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Predictive Analysis of VAT Revenue in 2025: The Effect of Macroeconomic Factors on VAT Revenue

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Abstract

Purpose: *The purpose of this study is to analyze the influence of macroeconomic factors—namely the rupiah exchange rate, inflation rate, and economic growth—on Value Added Tax (VAT) revenue in Indonesia. Additionally, the research aims to predict VAT revenue for 2025 using a regression-based Machine Learning algorithm and to analyze these predictions in the context of the planned VAT rate increase to 12%.*

Design/methodology/approach : *This study employs a quantitative approach using secondary time-series data from 2017 to 2024, sourced from Statistics Indonesia (BPS), Bank Indonesia, and the Ministry of Finance. The dependent variable is VAT revenue, while the independent variables include the rupiah exchange rate, inflation, and economic growth. The analysis began with classical assumption tests and multiple linear regression. Subsequently, predictive modeling was conducted using the KNIME platform, testing several Machine Learning algorithms—including linear regression (with and without lag variables), Gradient Boosting, and Random Forest—to find the most accurate model.*

Findings : *Statistical test results show that the rupiah exchange rate, inflation, and economic growth have no significant effect on VAT revenue, neither individually nor simultaneously. The linear regression, lag-variable, and Gradient Boosting models performed inadequately, showing low explanatory power (low R 2). In contrast, the Random Forest model proved superior with an R 2 of 0.844, significantly explaining the data's variability. Based on this model, VAT revenue in 2025 is predicted to follow a gradual upward trend throughout the quarters. An initial dip in revenue is analyzed as a consequence of global geopolitical instability and a domestic political transition impacting consumer purchasing power.*

Research limitations/implications: *The main limitation of this study is the relatively short time span of the data, which prevents the full capture of long-term trends. The implication is that simple linear models are insufficient for predicting VAT revenue, making complex models like Random Forest more relevant for fiscal policy analysis. Future research is recommended to expand the analysis period and incorporate other variables, such as taxpayer compliance rates and broader global economic conditions.*

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INTRODUCTION

Value Added Tax (VAT) is one of the main sources of state revenue that contributes significantly to the Anggaran Pendapatan dan Belanja Negara (APBN). In an effort to optimize tax revenue, the government implements various fiscal policies including changes in VAT rates. Based on Peraturan Menteri Keuangan (PMK) Nomor 131 tahun 2024, the VAT rate will increase from 11% to 12% starting in 2025. This policy is expected to increase state revenue to meet the financing needs of national development. However, the effectiveness of the VAT rate increase is still debatable considering that previous experience shows that rate increases are not always followed by a significant increase in tax revenue.

In 2022, the VAT rate was increased from 10% to 11% as stipulated in the Undang-Undang Harmonisasi Peraturan Perpajakan (UU HPP) Nomor 7 Tahun 2021. Despite the rate increase, the realization of tax revenue based on the tax ratio did not show a significant increase. Indonesia's tax ratio is still stagnant and tends to be lower than other countries in the ASEAN region. Since the government raised the VAT rate in 2022, tax performance has not improved. Indonesia's tax-to-GDP ratio in 2023 actually decreased from 11.6% in 2022 to 10.21% in 2023. This indicates that in addition to the VAT rate increase policy, there are macroeconomic factors that affect the performance of VAT revenue to be able to contribute significantly, such as the rupiah exchange rate, inflation rate, and economic growth.

Table 1. Indonesia's Taxation Ratio 2017-2024

Year	Ratio of Tax Revenue to GDP (Percent)
2017	9,9%
2018	10,2%
2019	9,8%
2020	8,3%
2021	9,11%
2022	11,6%
2023	10,21%
2024	10,1%

Source: data.worldbank

Solow's (1956) economic growth theory explains that capital accumulation and productivity improvements contribute to sustainable economic growth (Rustian & Kusumastuti, 2023). High economic growth can expand the tax base through increased consumption of goods and services. The Gross Domestic Product (GDP) approach also shows that increased consumption due to economic growth can directly increase VAT revenue (Daroen et al., 2024).

Purchasing Power Parity (PPP) Theory by Cassel (1918) explains that exchange rate

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fluctuations can affect the competitiveness of domestic products in the global market (Faustina Al, 2023). Research by Sandi et al. (2024) found that exchange rate depreciation can increase exports and increase tax revenue from the international trade sector, although under certain conditions excessive depreciation can trigger imported inflation and suppress people's purchasing power.

Meanwhile, the Quantity Theory of Money proposed by Irving Fisher states that high inflation can reduce people's purchasing power, but at the same time increase the nominal value of goods and services that are the basis for VAT imposition (Simanungkalit, 2020). However, if inflation is too high, the decrease in consumption can be greater than the increase in transaction value, which in turn can actually reduce VAT revenue (Rizani et al., 2023).

Considering these theories and empirical findings, a data-driven predictive analysis approach is important to understand the relationship between macroeconomic factors and VAT revenue. This data analysis is conducted using Machine Learning algorithms to model the relationship between macroeconomic variables and tax revenue through a regression-based predictive analysis approach. This model is used to analyze the effect of rupiah exchange rate, inflation rate, and economic growth on VAT revenue.

Based on this background, this study aims to:

1. Analyze the influence of macroeconomic factors, namely the rupiah exchange rate, inflation rate, and economic growth, on VAT revenue.
2. Predict state revenue in 2025 using a regression-based Machine Learning algorithm.
3. Analyze the prediction results of VAT revenue in 2025.

LITERATUR REVIEW

State Revenue

State revenue is a key component in a country's fiscal management. According to Kagan (2021), state revenue consists of tax revenue and non-tax revenue. Taxes, as the primary source of state revenue, serve to finance government expenditures for the provision of public goods and services. A study by the OECD (2022) shows that an effective tax structure can enhance economic growth and reduce inequality.

Tax revenue is divided into direct and indirect taxes, with Value Added Tax (VAT) being one of the main instruments for increasing state revenue. According to Keen et al. (2020), an efficient tax system should consider aspects of fairness, simple administration, and its overall economic impact. High taxes can reduce business competitiveness, while excessively low taxes may limit the government's capacity to provide adequate public services.

