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Analysis of the Relationship Between Taxes and Indonesia's Economic Growth Using the Vector Error Correction Model (VECM)

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Abstract

The Vector Error Correction Model (VECM) is a simultaneous modeling approach designed for variables that are stationary at the same order and exhibit cointegration relationships. This study aims to model the variables of Gross Domestic Product (GDP), Value Added Tax (VAT), Land and Building Tax (LBT), Income Tax (IT), and Import Duties using VECM, as well as to analyze the factors influencing the relationship between taxation and economic growth. The data used are annual data from 1990 to 2023, sourced from the Central Statistics Agency (BPS) and the World Bank. The analysis results indicate that the constructed model is a VECM with an optimal lag of 3 and a cointegration rank of 3. The long-term relationships in the VECM show that Income Tax and Import Duties affect Land and Building Tax and Value Added Tax. Meanwhile, short-term relationships reveal that GDP from the previous period influences Land and Building Tax, Income Tax, and current-period GDP. VAT from the previous period affects Land and Building Tax, Import Duties, and current-period VAT. Land and Building Tax from the previous period influences Income Tax, Import Duties, and current-period Land and Building Tax. Additionally, Import Duties from the previous period affect current-period VAT and Income Tax.

INTRODUCTION

In 1980, Christopher Sims introduced the latest macroeconometric model, the Vector Autoregressive (VAR) [1]. The VAR method is a simultaneous equation modeling method that incorporates multiple endogenous variables simultaneously, but each endogenous variable is explained by the lag of its own value and the other endogenous variables in the model. The VAR model is designed for variables that are stationary at a level. The level refers to the data in its original form, without transformation [2]. An extension of the VAR model is the Vector Error Correction Model (VECM).

The VECM model is designed for variables that are stationary at first differentiation, and there is a cointegration relationship between these variables. Cointegration means that there is a certain linear combination of these variables that is stationary. The presence of cointegration means that a number of time series data deviates from their mean in the short term, but moves together towards equilibrium in the long term.

One application of the VECM model in economics is to examine the relationship between tax revenue and economic growth, conducted by [3] using the AutoRegressive Distributed Lag (ARDL) method in Ethiopia. Previously [4] using the VAR method, showed that tax revenue has a positive and significant impact on economic growth. However, a study using the VECM method by [5] in Kosovo indicated that tax

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revenue had a negative impact on GDP in the long run. Meanwhile, a study by [6] using the Error Correction Model (ECM) method suggested that taxes had no significant impact on long-term economic growth but were significant in the short term. Furthermore, a study by [7] in Indonesia using the ARDL method actually stated that tax revenue had a significant and positive impact on economic growth in the short term but was insignificant in the long term. These previous studies show heterogeneity and inconsistent effects. This is likely due to macroeconomic conditions and other policies within a country or region.

The advantage of VECM in addressing cointegration issues makes it applicable to tax data on economic growth in Indonesia. The VECM method is expected to explain long- and short-term relationships and to understand how Value Added Tax (VAT), Land and Building Tax (PBB), Income Tax (PPh), Import Duties, and Gross Domestic Product (GDP) as indicators of economic growth influence each other using data from 1990 to 2023.

METHODS

This study was conducted using the Vector Error Correction Model (VECM) method. The aim was to construct a VECM model to explain the relationship between taxes and economic growth, as well as to examine the relationship between factors influencing taxes and economic growth. The variables tested included Value Added Tax (VAT), Land and Building Tax (PBB), Income Tax (PPh), Import Duties, and Gross Domestic Product (GDP). These variables were annual data from 1990-2023 obtained from the websites of the Central Statistics Agency (BPS) and the World Bank.

