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Analysis of Dependence on Oil and Gas, TPT, and Human Development Index (HDI) on Economic Growth and Poverty in Bojonegoro Regency 1995-2024

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Abstract

This study analyses the influence of Oil and Gas Revenue Sharing Funds (DBH Migas), the Open Unemployment Rate (TPT), the Human Development Index (HDI), and global oil prices on economic growth and poverty in Bojonegoro Regency during the 1995–2024 period. Using annual time-series data and a quantitative approach, the analysis employs the ADF stationarity test, Ordinary Least Squares (OLS), Two-Stage Least Squares (2SLS), the Durbin–Wu–Hausman endogeneity test, and the Toda–Yamamoto causality procedure. The results show that HDI positively affects economic growth, while unemployment and poverty negatively affect growth, though not all relationships are statistically significant. Oil and Gas DBH and global oil prices are not strong determinants of regional GDP, indicating Bojonegoro's reliance on external factors inherent in the oil and gas sector. In the poverty model, unemployment emerges as the most influential variable, whereas GDP, HDI, and oil prices do not exhibit significant direct effects. The Toda–Yamamoto causality test reveals causal relationships from HDI to GDP, from unemployment to poverty, and from poverty to HDI, whereas most variable pairs do not exhibit reciprocal causality. Overall, the findings suggest that Bojonegoro's economic development is driven more by improvements in human capital and employment opportunities than by fluctuations in oil and gas revenues.

INTRODUCTION

Regency Bojonegoro is one of the areas with potential oil and gas, the largest in Indonesia, primarily through the development of the Cepu Block, which contributes significantly to the area's income. With the Regional Budget (APBD), which exceeded Rp. 7.9 trillion, Bojonegoro ranks fourth in terms of national oil and gas production area. However, the phenomenon that occurred was precisely paradoxical. In 2023, the poverty level in the Regency of Bojonegoro reached 11.69%, the highest among the ten area producer oil and gas regions in Indonesia, even around triple that of Deli Serdang Regency, which recorded 3.44%. This shows that rich natural resources do not necessarily create a welfare economy for their people. On the other hand, Bojonegoro's unemployment rate is relatively low (TPT), and its Human Development

Index (HDI) continues to rise, making the economy attractive. This is investigated in depth.

Various studies have explored the connection between rich natural resources and economic growth. For example, a study by Safitri, Moehadi, Susilo, and Endang shows that HDI has a significant adverse effect on poverty in Indonesia, indicating that improving human capital is key to reducing poverty, even as economic growth continues (Safitri et al., 2023). At the regional-national level, research by Susilo, Kholilurrohman, and Hasan (2020) in Papua Province found that unemployment also has an indirect effect on the HDI through mechanisms of income distribution and employment opportunities, thereby emphasizing the importance of the quality of human development institutions and policies (Susilo et al., 2020). In the Indonesian context, Ramadhani's research in UMM's Journal of Development Economics shows that the management policy is not yet fully capable of significantly reducing poverty in the middle of the income distribution, which remains high (Ramadhani & Prasetyo, 2024). Findings. This is in line with research in the international publication " *Local Government Development Policy: Natural Resource Revenue Sharing and Economic Growth in Indonesia* ", which highlights that the mechanism of distribution results from natural resources does not always push economic growth, even potentially widening inequality interregional (Hidayat et al., 2024).

Empirically, dependence on the oil and gas sector and volatility in global oil prices affect regional economic stability and public welfare. A study by Fitri Nurfatriani revealed that the distribution of oil and gas revenue-sharing funds (DBH) is often not accompanied by the optimization of public spending and human development programs, resulting in low benefits to the Human Development Index (HDI) and poverty reduction (Nurfatriani et al., 2022). This aligns with John Narh's study, which emphasized that a country's or region's success in avoiding *the resource curse* is primarily determined by the quality of institutions and transparent economic governance (Narh, 2025). Meanwhile, other studies in provincial areas found that increasing the HDI reduces poverty, but its effects take time and require strong institutional conditions (Widiyono & Rahmayanti, 2023). From these various results, it is clear that the relationship between the oil and gas sector, welfare indicators (HDI), unemployment (TPT), economic growth, and poverty remains an open issue in the regional development literature.

The gap in previous research lies in the lack of long-term empirical studies that simultaneously integrate oil and gas DBH, TPT, HDI, and poverty variables at the oil- and gas-producing district level. The novelty of this study lies in the use of a more comprehensive set of time series econometric methods (ADF, OLS, 2SLS, Durbin–Wu–Hausman, and Toda–Yamamoto) to evaluate Bojonegoro's dependence on the oil and gas sector. This approach offers a more robust measurement of causal relationships and of potential endogeneity, which has not been sufficiently addressed in previous studies on oil and gas DBH. The main objective of this study is to describe, analyze, and explain the conditions and relationships between the studied variables, thereby gaining a comprehensive understanding of the patterns, trends, and influences that emerged during the study period.