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Value Added Tax (VAT)

VAT is one of the primary sources of tax revenue in many countries, including Indonesia. According to a study titled *The Urgency of Increasing Value Added Tax Rates Based on the Principle of National Interest* by (Agasie & Zubaedah, 2022), a well-designed VAT system can increase state revenue without causing significant economic distortions. The study also emphasizes that VAT is more efficient than other types of taxes due to its broad application and consumption-based nature. VAT is imposed on all individuals who consume specific goods as determined by regulations. The absence of exemptions for certain subjects, such as layering, makes VAT a powerful tool for increasing state revenue. The global implementation of VAT has significantly boosted government revenues. However, the effectiveness of VAT largely depends on tax administration and taxpayer compliance.

Rupiah Exchange Rate

The rupiah exchange rate represents the price of the rupiah against foreign currencies, reflecting its purchasing power in international trade. The exchange rate serves as an indicator of a country's economic stability and is influenced by various factors such as inflation, interest rates, monetary policy, and global market conditions (Afiezan et al., 2021). The rupiah exchange rate has a significant impact on state revenue, particularly in sectors related to trade and export-import industries. According to the Purchasing Power Parity (PPP) theory by Cassel (1918), exchange rate fluctuations can affect the competitiveness of domestic products in the global market (Faustina Al, 2023). Research by Sandi et al. (2024) found that currency depreciation can boost exports and increase tax revenue from the export sector. However, excessive depreciation may lead to import inflation and raise the burden of foreign debt.

Inflation

Inflation is defined as the percentage change in prices, calculated using the Consumer Price Index (CPI) as the primary measure. According to classical economic theory, inflation occurs when the money supply in the economy increases at a faster rate than the growth of goods and services output. Inflation is a factor that can affect tax revenue and people's purchasing power (Simanungkalit, 2020). According to Irving Fisher's Quantity Theory of Money, high inflation can reduce purchasing power, thereby decreasing consumption, but at the same time, the price base on which a tax is levied increases. This ultimately impacts tax revenue, particularly VAT. Inflation leads to higher prices of goods and services, which means that the tax base (transaction value) increases. This tends to boost VAT revenue since this tax is calculated as a percentage of the selling price. However, if high inflation significantly reduces people's purchasing power, overall consumption may decline, thereby lowering total VAT revenue (Rizani et al., 2023).

Economic Growth

Economic growth is closely related to the increase in state revenue. The classical theory

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by Solow (1956) suggests that capital accumulation and productivity improvements contribute to sustainable economic growth. In the context of state revenue, high economic growth tends to increase tax revenue automatically through an expanding tax base (Rustian & Kusumastuti, 2023). Economic growth is often represented by Gross Domestic Product (GDP). GDP, as the primary indicator of economic growth, can directly and indirectly affect VAT revenue. GDP from the Expenditure Approach directly influences VAT revenue because VAT is imposed on the consumption of goods and services. If consumption increases, the tax base for VAT also expands. Similarly, GDP from the Income Approach plays a role. Higher household income (through wages and business profits) can drive increased consumption, thereby boosting VAT revenue. However, if national income is concentrated among groups with a high tendency to save, the impact on VAT revenue may be smaller (Daroen et al., 2024).

The Relationship Between Exchange Rates and VAT Revenue

Exchange rates influence VAT revenue through import prices and domestic consumption. According to Rizqi & Ekowati (2022), the rupiah exchange rate has a positive and significant impact on VAT revenue. The exchange rate affects VAT revenue because fluctuations in the rupiah influence the prices of taxable goods and services (BKP and/or JKP). When the rupiah strengthens, selling prices decrease as a stronger exchange rate against the USD lowers production costs, particularly the cost of importing raw materials. Consequently, lower selling prices increase consumers' purchasing power, leading to higher VAT revenue. A study by the OECD (2022) shows that exchange rate stability and appreciation can boost VAT revenue, as more competitive import prices encourage higher consumption. With improved purchasing power, the consumption of VAT-taxable goods and services increases. Additionally, industries reliant on imported raw materials benefit from lower production costs, enabling higher output and expanding economic transactions subject to VAT. Therefore, exchange rate stability and appreciation play a crucial role in optimizing VAT revenue.

The Relationship Between Inflation and VAT Revenue

Inflation can impact VAT revenue through changes in the prices of goods and services. According to the IMF (2022), rising inflation increases the prices of goods and services, thereby expanding the VAT tax base. This can contribute to higher tax revenue in the short term. Additionally, controlled inflation can encourage producers to enhance the production and distribution of goods and services, increasing the number of transactions subject to VAT (World Bank, 2021). Under moderate inflation conditions, businesses tend to adjust selling prices while maintaining consumers' purchasing power through marketing strategies and production efficiency. This balance between rising prices and sustained consumption ultimately has a positive effect on VAT revenue. Therefore, stable inflation management plays a vital role in optimizing tax revenue from VAT.

The Relationship Between Economic Growth and VAT Revenue

Economic growth has a positive correlation with tax revenue. This is because

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macroeconomic growth serves as the basis for taxation, as stated by Sinaga (2010:3) in Subagyo (2020). When the tax base increases, tax revenue also rises, and vice versa. Economic growth is defined as the long-term expansion of a country's capacity to provide various economic goods to its population (Kuznets, 2009). This aligns with Joseph Schumpeter's growth theory and the purchasing power theory, which emphasize the role of entrepreneurs in driving economic innovation. By increasing the production of goods and services, economic activities expand, leading to higher consumption and purchasing power. Consequently, this growth contributes to increased VAT revenue. According to Zeng (2013), economic growth positively affects tax revenue. This supports the findings of Damayanti (2016), who stated that economic growth partially influences tax revenue in Asian countries. Based on this analysis, economic growth is expected to have a positive impact on VAT revenue.