2.1 Stationarity test

The stationarity test for variance is determined by the lambda value. According to Wei, if the value of the transformation parameter lambda (λ) is close to or equal to 1, then the data is stationary with respect to variance. If the data is not stationary, a Box-Cox transformation is required, with the following transformation formula [8].

$$T(Y_t) = Y_t(\lambda) = \begin{cases} \dfrac{{Y_t}^{\lambda} - 1}{\lambda}, & \lambda \neq 0 \\ \ln Y_t, & \lambda = 0 \end{cases}$$

The stationarity test for the mean was conducted using the Augmented Dicky-Fuller (ADF) unit root test with the following hypotheses:
H_0 : Y_t is non-stationary
H_1 : Y_t is stationary
The test statistics used are [9]:

$$t = \frac{\hat{\delta}}{SE(\hat{\delta})}$$

2.2 Determining Lag Length

The optimum lag length is determined by the Akaike Information Criterion (AIC) and Schwarz Criterion (SC) using the following equations [8]:

$$AIC(k) = T \ln\left(\frac{SSR(k)}{T}\right) + 2n$$

$$SC(k) = T \ln\left(\frac{SSR(k)}{T}\right) + n \ln T$$

2.3 Cointegration Testing

Cointegration testing can be performed using the trace test and the maximum eigenvalue test. The test hypotheses used are:

H_0: There is a positive r eigenvalue
H_1: There is a positive $r + 1$ eigenvalue
The test statistics for each test are [10]:

$$Tr(r) = -T \sum_{i=r+1}^{K} \ln\left(1 - \hat{\lambda}_i\right)$$

$$\lambda_{max}(r, r+1) = -T \ln\left(1 - \hat{\lambda}_{r+1}\right)$$

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2.4 VECM Model

According to Robert and Granger, VECM is a restricted VAR model designed for use on non-stationary time series known to have a cointegrating relationship. The VECM model, as [11]:

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + u_t$$

2.5 Granger Causality Test

The causality test aims to examine the direction of the relationship between variables in the model. The concept of causality was introduced, in which the Granger causality test is conducted to assess the influence of one variable on another. Granger states that the variable Y_{2t} has a causal relationship with variable Y_{1t} if information on the past and current values of variable Y_{2t} can help reduce the MSE (Mean Square Error) of Y_{1t} [12].

2.6 Diagnostic Test

The residual autocorrelation diagnostic test uses the portmanteau test to determine whether there is a correlation between the residuals and the test hypothesis [11]:

H_0: There is no residual correlation between lags

H_1: There is a residual correlation between lags

The residual normality diagnostic test assesses whether the skewness and kurtosis of the residuals are consistent with those of a normal distribution using the multivariate Jarque-Bera test. The test hypotheses are [13]:

H_0: The residuals have a multivariate normal distribution

H_1: The residuals do not have a multivariate normal distribution

RESULTS AND DISCUSSION

3.1 Descriptive Statistics

The results of the descriptive statistical analysis are presented in the following table.

TABLE 1. Descriptive Statistics

	PDB	PPN	PBB	PPh	Import duty
Number of Data	34	34	34	34	34
Mean	6.542.353	226.872	14.634	324.745	19.119
Standard Deviation	2.900.018	223.494	10.520	311.357	15.324
Median	5.651.932	138.778	17.848	223.633	15.810
Minimum	2.820.000	5.837	590	5.488	1.587
Maximum	12.301.394	742.2645	29.893	1.040.798	53.094

The analysis results show that GDP has the highest average value among the other variables, while the UN has the lowest average value. The high standard deviation values for each variable indicate a high level of data variation across periods.

3.2 Stationarity Test for Variance

The test results are shown in the following table.

TABLE 2. Lambda Values for Variables

Variable	Lambda Value (λ)	
	Before Transformation	After Transformation
PDB	0,227	1,001
PPN	0,177	1,011
PBB	0,176	0,991
PPh	0,325	1,013
Bea Masuk	0,331	1,006

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The test results show that the GDP, VAT, PBB, PPh, and Import Duty variables are not stationary with respect to variance. However, after transformation, the lambda value of each variable approaches or equals 1, indicating that it is stationary with respect to variance.

3.3 Test of Stationarity with respect to the Mean

The results of the stationarity test with respect to the mean using the ADF test are shown in the following table.

TABLE 3. ADF Test Results.