RESEARCH METHODS

time series analysis for the period 1995–2024 to examine the relationship between Oil and Gas Revenue Sharing (DBH), the Open Unemployment Rate (TPT), the Human Development Index (HDI), world oil prices, economic growth, and poverty levels in Bojonegoro Regency. This approach is associative and explanatory, aiming to

explain the influence and causal relationships among macroeconomic variables, as is commonly used in research on natural resource-based regional development (Ridena et al., 2021; Achmad et al., 2022). All data used are secondary, sourced from the Regency BPS Bojonegoro, the Directorate General of Balance Finance (DJPK), SKK Migas, the Ministry of Energy and Mineral Resources, and Brent oil price data obtained from *Investing.com*. The population comprises all annual data collected during the research period, with *purposive sampling* based on data availability. Dependent variables include the growth rate (GRDP ADHK) and the poverty level. In contrast, independent variables include DBH Oil and Gas, TPT, IPM, and world oil prices, all of which were tested for their influence in both models.

Stationarity Test (ADF)

Data analysis was conducted across several time-series econometric stages. The first stage was a stationarity test using the Augmented Dickey–Fuller (ADF) test to determine whether each variable has a unit root and its degree of integration (I(0), I(1), or I(2)). This test is important to avoid spurious regression, as emphasized in *regional time-series research.* (Hill & Pasaribu, 2022) . The model equation is formulated as follows:

$$\Delta Y_t = \alpha_0 + \gamma\, Y_{t-i} + \sum_{i=1}^{p} \delta_i\, \Delta Y_{t-i} + \varepsilon_t \quad \ldots\ldots(1)$$

OLS (Ordinary Least Squares) Test

After ensuring characteristics-based variables, we performed Ordinary Least Squares (OLS) estimation for two main models, namely model 1, which estimates the influence of DBH Oil and Gas, TPT, IPM, poverty, and oil prices on GRDP, as well as model 2, which estimates the influence of GRDP, TPT, IPM, and oil prices on poverty. This model examines the factors that influence the economic growth of Bojonegoro Regency, as measured by the Gross Regional Domestic Product (GRDP) at constant prices. The simultaneous structural model shows how economic growth is influenced by fiscal factors (DBH Oil and Gas), social factors (TPT and HDI), welfare conditions (poverty), and external pressures (world oil prices). This model is also applied in OLS and 2SLS analyses to account for endogeneity. The model equation is formulated as follows:

$$PDRB_t = \beta_0 + \beta_1 DBH_t + \beta_2 TPT_t + \beta_3 IPM_t + \beta_4 KEMISKINAN_t + \beta_5 HMINYAK_t + \varepsilon t \quad \ldots\ldots (2)$$

This model explains the factors influencing poverty levels in Bojonegoro Regency. In this model, poverty is viewed as a result of economic growth, labour market conditions, human resource quality, and external variables. Given the interaction between GRDP and poverty, this model is a system of simultaneous equations. Therefore, endogeneity testing and 2SLS estimation are necessary to ensure accurate results.

$$KEMISKINAN_t = \alpha_0 + \alpha_1 PDRB_t + \alpha_2 TPT_t + \alpha_3 IPM_t + \alpha_4 HMINYAK_t + ut \ldots\ldots (3)$$

Next, a series of classical assumption tests was conducted, including tests for normality, multicollinearity, heteroscedasticity, and autocorrelation, to ensure the validity of OLS estimation.

2SLS (Two Stage Least Squares) Test

Remember the connection between GRDP and poverty, and conducted testing using the Durbin–Wu–Hausman (DWH) endogeneity test to ensure estimator consistency. If variables are endogenous, the OLS method is not adequate because it produces biased estimates; therefore, the Two-Stage Least Squares (2SLS) approach is used. In the first stage, endogenous variables are estimated using relevant instruments such as lag variables, Oil and Gas DBH, TPT, HDI, and world oil prices. The second stage produces the central structural equation used in this study, namely:

$$PDRB_t = \beta_0 + \beta_1 DBH_t + \beta_2 TPT_t + \beta_3 IPM_t + \beta_4 \overline{KEMISKINAN_t} + \beta_5 HMINYAK_t + \varepsilon t \quad \ldots\ldots (4)$$

$$KEMISKINAN_t = \alpha_0 + \alpha_1 \overline{PDRB_t} + \alpha_2 TPT_t + \alpha_3 IPM_t + \alpha_4 HMINYAK_t + u_t \quad \ldots\ldots (5)$$

The model is used to obtain a consistent estimator under conditions of a simultaneous relationship between the main variables.

Toda-Yamamoto Causality Test

The stage of this research applies the Toda–Yamamoto causality method (TY-Granger Causality), which is the recommended approach when the research variables have different degrees of integration, including up to I(2), so that the Johansen and ECM cointegration methods cannot be used validly (Wahyudi & Palupi, 2023). In this method, all variables are treated as part of an endogenous dynamic system to identify the direction of causal relationships. The Toda–Yamamoto method estimates the VAR model by adding *dmax* (the highest degree of integration in the system) to the optimal lag, so that the system equation can be written in general as follows:

$$Y_t = \delta_0 + \sum_{i=1}^{k} \delta_1 Y_{t-i} + \sum_{j=1}^{k} \theta_j X_{t-j} + \sum_{m=1}^{dmax} \lambda_m X_{t-m} + \varepsilon_t \quad \ldots\ldots (6)$$

Overall, the research analysis flow consists of the ADF stationarity test, OLS (Ordinary Least Squares) estimation, classical assumption test, Durbin–Wu–Hausman test, 2SLS (Two Stage Least Squares) estimation, VAR(k + *dmax*) estimation, and Toda–Yamamoto causality test. This approach provides an analytical framework that is consistent with the characteristics of time-series data *and* the economic dynamics of oil- and gas-producing regions, such as Bojonegoro.