Conceptual Framework

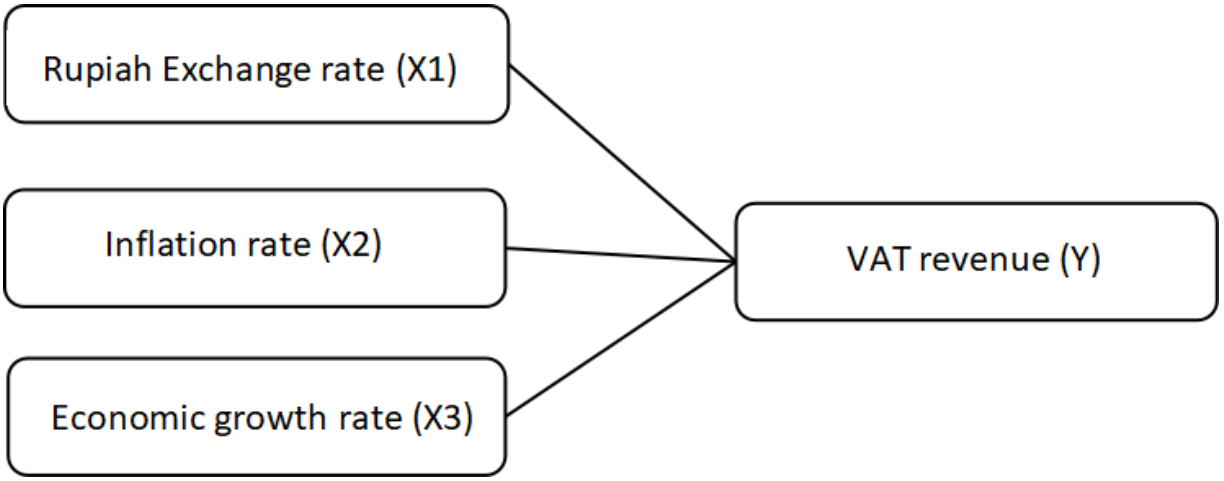

Figure 1. Conceptual Framework

Hypothesis Development

- The rupiah exchange rate is expected to have a positive and significant effect on VAT revenue.
- The inflation rate is thought to have a positive and significant effect on VAT revenue.
- The economic growth rate is thought to have a positive and significant effect on VAT revenue.

RESEARCH METHOD

Type & Object of Research

This research uses a quantitative approach that aims to determine the relationship and influence between two causal variables, namely between the independent variable (rupiah exchange rate, inflation rate, and economic growth) and the dependent variable (VAT revenue). The object of this research is Value Added Tax Revenue in Indonesia in 2017-2024. While the scope of this research is the influence of the rupiah exchange rate, inflation, and economic growth on VAT revenue.

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a. Dependent variable

- Value added tax revenue (Y)
  VAT is one of the main sources of revenue for the state. Changes in VAT revenue can reflect economic conditions and the effectiveness of the implemented tax policy. As a tax imposed on the consumption of goods and services, VAT revenue is strongly influenced by various economic factors that affect the level of public consumption.

b. Independent Variables

- Exchange Rate
  Exchange rate fluctuations can affect the price of imported goods and the competitiveness of domestic products. Changes in the rupiah exchange rate have a significant effect on Value Added Tax (VAT) revenues.
- Inflation
  Inflation describes the general price increase of goods and services in the economy. The inflation rate will affect the price of Taxable Goods and Taxable Services, where the basis for imposing VAT is the acquisition price. Thus, inflation affects VAT revenue.
- Economic Growth
  Economic growth is represented by GDP because GDP reflects the total value of goods and services produced by a country within a certain period. An increase in GDP usually indicates positive economic growth, which can increase people's purchasing power and consumption, thus potentially increasing VAT revenue.

Data Type

This research uses a quantitative approach with the type of data used is secondary data consisting of rupiah exchange rate data, inflation rate data, and economic growth data represented by Gross Domestic Product (GDP), as well as VAT revenue data. The time span of the data used is 2017-2024, However, we did not have data for q1-q3 of 2017 and used the average approach to replace the missing values.

Data Collection Methods

The data used is taken from the official websites of the Badan Pusat Statistik, Bank Indonesia, and the Kementerian Keuangan in the form of time series data.

Regression Model

The research uses a type of quantitative research method with time series data with multiple linear regression analysis techniques in the first place. The dependent variable in this study is VAT revenue. The independent variables in the study include the rupiah exchange rate, inflation, and economic growth. The regression equation is as follows.

$$Y_t = \alpha + \beta_{1t} + \beta_{2t} + \beta_{3t} + \varepsilon_t$$

Keterangan:

Y_t = VAT revenue in period t

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β_{1t} = **Rupiah exchange rate in period t**
β_{2t} = **Inflation rate in period t**
β_{3t} = **Economic growth rate in period t**
α = **Constant**
$\beta_{1t},\beta_{2t},\beta_{3t}$ = **Coeff**
ε = **Standard Error**

This research uses the elaboration of STATA and KNIME applications. The STATA application is used to conduct classical assumption tests, namely normality test, multicollinearity test, heteroscedasticity test, and autocorrelation test to obtain Best Linear Unbiased Estimator (BLUE) results. The test results were reprocessed using the KNIME application. KNIME integrates various components of machine learning and data mining techniques using *building blocks*, making it easier to get an overview of the data processing stages. Several models in KNIME are used to find the best results, namely m*ultiple linear regression,* m*ultiple linear regression (lag variables), gradient boost regression, and random forest regression.*

RESULTS

Descriptive statistics

Based on the test results, the descriptive statistical results are as follows:

Table 2. Descriptive statistic

	VAT Rev	Exchange Rate	Inflation	Economic growth
Mean	154.777	14.676,531	2,959	1,044
Maximum	264.715	16.394	5,95	5,05
Minimum	89,94	13.319	1,33	-4,19
Std. Dev.	43,474	840,916	1,182	2,366
Skewness	0,382	0,397	0,725	-0,091
Kurtosis	-0,215	-0,403	0,309	-0,904
Sum	4.952,876	469.649	94,7	33,41

Source: BPS, BI, and APBN Kita

From 2017 to 2024, VAT revenue shows a fluctuating development. VAT revenue data has an average of 154.777 trillion rupiah, with a maximum value of 264.715 trillion rupiah and a minimum of 89.94 trillion rupiah. The standard deviation for VAT revenue is 43.474, indicating that this data has a relatively small variation around the mean. The distribution of VAT Revenue is slightly skewed to the right, with a skewness value of 0.382, and its negative kurtosis (-0.215) indicates that this distribution is flatter than a normal distribution.

Furthermore, the Exchange Rate shows an average of 14,676.531 rupiah. The maximum value for the Exchange Rate is 16,394 rupiah, while the minimum value is 13,319 rupiah. With a very small standard deviation of 840.916, the variability of the Exchange Rate data is low. The distribution of the Exchange Rate is skewed to the right, with a skewness of 0.397, and its negative kurtosis (-0.403) indicates that it is also flatter.

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Inflation has an average of 2.959%. The maximum value for Inflation is 5.95%, while the minimum value is 1.33%. The standard deviation is 1.182, indicating that the Inflation data has low variability. The distribution of Inflation is skewed to the right, with a skewness of 0.725, and a positive kurtosis (0.309) indicating that this distribution is sharper than the normal distribution.