Variable	Before Differentiation		After First Differentiation	
	Statistical Value	*p-value*	Statistik Value	*p-value*
$LPDB$	$-1{,}738$	$0{,}675$	$-4{,}210$	$0{,}014$
$LPPN$	$-0{,}708$	$0{,}960$	$-5{,}870$	$0{,}010$
$LPBB$	$-0{,}742$	$0{,}957$	$-4{,}704$	$0{,}010$
$LPPh$	$-0{,}987$	$0{,}925$	$-6{,}547$	$0{,}010$
$LBea$	$-2{,}499$	$0{,}380$	$-6{,}846$	$0{,}010$

The ADF test on the original data indicates that the data for each variable is not stationary. However, after the first differentiation, the p-value is found to be less than α=0.05, indicating that H_0 is not rejected. The conclusion is that the LPDB, LPPN, LPPh, and LBea variables are stationary.

3.4 Determining Lag Length

The lag length is determined from the smallest AIC and SC values.

TABLE 4. AIC and SC Values

Lag	AIC	SC
1	$-25{,}3331$	$-23{,}8814$
2	$-27{,}3034$	$-24{,}6420$
3	$-28{,}3274$	$-24{,}4564$
4	$-33{,}3328$	$-28{,}2469$

The smallest AIC and SC values are at lag 4. Therefore, the optimal lag chosen is lag p-1=4-1=3.

3.5 Cointegration Test

The results of the trace and maximum eigenvalue cointegration tests are shown in the following table.

TABLE 5. Trace test results

H_0	H_1	Trace Test Statistics	Johansen Table Value 5%	Decision	Conclusion
$r = 0$	$r > 0$	113,76	76,07	H_0 is rejected	$r > 0$
$r \leq 1$	$r > 1$	72,30	53,12	H_0 is rejected	$r > 1$
$r \leq 2$	$r > 2$	39,88	34,91	H_0 is rejected	$r > 2$
$r \leq 3$	$r > 3$	19,87	19,96	H_0 is accepted	$r \leq 3$
$r \leq 4$	$r > 4$	7,00	9,24	H_0 is accepted	$r \leq 4$

TABLE 6. Results of the maximum eigenvalue test

H_0	H_1	Test Statistics	Johansen Table Value 5%	Decision	Conclusion
$r = 0$	$r = 1$	41,46	34,40	H_0 is rejected	$r = 1$
$r = 1$	$r = 2$	32,42	28,14	H_0 is rejected	$r = 2$
$r = 2$	$r = 3$	20,01	22,00	H_0 is accepted	$r = 2$
$r = 3$	$r = 4$	12,88	15,67	H_0 is accepted	$r = 3$
$r = 4$	$r = 5$	7,00	9,24	H_0 is accepted	$r = 4$

Testing with the trace test indicates three cointegration relationships, while the maximum esigenvalue test results indicate two cointegration relationships. [14] stated that the trace test is better for detecting

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cointegration relationships when there is more than one cointegration relationship, therefore, in this study, the cointegration rank r = 3 was chosen.

3.6 VECM Modeling

The VECM model parameters for each variable are shown in the following table.

TABLE 7. VECM Model

	VECM Model				
	PDB	PPN	PBB	$\boldsymbol{PPh}$	**Import duty**
$ECT_{1,t-1}$	0,5811	0,1849	1,4696	0,5811	–0,8355
$ECT_{2,t-1}$	–0,8277	0,0431	–3,1245	–0,8277	2,0852
$ECT_{3,t-1}$	0,4228	0,2887	0,1062	0,4228	0,1130
Constant	–5,7318	–1,1123	–16,9772	–5,7318	10,6122
$\Delta LPDB_{t-1}$	–2,5410	–0,6873	–1,8583	–2,5410	1,9120
$\Delta LPDB_{t-2}$	–1,4643	–0,1315	–3,3503	–1,4643	–2,7567
$\Delta LPDB_{t-3}$	–2,3986	–1,8407	–1,7620	–2,3986	–1,2976
$\Delta LPPN_{t-1}$	0,9149	–0,4849	2,0838	0,9149	–1,7054
$\Delta LPPN_{t-2}$	0,0795	–0,5136	1,2936	0,0795	–0,9262
$\Delta LPPN_{t-3}$	–0,5435	–0,9586	0,8743	–0,5435	–1,4842
$\Delta LPBB_{t-1}$	–0,2753	–0,2623	–0,3049	–0,2753	0,2230
$\Delta LPBB_{t-2}$	–0,3964	–0,0802	–0,6381	–0,3964	0,0918
$\Delta LPBB_{t-3}$	–0,1048	0,2491	–0,1465	–0,1048	0,6207
$\Delta LPPh_{t-1}$	–0,4890	0,2930	–1,1754	–0,4890	0,9246
$\Delta LPPh_{t-2}$	–0,4059	–0,0384	–0,9428	–0,4059	0,5504
$\Delta LPPh_{t-3}$	0,1008	0,3616	–0,6918	0,1008	1,1175
$\Delta LBea_{t-1}$	–0,3146	0,1177	–0,6873	–0,3146	0,2750
$\Delta LBea_{t-2}$	–0,1874	0,0806	–0,3142	–0,1874	0,1772
$\Delta LBea_{t-3}$	0,1366	0,2824	–0,1658	0,1366	0,2531