RESULTS AND DISCUSSION

Stationarity Test (ADF)

Stationarity tests were conducted to determine the degree of integration of each variable in the study. This test was conducted using the Augmented Dickey–Fuller (ADF) method at the level, *first-difference*, and *second-difference levels* for variables that were not stationary in the previous stage.

Table 1. Stationarity Test Results (Level)

Variables	Augmented Dickey–Fuller		Description
	Statistical Test	Prob	
GRDP	-0.738789	0.8207	*Not Stationary*
POVERTY	-1.676234	0.4323	*Not Stationary*
Oil and Gas DBH	1.476796	0.9986	*Not Stationary*
TPT	-3.360188	0.0211	*Stationery*
HDI	-5.100559	0.0003	*Stationery*
OIL PRICE	-1.843893	0.3528	*Not Stationary*

The test results at the level indicate that the TPT and IPM variables are stationary (I(0)), whereas the GRDP, Poverty, Oil and Gas DBH, and Oil Price variables are not. Because most of the variables do not yet fulfil the stationarity conditions at this level, the test is continued at the *first-difference level*.

Stationarity Test Results (*First Difference*)

Variables	Augmented Dickey–Fuller		Description
	Statistical Test	Prob	
GRDP	-2.472317	0.1326	*Not Stationary*
POVERTY	-4.169842	0.0031	*Stationery*
Oil and Gas DBH	8.409923	1,0000	*Not Stationary*
OIL PRICE	-5.302559	0.0002	*Stationery*

The results of the ADF test at *the first-difference level* indicate that the Poverty and Oil Price variables are stationary (I(1)). On the other hand, GRDP remains nonstationary, and Oil and Gas DBH shows no improvement. Therefore, the test is continued at the *second-difference level*.

Table 3. Stationarity Test Results (*Second Difference*)

Variables	Augmented Dickey–Fuller		Description
	Statistical Test	Prob	
GRDP	-4.786863	0.0008	*Stationery*
Oil and Gas DBH	5.809262	1,0000	*Not Stationary*

Test results at the *second-difference* level show that the GRDP finally becomes stationary at the level and can be categorized as a variable of degree of integration (I(2)). While that, DBH Oil and Gas remains nonstationary. However, it has tested until *the second difference*, which indicates the existence of structural problems in the data, for example, *outlier*s, extreme changes in policy, or deterministic patterns that the ADF does not capture.

The overall results of the ADF stationarity test indicate that the variables under study exhibit different degrees of integration. At level (I(0)), only TPT and HDI are stationary, while other variables remain nonstationary. After the first difference, Poverty and Oil Prices become stationary (I(1)), but GRDP and Oil and Gas DBH remain unstable. GRDP is stationary only at the second difference, so it is included in I(2). At the same time, Oil and Gas DBH remains nonstationary even after being differentiated twice, suggesting the possibility of structural problems or extreme volatility.

The non-uniformity of integration orders (I(0), I(1), and I(2)) makes the Johansen and ECM cointegration methods unusable because they require all variables to be in order I(1). Furthermore, the nonstationary Oil and Gas DBH cannot be included in the long-term model. Therefore, the study uses Toda–Yamamoto causality, which accommodates variables with a mixture of integration orders up to the highest level (*dmax* = 2), making it the most appropriate approach for this data condition.

OLS (Ordinary Least Squares) Model 1 test

In the OLS (Ordinary Least Squares) test**,** Model 1 was estimated with GRDP as the dependent variable and DBH Oil and Gas, Open Unemployment Rate (TPT), Human Development Index (HDI), Poverty, and Oil Prices as the independent variables. Results estimate regression presented in the table following:

Table 4. Results OLS Model 1 Estimation

Variable	Coefficient	Std. Error	t-Statistic	P-value
C	-3499.742	70559.33	-0.049600	0.9609
Oil and Gas DBH	6.52E-09	3.79E-09	1.722337	0.0979
TPT	1206,814	484.8848	2.488867	0.0201
HDI	1347,869	905.5591	1.488439	0.1497
POVERTY	-118.9021	63.28230	-1.878916	0.0725
OIL PRICE	-22.20362	3.720263	-5.968294	0.0000
R-squared	0.951283	*F-statistic*		93.72730
Adjusted R-squared	0.941133	*Prob(F-statistic)*		0.000000
SE of Regression	4521.755	*Durbin-Watson stat*		1.118467

This model explains how each variable (DBH, TPT, HDI, Poverty, and Oil Price) affects Bojonegoro's GRDP. Based on these results, the regression equation for Model 1 can be written as follows:

GRDP = – 3499,742 + 6.52E-09DBH + 1206,814TPT + 1347,869IPM – 118,9021POVERTY – 22,20362HOIL .....(7)

The negative constant (–3499.742) serves only as a mathematical adjustment without any economic significance. The coefficient of oil and gas DBH (6.52E-09) indicates that oil and gas revenues are not the main driver of Bojonegoro's GRDP. The positive TPT coefficient (1206.814) indicates that the increase in unemployment is in line with GRDP, possibly due to the capital-intensive nature of the oil and gas sector. The HDI contributes significantly to economic growth (coefficient 1347.869), while the increase in poverty (–118.9021) depresses GRDP through decreased productivity and purchasing power. World oil prices also negatively affect GRDP (–22.20362), indicating sensitivity to global energy fluctuations.