Finally, Economic Growth is the variable that attracts the most attention, having an average of 1.044%, with a maximum value of 5.05% and a minimum of -4.19%. The standard deviation for Economic Growth is 2.366, showing significant variation. The distribution of Economic Growth is slightly skewed to the left, with a skewness of -0.091, and a negative kurtosis (-0.904) indicating that it is also flatter.

Classical Assumption Test

The classical assumption test is carried out before hypothesis testing, to ascertain whether the equation in the regression model is econometrically acceptable. Classical assumption testing is carried out by testing normality, multicollinearity, heteroscedasticity and autocorrelation. In this study, the author used the STATA / SE 18.0 application to test classical assumptions due to limited tools in the Knime application. The data used is data that has been normalized using the Knime application. Normalized data aims to standardize all data so that it becomes a range of 0-1.

a. Normality Test

Table 3. Normality Test

Skewness and kurtosis test for normality

				---------- Joint test ----------	
Variable	Obs	Pr(skewness)	Pr(kutosis)	Adj chi2(2)	Prob>chi2
resid	32	0.6217	0,6456	0,47	0,7912

Source:

Source: processed by the author

The normality test is carried out to determine whether the data used is normally distributed or not. Data can be said to be normal when the significance> 0.05. The normality test results in the table above show that the value obtained is 0.7912 so that the data to be analyzed is normally distributed.

b. Multicollinearity Test

Table 4. Multicollinearity Test

VIF

Variable	VIF	1/VIF
Inflasi	1.01	0.990701
pert_eko	1.01	0.993827
KursRp	1.00	0.996291

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Mean VIF	1.01

Source: processed by the author

Multicollinearity test is a condition where there is a perfect or near linear relationship between the independent variables of a regression model. A regression model is said to be multicollinear if some or all of the independent variables in the linear function have a perfect linear function. Symptoms of multicollinearity include looking at the variance inflation factor (VIF) and tolerance value. If based on the multicollinearity test results, the Tolerance value> 0.01 or the Variance Inflation Factor (VIF) value < 10, the regression model is free from multicollinearity symptoms. The multicollinearity test results in the table above show that the VIF value is 1.01, so it can be concluded that there is no multicollinearity between the independent variables in the regression model.

c. Heteroscedasticity Test

Table 5. Heteroscedasticity Test

hettest resid
Breusch-Pagan/Cook-Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: **resid**

H0: Constant variance

Chi2(1) = 0,55
Prob > chi2 = 0,4603

Source: processed by the author

The heteroscedasticity test is used to test whether in the regression model there is an inequality of variance from the residuals of one observation to another. Heteroscedasticity is a condition in which the variance of the residuals (errors) in the regression model is not constant across the entire range of independent variables. This violates the classical assumption in linear regression, which requires the residuals to have a fixed variance (homoscedasticity). If heteroscedasticity occurs, the regression estimation results can be inefficient, leading to errors in coefficient interpretation and significance tests. The heteroscedasticity test results in the table above show that the value obtained is 0.4603, where if Prob>chi2 exceeds 0.05 then the data is not heteroscedastic or homoscedastic.

d. Autocorrelation Test

Table 6. Autocorrelation Test

estat bgodfrey, lags (2)

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Breusch-Godfrey LM test for autocorrelation

Lags(p)	chi2	df	Prob > chi2
2	0,433	2	0,8054

H0: no serial correlation

Source: processed by the author

The autocorrelation test is carried out to determine whether there is a correlation between the independent variables in the prediction model with changes in time. By using the bgodfrey estat test if the results of the Prob>chi2> 0.05 value are obtained, it is concluded that there is no correlation between the independent variables. Based on the table above, it shows that the Prob> Chi2 value is 0.8054> 0.05, so in this regression model there is no autocorrelation.

Based on the classical assumption test that has been carried out, the results show that the data analyzed have met all tests. If the regression model meets all these classical assumptions, then the model can be said to be BLUE (Best Linear Unbiased Estimator), which means that the regression estimate is the best, linear, and unbiased. Therefore, the data that has been obtained can be used and will result in the validity of the analysis results.

Hypothesis Test

1. F Test

The F test in regression is used to test the overall significance of the regression model. That is, this test helps determine whether at least one independent variable in the model has a significant relationship with the dependent variable.

Table 7. F Test

Source	SS	df	MS	
Model	0,276247836	3	0,092082612	Number of obs = 32
Residual	1,64183486	28	0,058636959	F(3,28) = 1,57
Total	1,9180827	31	0,061873635	Prob>F = 0,2186
				R-squared = 0,1440
				Adj R-squared = 0,0523
				Root MSE = 0,24215

PPN	Coefficient	Std. Err.	t	P>|t|	[95% conf.	Interval]
KursRp	0,3070761	0,1593324	1,93	0,064	-0,0193015	0,6334538
Inflasi	0,1891153	0,1708373	1,11	0,278	-0,1608291	0,5390596
Pert_eko	-0,0045263	0,1703585	-0,03	0,979	-0,3534898	0,3444372
_cons	0,1712773	0,1380922	1,24	0,225	-0,1115918	0,4541463

Source: processed by the author

Based on the regression results, the significance value is 0.2186. These results indicate that the rupiah exchange rate, inflation, and economic growth simultaneously have no significant effect on VAT revenue because the significance value is >0.05.

2. T Test

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The t-test in regression is used to test whether each independent variable individually has a significant effect on the dependent variable.

Table 8. T Test

Variable	Coeff	Std. Err	t-value	P>|t|
Kurs (rp)	0.195	0.179	1.092	0.287
Inflasi (%)	0.074	0.246	0.302	0.765
Pertumbuhan Ekonomi	0.047	0.186	0.255	0.801
Intercept	0.244	0.165	1.474	0.155

Source: processed by the author

The equation results of the regression are

Y = 0,244 + 0,195 (Kurs) + 0,074 (Inflasi) + 0,047 (Pertumbuhan Ekonomi)

Although there is a positive relationship, the t-test results show that none of the independent variables are statistically significant at the 5% significance level (p value > 0.05). This indicates that, despite the positive influence, the three variables do not significantly affect VAT revenue in the model.