3.7 Causality Test

The results of the Granger causality test for each hypothesis are shown in the following table.

TABLE 8. Causality Test Results

Null Hypothesis	F value	*p-value*
LPBB tidak mempengaruhi LBea	1,0143	0,4036
LBea tidak mempengaruhi LPBB	0,8237	0,4937
LPDB tidak mempengaruhi LBea	13,6745	0,0002
LBea tidak mempengaruhi LPDB	2,2184	0,1120
LPPh tidak mempengaruhi LBea	3,0081	0,0500
LBea tidak mempengaruhi LPPh	5,8268	0,0039
LPPN tidak mempengaruhi LBea	2,4107	0,0917
LBea tidak mempengaruhi LPPN	2,2468	0,1087
LPDB tidak mempengaruhi LPBB	2,1732	0,1174
LPBB tidak mempengaruhi LPDB	0,7091	0,5560
LPPh tidak mempengaruhi LPBB	0,1575	0,9238
LPBB tidak mempengaruhi LPPh	1,0255	0,3989
LPPN tidak mempengaruhi LPBB	0,4698	0,7062
LPBB tidak mempengaruhi LPPN	1,1801	0,3382
LPPh tidak mempengaruhi LPDB	0,6498	0,5908
LPDB tidak mempengaruhi LPPh	1,6519	0,2039
LPPN tidak mempengaruhi LPDB	1,3365	0,2859
LPDB tidak mempengaruhi LPPN	1,1987	0,3315
LPPN tidak mempengaruhi LPPh	2,8203	0,0604
LPPh tidak mempengaruhi LPPN	2,5056	0,0832

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The results show that LPDB against LBea and LBea against LPPh have a one-way causal relationship.

3.8 Diagnostic Tests

The diagnostic tests performed were a residual autocorrelation test using the Portmanteau test and a multivariate normality test using the multivariate Jarque-Bera test.

TABLE 9. Diagnostic Test Results

Testing	Statistical Value	*p-value*	Conclusion
Autocorrelation Test	249,49	0,9997	H_0 is accepted
Normality Test	16,16	0,0952	H_0 is accepted

The results of the portmanteau autocorrelation test conclude that the null hypothesis fails to be rejected, meaning there is no residual autocorrelation between lags. Meanwhile, the results of the multivariate normality test using the multivariate Jarque-Bera test also indicate that the model residuals have a multivariate normal distribution.

CONCLUSION

The VECM model is constructed with an optimum lag length of 3 and a number of cointegration relationships of 3. This means the short-term model uses changes in its own variable and other variables up to the previous three years in its modeling. The long-term model has 3 ECT values, derived from the rank of the cointegration matrix, which is equal to 3.

The relationship between taxes and economic growth, when viewed from the cointegration vector, shows that Income Tax (PPh) is a factor that increases Land and Building Tax (PBB) and decreases GDP and VAT in the long run, and Import Duty is a factor that in the long run increases GDP and VAT but decreases Land and Building Tax. The short-term relationship shows that GDP from the previous period influences Land and Building Tax (PBB), Income Tax (PPh), and current GDP. The previous period's VAT influences Land and Building Tax (PBB), Import Duty, and current VAT in the short run. The previous period's PBB influences Income Tax, Import Duty, and current Land and Building Tax. The previous period's Import Duty influences current VAT, and the previous period's Income Tax influences current Import Duty. The ECT values show that only the PBB variable adjusts back to long-term equilibrium.

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