F Test (Simultaneous Significance Test)

The OLS estimation results for Model 1 yield an F-statistic of 93.72730, which exceeds the F-table value ($\alpha = 5\%$) of 2.62. Therefore, H_0 is rejected, which indicates that DBH Oil and Gas, TPT, HDI, poverty, and oil prices simultaneously have a significant influence on GRDP.

t-test (Partial Significance Test)

The test results show that TPT and oil prices have t-statistic values greater than the 5% t-table value of 2.064, indicating significant influence on GRDP. Meanwhile, DBH Oil and Gas and poverty are significant at the 10% level (1.711), whereas the HDI is not.

The following results were obtained: 1) Oil and Gas DBH is significant at 10%, due to the t-statistic of 1.722 > 1.711 from the t-table. It has a positive effect on GRDP. Oil and gas revenues provide a boost to economic growth through regional government spending, although the effect is small; 2) TPT is significant at 5%, due to the t-statistic of 2.489 > 2.064 from the t-table. It has a positive effect on GRDP. This result is not typical, but may be due to the dominance of the informal sector and the non-labour-intensive structure of the oil and gas economy, so that the increase in TPT does not reduce economic production; 3) HDI is not significant, due to the t-statistic of 1.488 < 1.711 from the t-table. It is not strong enough to explain GRDP directly. Improving the quality of human resources is more long-term; 4) Poverty is

significant at 10%, due to the t-table of 1.879 > 1.711 from the t-table. It has a significant adverse effect on GRDP. The increase in poverty reduces purchasing power and productivity, thus weakening GRDP; and 5) Oil prices have a t-statistic of 5.968 > 2.064 from the t-table. It has a substantial adverse effect on GRDP. The increase in oil prices increases production costs and puts pressure on the regional economy, even though Bojonegoro is an oil and gas-producing region.

Coefficient of Determination Test

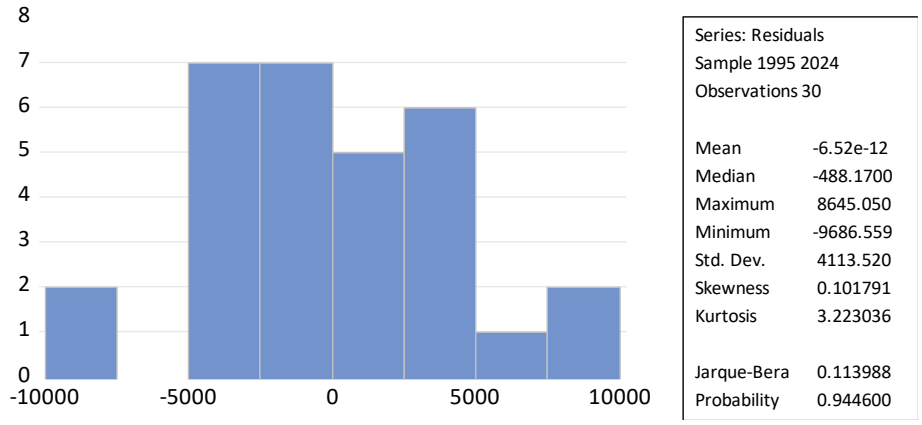
The R-squared value of 0.951 indicates that 95.1% of the variation in GRDP can be explained by the Oil and Gas DBH, TPT, HDI, Poverty, and Oil Price variables, while factors outside the model explain the remaining 4.9%. The high Adjusted R-squared (94.1%) indicates that the model remains stable despite the presence of many variables.

Classical Assumption Test Model 1

Normality Test

Results: The Jarque–Bera test for normality yields a p-value of 0.9446, well above the 0.05 significance level. The residual in Model 1 is stated to be normally distributed, so the normality assumption is fulfilled.

Figure 1. Results: Test Normality of Model 1



Test Multicollinearity

Based on the results of the multicollinearity test, all variables have *centred* VIFs < 10, except the HDI (Human Development Index) variable (69.28) and the poverty variable (61.93), which are relatively high. Although the VIF value is significant in *time-series* data, it does not always indicate a serious violation, especially if the model remains significant overall and the direction coefficient is not problematic. In general, this model still does not exhibit severe multicollinearity.

Multicollinearity Test Results for Model 1

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	4.98E+09	7304.932	NA
Oil and Gas DBH	1.43E-17	3.146499	2.415822
TPT	235113.3	13.26845	1.994652
HDI	820037.4	4483.721	69.28624
POVERTY	4004.649	499,8652	61.93119
OIL PRICE	13.84036	11.46013	2.182118

Heteroscedasticity Test

The Breusch–Pagan-Godfrey heteroscedasticity test shows a p-value of 0.1840 and an F-statistic of 0.1741, both of which are well above 0.05. This indicates that there is no heteroscedasticity, so the residual variance is homogeneous.