Regression results

The next process is to divide the data into two partitions: 80% of the data is used for model training, while the remaining 20% is used for model testing. The linear regression model is built using Linear Regression Learner on the KNIME platform. Based on the results of multiple linear regression analysis as shown in Table 9, the regression coefficients for each independent variable are as follows: rupiah exchange rate (0.195), inflation (0.074), economic growth (0.047) and a constant of 0.244. Although there is a positive relationship, the t-test results show that none of the independent variables are statistically significant at the 5% significance level (p-value > 0.05). This shows that, despite the positive influence, the three variables do not significantly affect VAT revenue in the constructed model.

Table 9. Linear regression model

Variable	Coeff	Std. Err	t-value	P>|t|
Kurs (rp)	0.195	0.179	1.092	0.287
Inflasi (%)	0.074	0.246	0.302	0.765
Pertumbuhan Ekonomi	0.047	0.186	0.255	0.801
Intercept	0.244	0.165	1.474	0.155

Source: processed by the author

The model was evaluated using Numeric Scorer, which measures how well the model predicts VAT values based on the prepared test data. Based on the evaluation results as shown in Table 10, a number of statistical metrics provide an overview of the quality of the resulting predictions. The obtained R^2 is 0.232, indicating that the model is only able to

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explain around 23.2% of the variation in VAT revenue. This figure shows that the model has a limited explanatory power for the variability of the existing data. Furthermore, the mean absolute error (MAE) of 0.229 and the root mean squared error (RMSE) of 0.256 indicate that the prediction error is relatively high, with a large average absolute error and a large error penalty on the RMSE. The mean squared error (MSE) of 0.066 also confirms that the model prediction is still far from the actual value. Finally, the adjusted R^2 of 0.232 also shows that after considering the number of variables in the model, the results still show very limited explanatory power.

Table 10. Regression model evaluation results

	VAT Prediction
R^2	0.232
mean absolute error	0.229
mean squared error	0.066
root mean squared error	0.256
mean signed difference	0.035
mean absolute percentage error	6.18
adjusted R^2	0.232

Source: processed by the author

Overall, these metrics indicate that the linear regression model used does not provide adequate results for predicting VAT receipts, and the model needs improvement or the use of another more sophisticated approach. To address this issue, a stepwise backward elimination technique was used, which aims to remove insignificant variables from the model. Stepwise backward elimination is an iterative method for selecting features that starts with a model that includes all possible predictors, then gradually eliminates less significant predictors one by one until only the most important predictors remain in the model. The use of this method is supported by the fact that it can simplify the model, improve model interpretation, and potentially improve prediction accuracy by minimizing the risk of overfitting (James et al., 2013). The previous regression results show that the economic growth variable is the least significant, so this variable is excluded from the model. After removing the economic growth variable, the regression model still shows inadequate results with a still high p-value of the inflation variable (0.724) (Table 11). Therefore, a re-linear regression was carried out without the inflation variable, but the results still did not show adequate success, with the p-value of the exchange rate variable still greater than 0.05 (Table 12). Although the linear regression model provides a general picture of the effect of exchange rates and inflation, the results are insufficient to produce accurate predictions and have implications for the model's low ability to predict VAT revenue significantly. Therefore, another model is needed that can capture the complexity of macroeconomic variables.

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Table 11. Regression model without economic growth variable

Variable	Coeff	Std. Err	t-value	P>|t|
Kurs (rp)	0.195	0.175	1.117	0.276
Inflasi (%)	0.085	0.237	0.357	0.724
Intercept	0.267	0.134	1.993	0.059

Table 12. Regression model without economic growth and inflation variables

Variable	Coeff	Std. Err	t-value	P>|t|
Kurs (rp)	0.178	0.165	1.08	0.291
Intercept	0.304	0.086	3.534	0.002

After the linear regression model that uses the variables of exchange rate, inflation, and economic growth does not provide adequate results, one alternative that can be tried is to use the variable in the form of a lag. The use of lag variables is based on the assumption that economic variables such as exchange rates, inflation, and economic growth have an indirect and delayed impact on VAT receipts. This means that changes in these variables in the previous period may have a more pronounced effect on VAT in the following period, given the delay in market adjustments and the overall economic impact.

Using lags in economic models is a common practice in economic prediction and time series analysis. A study by (Virgantari & Rahayu, 2021) shows that models with lag variables provide more stable and accurate results in predicting dependent variables because they are able to capture the impact of independent variables in previous periods as well as more complex relationship patterns over time. Therefore, to improve the accuracy of the model, this study examines the application of lag variables for exchange rates, inflation, and economic growth.

Based on the evaluation of the model using lag variables, there are several important findings that show that although the model with lag 1 provides an improvement compared to the initial linear regression model, its performance is still less than optimal. Table 13 shows the R^2 result on the lag 1 model reaching 0.357, which shows an improvement compared to the previous model, but this value is still relatively low. Other metrics such as the mean absolute error (MAE) of 0.181 and the root mean squared error (RMSE) of 0.203 show significant prediction errors, although lower than the previous model. On the other hand, the adjusted R^2, which is also 0.357, reinforces this finding, showing that the lag 1 model is only able to explain a small part of the variability of VAT revenue data. This indicates that the regression model is still not strong enough to predict VAT revenue, although the application of the lag slightly improves its performance.

The experiment on the lag 2 model shows a decrease in results (Table 14). The recorded R^2 is -0.473, which indicates that the lag 2 model actually gives worse results than the model without lag. In addition, the higher MAE (0.259) and RMSE (0.308) metrics, as well as the mean absolute percentage error (MAPE) reaching 3,646, further indicate that the lag 2 model is unable to handle variability in the data properly. The negative adjusted R^2 (-0.473) shows that this model is even worse than the model that does not involve lag, which suggests that

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the use of lag 2 actually worsens the prediction accuracy. Based on these results, it can be concluded that the approach with linear regression, even with lag variables, is not effective enough and requires a more sophisticated machine learning model to provide more accurate results. Therefore, replacing the model with more complex techniques such as Gradient Boosting, ARIMA, and finally Random Forest Regression will be a necessary step to obtain more optimal predictions.

