and gas statistics 2023. Ministry of Energy and Mineral Resources.
[9]. Faridha, Oktaviani, K., Zulkarnain, Suntoro, D., Ladiba, AF, Sasti, HT, Anggono, T., & Negara, I.
[10]. GNASP (2021). Biodiesel: A Long Path of Struggle. ESDM Research and Development Agency, Ministry of Energy and Mineral Resources.
[11]. Iba, Z., & Wardhana, A. (2024). Regression analysis and path analysis for business research using SPSS 29.0 & Smart-PLS 4.0. Eureka Media Aksara.
[12]. Ministry of Energy and Mineral Resources. (2008). Regulation of the Minister of Energy and Mineral Resources Number 32 of 2008 concerning the provision, utilization, and trade of biofuels as alternative fuels.
[13]. Ministry of Energy and Mineral Resources. (2013). Regulation of the Minister of Energy and Mineral Resources Number 25 of 2013 concerning amendments to ESDM Regulation No. 32 of 2008.
[14]. Ministry of Energy and Mineral Resources. (2014). Regulation of the Minister of Energy and Mineral Resources Number 20 of 2014 concerning amendments to ESDM Regulation No. 32 of 2008.
[15]. Ministry of Energy and Mineral Resources. (2015). Regulation of the Minister of Energy and Mineral Resources Number 12 of 2015 concerning the third amendment to ESDM Regulation No. 32 of 2008.
[16]. Ministry of Energy and Mineral Resources. (2019). Decree of the Minister of Energy and Mineral Resources Number 227 K/12/MEM/2019 concerning the mandatory determination of biodiesel.
[17]. Ministry of Energy and Mineral Resources. (2022). Decree of the Minister of Energy and Mineral Resources Number 205.K/EK.05/DJE/2022 concerning the determination of biodiesel utilization.
[18]. Ministry of Energy and Mineral Resources. (2024). Decree of the Minister of Energy and Mineral Resources Number 341.K/EK.01/MEM.E/2024 concerning the establishment of the latest biodiesel policy.
[19]. Ministry of Energy and Mineral Resources. (2025). The implementation of the B40 mandate has successfully reduced Indonesia's diesel imports, aiming for an import-free system by 2026. https://www.esdm.go.id/id/media-center/news-archive/mandatory-b40-realization-successfully-suppresses-diesel-imports-in-Indonesia-targets-to-be-import-free-in-2026
[20]. Macrotrends. (nd). Crude oil prices: Historical chart (1946–2026). https://www.macrotrends.net/datasets/1369/crude-oil-price-history-chart
[21]. Ministry of Energy and Mineral Resources, Directorate General of Oil and Gas. (2009). Indonesia oil and gas statistics 2009: Annual report. Directorate General of Oil and Gas.
[22]. Reuters. (2026, May 6). Palm oil rally seen continuing as biodiesel demand rises, analyst says. Reuters.https://www.reuters.com/sustainability/climate-energy/palm-oil-rally-seen-continuing- biodiesel-

demand-boost-analyst-mistry-says-2026-05-06/

[23]. Sahara, Dermawan, A., Amaliah, S., Irawan, T., & Dilla, S. (2022). Economic impacts of biodiesel policy in Indonesia: A computable general equilibrium approach. ***Journal of Economic Structures***, 11(22).https://doi.org/10.1186/s40008-022-00281-9.