Table 6. Results of Heteroscedasticity Test for Model 1

F-statistic	1.654751	*Prob. F(5,24)*	0.1840
*Obs *R-squared*	7.690850	*Square Prob. (5)*	0.1741
Scaled explained SS	5.471051	*Square Prob. (5)*	0.3611

Autocorrelation Test

autocorrelation test (Breusch–Godfrey LM Test) shows mark *Prob. F* = 0.0424 and *Prob. Chi-Square* = 0.0236, both < 0.05. Thus, Model 1 exhibits positive autocorrelation, indicating that the residuals are not independent and that there is a correlation pattern across periods.

Table 7. Autocorrelation Test Results for Model 1

F-statistic	3.662620	*Prob. F(4.25)*	0.0424
*Obs *R-squared*	7.493791	*Square Prob. (5)*	0.0236

In a way, Model 1 satisfies the assumptions of normality, no heteroscedasticity, and no multicollinearity. Still, within the limits that can be handled, the model does not fulfil the assumption of free autocorrelation. Therefore, OLS Model 1 cannot serve as the final model; we need to use an alternative method. This 2SLS approach provides more reliable estimates.

OLS (Ordinary Least Squares) Model 2 test

OLS (Ordinary Least Squares) Test model 2 uses poverty as the dependent variable, with GRDP, Open Unemployment Rate (TPT), Human Development Index (HDI), and Oil Prices as the independent variables. Results of the OLS estimates are shown in the table following:

Table 8. Results OLS Model 2 Estimation

Variable	Coefficient	Std. Error	t-Statistic	P-value
C	914.6217	97.35939	9.394284	0.0000
GRDP	-0.000780	0.000626	-1.245367	0.2245
TPT	3.721015	1.664396	2.235655	0.0345
HDI	-10.17640	2.069398	-4.917566	0.0000
OIL PRICE	-0.024013	0.019020	-1.262520	0.2184
R-squared	0.981832	*F-statistic*		337.7591
Adjusted R-squared	0.978925	*Prob(F-statistic)*		0.000000
SE of Regression	15.15879	*Durbin-Watson stat*		0.643067

This model is an equality regression that describes how the variables GDP, Open Unemployment Rate (TPT), Human Development Index (HDI), and Oil Prices influence poverty levels in the Regency of Bojonegoro. Based on these results, the regression equation for Model 2 can be written as follows:

POVERTY = 914.6217 – 0.000780GRDP + 3.721015TPT – 10.17640HDI – 0.024013HOIL .....(8)

The constant 914.6217 indicates that if all other variables are zero, the predicted poverty rate is 914.62; although unrealistic, it is important for the analysis.

The GRDP coefficient of −0.000780 indicates that a 1-unit increase in GRDP reduces poverty only slightly, suggesting that economic growth in Bojonegoro does not automatically reduce poverty. The TPT coefficient of 3.721015 indicates that every 1% increase in unemployment increases poverty by 3.72 units, reflecting the negative impact of unemployment on household income. The HDI coefficient of −10.17640 indicates that a 1-point increase in the HDI reduces poverty by 10.17 units, underscoring the importance of education and health. The world oil price coefficient of −0.024013 indicates a small impact: an increase in oil prices benefits the government more than people with low incomes.

F Test (Simultaneous Significance Test)

The OLS estimation results for Model 2 show an F-statistic of 337.7591. At a significance level of α = 5%, the F-table value is 2.76 (df1 = 4; df2 = 25). Considering that the F-statistic (337.7591) is greater than the F-table (2.76), H_0 is rejected. Therefore, statistically, it can be concluded that GRDP, TPT, HDI, and world oil prices simultaneously have a significant influence on the poverty rate in Bojonegoro Regency.

t-test (Partial Significance Test)

At a significance level of α = 5% with 25 degrees of freedom, the t-table value is 2.060. GRDP recorded a t-statistic value of -1.245, which is lower than the t-table (2.060). This suggests that GRDP does not have a significant impact on poverty, confirming that economic growth in Bojonegoro remains largely inclusive. In contrast, the Open Unemployment Rate (TPT) shows a t-statistic value of 2.236, which exceeds the t-table (2.060). Therefore, H_0 is rejected, indicating that TPT has a positive and significant effect on the poverty rate. This means that the higher the unemployment rate, the higher the poverty rate. The Human Development Index (HDI) recorded a t-statistic of -4.918, which, in absolute terms, is much greater than the t-table value. This indicates that the HDI has a very significant adverse effect on poverty, where improving the quality of education, health, and living standards has proven effective in reducing poverty levels. Finally, the World Oil Price recorded a t-statistic value of −1.263, which is lower than the t-table (2.060). This indicates that world oil prices do not significantly influence poverty levels. Changes in oil prices have a greater impact on fiscal policy and oil and gas companies than on the welfare of poor households.