Table 13. Test of linear regression model with lag 1

	VAT Prediction
R^2	0.357
mean absolute error	0.181
mean squared error	0.041
root mean squared error	0.203
mean signed difference	0.092
mean absolute percentage error	1.311
adjusted R^2	0.357

Table 14. Test of linear regression model with lag 2

	VAT Prediction
R^2	-0.473
mean absolute error	0.259
mean squared error	0.095
root mean squared error	0.308
mean signed difference	0.086
mean absolute percentage error	3.646
adjusted R^2	-0.473

Gradient Boosting is an ensemble method that iteratively builds decision trees and combines the prediction results from each tree to reduce overall model error. This technique works by correcting previous model errors, making it very effective for handling non-linearity problems in data and progressively improving prediction accuracy. Several studies show that Gradient Boosting performs well because this method is able to produce accurate and robust predictive models, especially in handling unclean data or data with outliers. This algorithm works by building models in stages, where each new model focuses on the errors made by the previous model, thereby iteratively improving prediction accuracy. In addition, Gradient Boosting can handle various types of loss functions, such as least-squares, least absolute deviation, and Huber loss, making it flexible for a variety of regression and classification problems (Friedman, 2001).

However, although Gradient Boosting often produces excellent results in many cases, the results of this experiment did not produce significant improvements compared to the previous model. The evaluation results using Numeric Scorer for the Gradient Boosting

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model in Table 15 show an R^2 of 0.213, which indicates that this model can only explain about 21.3% of the variability of VAT receipt data, which is considered low. The Mean Absolute Error (MAE) value of 38,354 and the Mean Squared Error (MSE) of 2,096,355 indicate a significant prediction error, although lower than the previous result. The Root Mean Squared Error (RMSE) was recorded at 45,786, which is higher than the results of the linear regression model, while the Mean Absolute Percentage Error (MAPE) was recorded at 0.327, indicating that despite some improvements in absolute error, this model is still unable to provide sufficiently accurate predictions for VAT receipts. The Adjusted R^2 result of 0.213 further confirms the limitations of this model in explaining data variability.

Table 15 Gradient Boosting model evaluation results

	VAT Prediction
R^2	0.213
mean absolute error	38.354
mean squared error	2,096.355
root mean squared error	45.786
mean signed difference	15.876
mean absolute percentage error	0.327
adjusted R^2	0.213

Based on these results, it can be concluded that although Gradient Boosting provides a slight improvement compared to the linear regression model, the results are still insufficient for accurate predictions. Therefore, this study continues to try other approaches, such as Random Forest Regression, which is expected to provide better results.

Random Forest is an ensemble method that is very effective for classification and regression. This method works by combining many randomly constructed decision trees, each reducing errors by making predictions based on random attribute selection from training data. Random Forest has the advantage of handling complex data and having variables that interact non-linearly with each other. This technique also reduces overfitting, which often occurs in single decision tree models, by using multiple decision trees and combining their results to produce more stable and accurate predictions (Breiman, 2001).

In this study, Random Forest is used to predict VAT receipts using three independent variables, namely exchange rate (IDR rate), inflation, and economic growth. This model is trained with 80% training data and tested with 20% testing data. The results from the Random Forest Learner show that this model can produce better predictions compared to previous models, as seen in the prediction results by comparing the realization column (original data) with the prediction column (prediction results) in Figure 8 and the small difference between the blue line (original data) and the green line (prediction results) in Figure 2.

Table 16 Random Forest model prediction results

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Date	Realization per quarter	Exchange Rate	Inflation(%)	Economic Growth (%)	Realization per quarter (trillion)	Realization per quarter (prediction variance)	model count	VAT Prediction
31/03/23	185.7	14977	4.97	-0.9	161.559	704.268	46	174.595
30/06/23	171.07	15000	3.52	3.86	156.438	460.721	40	165.217
30/09/23	179.96	15487	2.28	1.6	174.267	1,686.981	36	177.911
31/03/24	155.79	15873	3.05	-0.83	193.046	2,624.392	41	171.065
30/06/24	177.02	16394	2.51	3.79	168.708	3,197.984	34	174.194
30/09/24	213.84	15144	1.84	1.5	175.553	1,997.036	28	203.12
31/12/24	264.715	16157	1.57	0.53	164.57	2,291.356	31	233.67

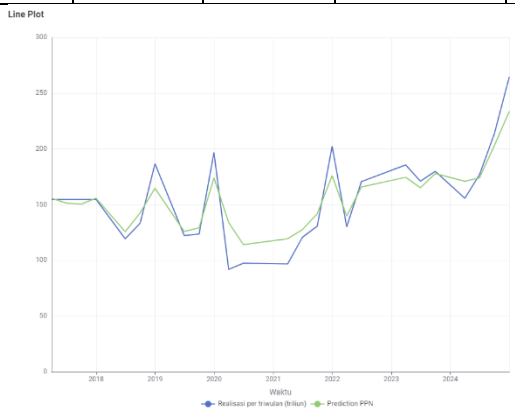

Figure 2 Visualization of Random Forest prediction results

The Numeric Scorer result for the Random Forest model shows better performance than the previous model. Table 17 shows an R^2 value of 0.844, which indicates that the model is able to explain around 84.4% of the variability in VAT revenue data, a significant improvement over previous models. The Mean Absolute Error (MAE) value is 11.92, which indicates that the average prediction error is 11.92 trillion. The Mean Squared Error (MSE) and Root Mean Squared Error (RMSE) were recorded at 248.89 and 15.77 respectively, indicating that the prediction errors remain under control. In addition, the Adjusted R^2 of 0.822 confirms that this model not only provides high results, but can also handle variations in data efficiently, without overfitting.

Table 17 Random Forest model evaluation results

	VAT Prediction
R^2	0.844
mean absolute error	11.926
mean squared error	248.89
root mean squared error	15.776
mean signed difference	0.16
mean absolute percentage error	0.085

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adjusted R^2	0.822

Based on these results, it can be concluded that Random Forest provides better results in predicting VAT revenue compared to other models that have been tested. These results show that Random Forest is better able to handle non-linear and complex relationships between variables in VAT revenue data.

To predict the amount of VAT revenue in 2025, it is necessary to estimate the value of the independent variables in each quarter of 2025. The approach used in this study is the moving average, which makes it possible to overcome the uncertainty of data that is not available for 2025. The moving average is used to estimate the value of the independent variables by calculating the difference between the moving averages of two consecutive years, then adding it to the value in Q1 2024 to produce an estimate of the value in Q1 2025. This approach provides a more realistic projection, given that economic fluctuations tend to stabilize in the next year and can provide a more accurate picture of the economic conditions faced in 2025.