Coefficient of Determination Test

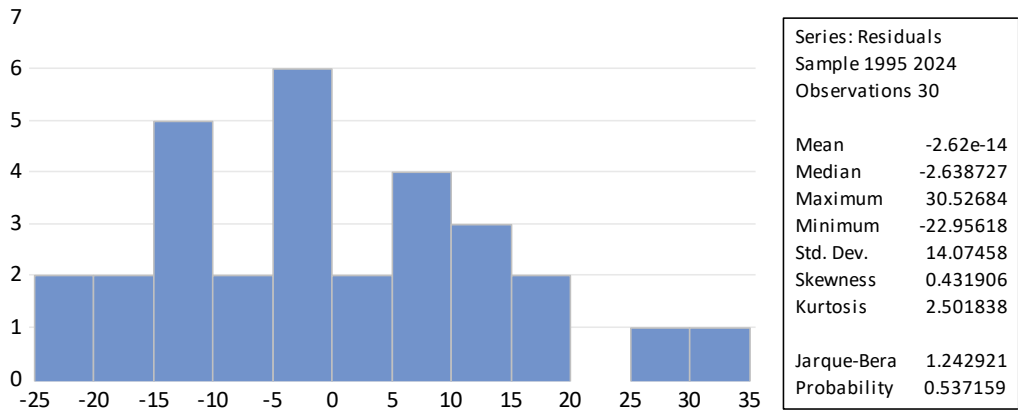
The R-squared value of 0.9818 indicates that GRDP, TPT, HDI, and oil prices can explain 98.18% of the variation in poverty levels. The remaining 2% is influenced by other factors not included in the model, such as income inequality, access to employment, regional inflation, and the distribution of government social spending. The high R-squared value indicates that this model has extreme explanatory power.

Classical Assumption Test Model 2

Normality Test

Results from the Jarque–Bera test show a probability of 0.5371, so the residuals in Model 2 are approximately normally distributed and fulfil the normality assumption.

Figure 2. Results Test Normality of Model 2



Test Multicollinearity

Results of the VIF test for multicollinearity show that the GRDP (VIF = 17.20) and HDI (VIF = 32.19) variables have VIFs above the general limit of 10, indicating strong multicollinearity for both variables. Meanwhile, the TPT variable (Top Level) Unemployment Open and Price Oil has a VIF < 10, indicating no multicollinearity.

Multicollinearity Test Results for Model 2

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	9478.850	1237,507	NA
GRDP	3.92E-07	94.28124	17.20137
TPT	2.770213	13.91044	2.091164
HDI	4.282409	2083.426	32.19484
OIL PRICE	0.000362	26.65393	5.075160

Heteroscedasticity Test

Heteroscedasticity test results, Breusch–Pagan–Godfrey, show the value of *Prob Obs *R- R-squared* = 0.0043<0.05, so Model 2 experiences heteroscedasticity. This indicates the presence of inequality in the residual variance across observations.

Table 10. Results of Heteroscedasticity Test for Model 2

F-statistic	6.401496	*Prob. F(4.25)*	0.0011
*Obs *R-squared*	15.17962	*Square Prob. (5)*	0.0043
Scaled explained SS	7.915741	*Square Prob. (5)*	0.0947

Autocorrelation Test

Autocorrelation test results (Breusch–Godfrey LM Test) show mark *Prob. F* = 0.0010 and *Prob. Chi-Square* = 0.0012, both < 0.05. Thus, Model 2 contains autocorrelation, so the residuals are not independent between periods.

Table 11. Autocorrelation Test Results for Model 2

F-statistic	9.391460	*Prob. F(4.25)*	0.0010
*Obs *R-squared*	13.48608	*Square Prob. (5)*	0.0012

In a way, this Model 2 No fulfil part big assumptions classic, namely experience multicollinearity, heteroscedasticity, and autocorrelation, although the residuals are normally distributed. Therefore, Model 2 cannot be used as the final model without applying correction methods or alternative estimation approaches.

2SLS (Two-Stage Least Squares) Test Model 1

Durbin–Wu–Hausman Endogeneity Test

Table 12. Results of the Endogeneity Test for DWH Model 1

Statistics	Mark	Prob.
Wu-Hausman F-statistic	73.24369	0.000000

The results of the Durbin-Wu-Hausman endogeneity test show that the Wu–Hausman *F-statistic* is 73.24369 with a p-value of 0.000000, so that H_0, the null hypothesis, is rejected. Thus, the Poverty variable is endogenous, so OLS is invalid for Model 1. Therefore, the Two-Stage Least Squares (2SLS) method is appropriate and necessary to obtain unbiased estimates.

Table 13. 2SLS Test Model 1

Variable	Coefficient	Std. Error	t-Statistic	P-value
C	-76216.17	97260.63	-0.783628	0.4413
Oil and Gas DBH	4.79E-09	4.16E-09	1.150763	0.2617
TPT	880.9157	576.7127	1.527478	0.1403
HDI	2276.216	1243.138	1.831025	0.0801
POVERTY	-51.30756	88.45007	-0.580074	0.5675
OIL PRICE	-22.14632	3.820999	-5.795950	0.0000
R-squared	0.948842	*F-statistic*		85.02147
Adjusted R-squared	0.937721	*Prob(F-statistic)*		0.000000
SE of Regression	4633.664	*Durbin-Watson stat*		1.008497

This econometric model describes the factors that influence GRDP (gross regional product) in the Regency of Bojonegoro, after correction using the 2SLS (Two-Stage Least Squares) method. Referring to the value coefficients obtained, the equality regression formed is as follows:

GRDP = – 76216.17 + 4.79E-09DBH + 880.9157TPT + 2276.216IPM – 51.30756POVERTY – 22.14632HOIL .....(9)

The constant –76.216 indicates that GRDP is estimated at –76.216 if all variables are zero, which is important for the analysis, although not economically meaningful. The coefficient of Oil and Gas DBH of 4.79E-09 indicates that a 1 rupiah increase in Oil and Gas DBH increases GRDP only slightly, suggesting that Oil and Gas DBH is not the main driver of growth. The TPT value of 880.9157 means that a 1% increase in TPT raises GRDP by approximately 880.92 billion, reflecting an economic structure that is not labour-intensive. The HDI coefficient of 2276.216 indicates that a 1-point increase in HDI contributes 2,276 units to GRDP, underscoring the importance of education and health. The poverty coefficient of –51.30756 indicates that a 1% increase in poverty reduces GRDP by approximately 51.3 units, although it is not significant in the 2SLS model. The world oil price of –22.14632 indicates that a $1 increase in global oil prices reduces Bojonegoro's GRDP by 22.14 units, with a significant negative impact.

F Test (Simultaneous Significance Test)

The F test for the 2SLS Model 1 is used to test for joint significance, namely to determine whether all independent variables simultaneously influence the dependent variable for Bojonegoro Regency GRDP. The F-statistic (85.02147) is greater than the F-table (2.62), so H_0 is rejected. The rejection of H_0 indicates that Oil and Gas DBH, TPT, HDI, Poverty, and World Oil Prices simultaneously have a significant influence on GRDP within the 2SLS structural model framework.

t-test (Partial Significance Test)

T-test of the results of the 2 SLS Model 1 test, 5%= 2.064 and 10% = 1.711. Oil and Gas DBH has a calculated t-value of 1.151, which is smaller than the t-table values at the 5% and 10% levels, so it does not have a significant effect on GRDP. This indicates that after endogeneity correction, oil and gas revenues are not the primary determinant of regional economic growth. The Open Unemployment Rate (TPT) is also insignificant because the calculated t-value of 1.527 is smaller than the t-table value. This finding indicates that the positive relationship between TPT and GRDP observed in the previous OLS is biased by simultaneity. The Human Development Index (HDI) has a calculated t-value of 1.831, which is greater than the 10% t-table value (1.711) but smaller than the 5% t-table value, so it is significant at the 10% level. This means that improving the quality of human resources begins to show a real contribution to economic growth after the endogeneity problem is corrected. Poverty is not statistically significant because the calculated t-value of 0.580 is smaller than the t-value from the t-table. This indicates that in a simultaneous framework, poverty does not directly affect GRDP. World Oil Prices have a calculated t-value of 5.796, which far exceeds the t-value in the t-table at all significance levels, indicating a negative and highly significant effect (α = 1%) on GRDP. This confirms the Bojonegoro economy's intense sensitivity to fluctuations in global energy prices.

Coefficient of Determination Test

The R-squared value of 0.9488 indicates that the independent variables in the 2SLS model explain 94.88% of the variation in GRDP. In comparison, the remaining 5.12% is influenced by other factors not included in the model. The high *adjusted R-squared value* indicates that this model remains robust, even after adjusting for the number of variables. This model implies that the 2SLS model has excellent explanatory power. Although some variables may be insignificant, the model's overall structure remains strong and relevant.

Durbin–Watson test

A DW value of 1.008, which is less than 2, indicates positive autocorrelation. This indicates a residual correlation pattern between years, requiring further testing, such as the LM Test (Breusch–Godfrey), model refinement using the Cochrane–Orcutt method, or the addition of dynamic variables. Autocorrelation is often found in regional time series data, as GRDP movements tend to be continuous.

2SLS Model 2 Test

Durbin–Wu–Hausman Endogeneity Test

Table 14. Results of the Endogeneity Test for DWH Model 2

Statistics	Mark	Prob.
Wu-Hausman F-statistic	253.8458	0.000000

The Durbin–Wu–Hausman (DWH) endogeneity test in Model 2 shows a Mark *F-statistic of* 253.8458 with a probability of 0.000000. However, based on the mark, the first residual probability (RES_PDRB) is 0.1384, obtained at the testing stage for endogeneity. No, there is no significant endogeneity on the GRDP variable. Thus, Model 2 is essentially a no-experience problem of simultaneity, so OLS is still worth using. Thus, the Two-Stage Least Squares estimate remains *robust* to potential

partial TaS Test Comparisons del 2

Variable	Coefficient	Std. Error	t-Statistic	P-value
C	1000.389	110.8394	9.025566	0.0000
GRDP	-0.000146	0.000734	-0.198623	0.8442
TPT	3.795456	1.798826	2.109963	0.0455
HDI	-12.14999	2.391573	-5.080333	0.0000
OIL PRICE	-0.010052	0.020988	-0.478930	0.6363
R-squared	0.979900	*F-statistic*		292.4222
Adjusted R-squared	0.976550	*Prob(F-statistic)*		0.000000
SE of Regression	15.37737	*Durbin-Watson stat*		0.645671