Table 18 estimation of exchange rate, inflation, and economic growth variables in Q1-Q4 2025

Date	Exchange Rate	Inflation	Economic Growth
31/03/2025	16152	0.72	-0.815
30/06/2025	16992	0.135	3.755
30/09/2025	15592.5	0.2725	1.4975
31/12/2025	16823.25	0.4675	0.525

Source: processed by the author

The estimation calculation of the independent variables can be seen in table 18. For the Inflation variable, the Q1 2025 estimation results show a figure of 0.72%, which is very close to the inflation projection figure announced by the Central Statistics Agency (BPS) in January 2025, which is 0.76% (BPS, 2025). This shows that the estimation method used in this study is consistent with projections made by government agencies, and confirms the validity of the moving average approach used in calculating inflation. For the exchange rate variable, the Q1 2025 estimate calculation results in a value of IDR 16,152, which is in line with the rupiah exchange rate recorded in mid-February 2025 at IDR 16,365 (Bank Indonesia, 2025). Finally, the estimated economic growth for Q1 2025 shows a figure of -0.815%, which when added up as the total estimated growth for Q1-Q4 2025 is 4.9625%. This figure is consistent with the Indonesian government's projections that Indonesia's economic growth in 2025 is expected to reach around 5%. Thus, the calculation results for economic growth are also in line with government expectations, adding credibility to the estimation approach used in this study. Thus, the estimation results obtained using the moving average approach for Exchange Rate, Inflation, and Economic Growth in Q1-Q4 2025 can be considered valid and in accordance with existing projections at the government level, providing a strong basis for continuing the 2025 VAT revenue projections.

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DISCUSSIONS

The effect of rupiah exchange rate on VAT revenue

Based on the t statistical test, the rupiah exchange rate has a beta value of 0.195 and its significance is 0.287. The regression test results of the rupiah exchange rate with VAT revenue obtained a positive and insignificant relationship. This means that as the rupiah exchange rate increases, it will have an impact on increasing VAT revenue. This is because the rupiah exchange rate can affect the price of taxable goods/services that will be imported from abroad. This will affect people's consumption patterns so that the next impact is on VAT revenue. The rupiah exchange rate can change in line with economic conditions and inflation that occurs. This is motivated by many factors, such as the level of domestic consumption, economic stability, fixed tax rates in local currency, and government policies.

From the results of this study, the rupiah exchange rate data processed had no significant effect on economic growth. These results are in accordance with the results of research conducted by (Putri et al., 2024), (Arifatunnisa & Witono, 2022), and (Maulidya et al., 2021).

The effect of inflation rate on VAT revenue

The regression test results in this study show that the significance level of inflation in the regression model is 0.765 which is greater than the critical limit of 0.05. This shows that although there is a positive relationship between inflation and VAT revenue, the relationship is not statistically significant.

This result is consistent with Krisnafani's research (2022) which found that inflation has no significant effect on VAT revenue, although in theory an increase in inflation can increase the nominal value of taxes collected. This can be explained by the company's strategy in reducing production and operational costs to keep prices stable so that the increase in inflation does not directly affect VAT revenue. In addition, research by Yulianingtyas (2018) also shows similar results where inflation has no significant effect on VAT revenue. This study highlights that other factors such as the number of Taxable Entrepreneurs (PKP) and the level of taxpayer compliance have a more dominant role in determining VAT revenue compared to inflation.

Some other studies provide different findings. Yeni et al. (2018) found that inflation has a significant effect on VAT revenue because the increase in the price of goods and services causes an increase in the nominal value of taxes collected. This is also in line with economic theory which states that an increase in the price of goods and services will increase the VAT tax base. However, under certain economic conditions, this effect can be reduced by a decrease in people's purchasing power and changes in consumption patterns due to high inflation.

The effect of Economic Growth rate on VAT revenue

Based on the results of the t statistical test, economic growth has a beta value of 0.047 and its significance is 0.801. This means that economic growth has a positive but insignificant effect on VAT revenue. This means that as economic growth increases, it will

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have an impact on increasing VAT revenue in the long run. The increase in the production of goods and services that are the object of VAT, accompanied by an increase in public prosperity, will increase people's purchasing power, resulting in increased VAT revenue. State revenue will be increased by economic growth, which is reflected in the increase in GDP. As the productivity of goods and services produced in the economy increases, the number of tax objects, namely taxable goods and services, also increases, so that VAT revenue increases.

From the results of this study, the processed economic growth data has no significant effect on VAT revenue. This research is in line with the study of Gemmell, Kneller, and Sanz (2011) which highlights the importance of considering the short-term and long-term effects of economic growth on VAT revenue.

Prediction of VAT receipts in 2025 using a regression-based Machine Learning Algorithm

Table 19 and figure 3 show the predicted VAT Revenue for 2025 generated by the Random Forest model based on estimated Exchange Rate, Inflation, and Economic Growth variables.

Table 19 Predicted VAT revenue in 2025 by the Random Forest model

Date	Realization per quarter (trillion)	Exchange Rate (Rp)	Inflation (%)	Economic Growth (%)	VAT Prediction
30/09/21	130.76	14321	1.6	1.57	141.925
31/12/21	202.55	14278	1.87	1.05	176.143
31/03/22	130.15	14357	2.64	-0.94	139.736
30/06/22	170.75	14882	4.35	3.73	165.928
30/09/22	184.6	15232	5.95	1.83	180.843
31/12/22	202.09	15592	5.51	0.36	190.697
31/03/23	185.7	14977	4.97	-0.9	174.595
30/06/23	171.07	15000	3.52	3.86	165.217
30/09/23	179.96	15487	2.28	1.6	177.911
31/12/23	227.61	15439	2.61	0.45	187
31/03/24	155.79	15873	3.05	-0.83	171.065
30/06/24	177.02	16394	2.51	3.79	174.194
30/09/24	213.84	15144	1.84	1.5	203.12
31/12/24	264.715	16157	1.57	0.53	233.67
31/03/25		16152	0.72	-0.815	180.774
30/06/25		16992	0.135	3.755	174.841
30/09/25		15992	0.273	1.498	180.529
31/12/25		16823	0.468	0.525	187.481

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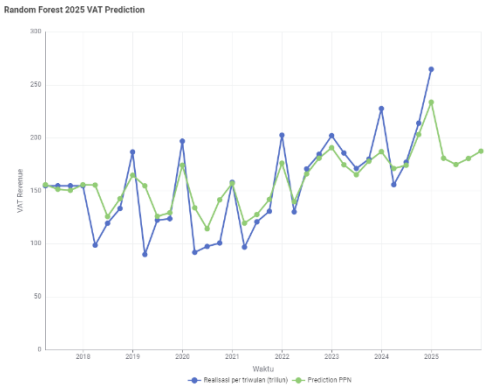

Figure 3 Visualization of VAT revenue in 2025 by the Random Forest model

1. Q1 2025: Estimated VAT revenue reaches 180.77 trillion with an exchange rate of 16152, inflation of 0.72%, and economic growth of -0.815%.
2. Q2 2025: Estimated VAT revenue reaches 174.84 trillion with an exchange rate of 16992, inflation of 0.135%, and economic growth of 3.755%.
3. Q3 2025: Estimated VAT revenue reaches 180.53 trillion with an exchange rate of 15592, inflation of 0.2725%, and economic growth of 1.4975%.
4. Q4 2025: Estimated VAT revenue reaches 187.48 trillion with an exchange rate of 16823, inflation of 0.4675%, and economic growth of 0.525%.

Using this approach, the model successfully predicts VAT revenue for each quarter in 2025 based on existing economic variables. In terms of trends, it can be seen that VAT revenue increases gradually from Q1 2025 to Q4 2025, reflecting the projected increase in economic value which is more stable throughout the year. If we compare the results of this prediction with the actual data from previous years, there is consistency in the movement of VAT Revenue, although there are some fluctuations. This shows that the Random Forest model can accurately predict VAT revenue in 2025, with some relevant and realistic figures.

Analysis of the predicted VAT revenue in 2025

One of the main possible causes of the decline in VAT revenue in early 2025 is the increase in global geopolitical tensions that have been going on for the past few years. Tensions in regions such as the Middle East, Eastern Europe, or Asia Pacific can cause volatility in energy and food prices, which in turn affect investor confidence, the exchange rate of the rupiah against foreign currencies, and rising production costs. This is explained in the Press Release on Maintaining Financial System Stability Amid Global Geopolitical Dynamics and the Direction of Monetary Policy Easing (Ministry of Finance of the Republic of Indonesia, 2024). As a result, the prices of goods and services have increased, causing a decline in people's purchasing power.

In addition, the political transition due to the change of president at the end of 2024 may also contribute to policy uncertainty in the short term. Usually, investors and economic actors tend to wait for policy clarity before expanding their business, which has an impact on the slowdown of economic activity and community consumption (Wahyuni, D., 2018. This change of leadership also affects the new president's priority policy, which in this context is known as the Free Nutritious Meal (Makan Bergizi Gratis, MBG) program. The

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implementation of this new policy is likely to change the fiscal structure and state spending, which in the short term can cause a slowdown in public consumption and investment, as well as affecting VAT revenue. This is explained (Ministry of Finance of the Republic of Indonesia, 2023) in its discussion on Navigating the Economy in Transition by the Directorate General of Treasury.

Some of the above factors directly affect the three main macroeconomic variables that correlate with VAT revenue. The rupiah tends to weaken due to global political and economic instability, which increases the price of imported goods and reduces people's purchasing power. Rising inflation due to external and domestic factors causes an increase in the prices of goods and services, thus reducing people's purchasing power. This decline in purchasing power has a direct impact on household consumption, which is the main contributor to VAT revenue. In addition, national economic growth also tends to slow down due to policy uncertainty and weakening consumption, which has an impact on overall tax revenue.

Estimates of the value of the rupiah exchange rate, inflation, and economic growth in 2025 used to predict VAT revenue in 2025, using moving average calculations between quarters of 2023 and 2024 as well as original data in 2024 in the relevant quarter. This means that the estimated value of the three independent variables contains economic dynamics in 2023 and 2024, for example global geopolitical tensions, so that it can illustrate conditions in 2025 which still have the same economic dynamics. If the estimated value can illustrate the existing economic problems, then the logical consequence is that the value can also illustrate the solutions implemented by the Indonesian government in previous years. One of the measures implemented by the Indonesian government is the shock absorber policy to overcome the impact of global geopolitical conflicts. The government can implement risk mitigation policies such as energy subsidies, food price stabilization, and diversification of import sources so as not to be too dependent on countries experiencing conflict. Like the energy subsidy that was implemented in 2024, where the government allocated IDR 169.5 trillion for energy subsidies, and planned to increase it to IDR 197.75 trillion in 2025. This step aims to maintain the affordability of energy prices for the community (budget.kemenkeu.go.id). In addition, the government's fiscal policy and priority programs after the transition of political power are also important factors in describing the results of this VAT revenue projection. The estimated value adjusted for the real value of the exchange rate, inflation, and economic growth in January and February 2025 can also provide an overview of the impact of the new government policy.

CONCLUSIONS

Based on the analysis and discussion as well as hypothesis testing that has been carried out in this study, it can be concluded that there are several important points related to "The Effect of Economic Factors on VAT Revenue in Indonesia 2017-2024".

1. Exchange rates, inflation, and economic growth have a positive relationship but have no significant effect on VAT revenue.
2. Based on the prediction results, the Random Forest model is able to estimate VAT revenue in 2025 by considering the variables of exchange rates, inflation, and economic growth. The estimated VAT revenue shows a gradual increasing trend from the first

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quarter to the fourth quarter of 2025, reflecting better economic stability. The model also shows a prediction pattern that is consistent with historical data, although there are still fluctuations due to dynamic economic factors.

3. The decline in VAT revenue in early 2025 can be attributed to global geopolitical instability that affects the rupiah exchange rate, inflation, and people's purchasing power. In addition, the political transition in Indonesia at the end of 2024 is also expected to cause policy uncertainty in the short term, resulting in a slowdown in consumption and investment. These factors directly affect the macroeconomic variables on which VAT revenue predictions are based. The government can respond to these dynamics by implementing risk mitigation policies, such as energy subsidies and food price stabilization, to maintain people's purchasing power and support more stable VAT revenue throughout 2025.

One of the limitations of this study is that the time span analyzed is relatively narrow, so it cannot fully capture the long-term trends in the relationship between exchange rates, inflation, and economic growth with VAT revenue. Therefore, future research should use a broader time coverage and consider other factors outside the model, such as the level of taxpayer compliance and global economic conditions that have the potential to have a major influence on VAT revenue.

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