Referring to the value coefficients obtained, the equality regression formed is as follows:

POVERTY = 1000.389 – 0.000146GRDP + 3.795456TPT – 12.14999HDI – 0.010052HOIL .....(10)

The constant 1000.389 indicates that, if all variables are zero, the poverty level is estimated at around 1000 units, although it has no direct economic meaning. The GRDP coefficient (–0.000146) indicates that economic growth is not significant in reducing poverty (p = 0.8442), suggesting non-inclusive growth driven by the dominance of the oil and gas sector. The significant TPT coefficient (+3.795456) (p = 0.0455) indicates that a 1% increase in the unemployment rate increases poverty by 3.79 units. The highly significant HDI coefficient (–12.14999) (p = 0.0000) means that every 1 point increase in the HDI reduces poverty by approximately 12.15 units, emphasizing the importance of education and health. The world oil price coefficient (–0.010052) indicates that oil price fluctuations do not have a significant impact on poverty (p = 0.6363), because oil and gas revenues do not flow directly to poor households.

F Test (Simultaneous Significance Test)

The F-test on Model 2 shows that the F-statistic value of 292.4222 is much greater than the F-table of 2.62 at the 5% significance level. The null hypothesis is rejected, which means that GRDP, the Open Unemployment Rate (TPT), the Human Development Index (HDI), and world oil prices simultaneously have a significant effect on the poverty rate in Bojonegoro Regency. Therefore, Model 2 is declared significant overall and is suitable for further analysis.

t-test (Partial Significance Test)

The t-test in Model 2 of the 2SLS was used to test the partial significance of each independent variable on poverty levels in Bojonegoro Regency, after the potential simultaneity bias was accounted for using the Two-Stage Least Squares approach. t-table (α = 5%) = 2.060 and t-table (α = 10%) = 1.708. GRDP has a t-statistic value (-0.198623) smaller than the t-table at all significance levels. This indicates that economic growth has no significant effect on poverty. This finding indicates that

economic growth in Bojonegoro is not yet inclusive and does not directly reduce poverty. The Open Unemployment Rate (TPT) has a t-statistic (2.109963) greater than the t-table value at the 5% significance level, indicating a positive and significant effect on poverty. This means that rising unemployment directly increases the number of poor people, confirming the labour market's role as a major determinant of poverty. The Human Development Index (HDI) has the highest t-statistic value (-5.080333), far exceeding the t-table at all significance levels. Thus, the HDI has a negative, highly significant effect on poverty (α = 1%). Improving education, health, and living standards has proven to be the most effective way to reduce poverty. The t-statistic for world oil prices (-0.478930) is smaller than the t-table value, so world oil prices do not have a significant effect on poverty. This indicates that oil price fluctuations have a greater impact on the fiscal position and the oil and gas sector than on the welfare of poor households.

Coefficient of Determination Test

The R-squared value of 0.9799 indicates that 97% of the GRDP, TPT, HDI, and Oil Price variables explain 97.99% of the remaining 2.01%; the remaining 2.01% is influenced by other factors not included in the model, such as income distribution, labour mobility, institutional quality, and social assistance programs. The very high *Adjusted R-squared value* indicates that this model has strong predictive ability, even given the number of variables and observations.

Durbin–Watson test

A DW value of 0.645 indicates strong positive autocorrelation, meaning that past poverty levels significantly influence current poverty. This is a common characteristic of path-dependent social variables and should therefore be understood as a structural feature rather than simply a methodological issue.

Test Toda-Yamamoto Causality

Table 16. Results Test Toda-Yamamoto Causality

Hypothesis Causality	Chi-sq	Prob.	Description
GRDP POVERTY→	2.004821	0.5714	Not Significant
TPT →GRDP	0.679242	0.8781	Not Significant
HDI →GRDP	9.403854	0.0244	Significant
GRDP →OIL	0.591126	0.8985	Not Significant
GRDP →POVERTY	2.091613	0.5536	Not Significant
POVERTY RATIO→	6.614768	0.0852	Significant 10%
POVERTY HDI→	5.530217	0.1368	Not Significant
OIL →OF POVERTY	0.251128	0.9689	Not Significant
GRDP →TPT	2.256881	0.5208	Not Significant
TPT POVERTY→	1.668226	0.6440	Not Significant
Human Development Index (HDI →) of TPT	1.042174	0.7910	Not Significant
TPT OIL→	1.430786	0.6983	Not Significant
GRDP →HDI	2.891457	0.4087	Not Significant
POVERTY →HDI	8.530508	0.0362	Significant
TPT →IPM	1.991616	0.5741	Not Significant
HMINYAK →IPM	2.015861	0.5691	Not Significant
GRDP →OF OIL	23.89636	0.0000	Significant
OIL →POVERTY	2.234287	0.5252	Not Significant

TPT →HMINYAK	8.236650	0.0414	Significant
Oil and Gas Industry →HDI	32.65172	0.0000	Significant

The results of the Toda–Yamamoto causality test indicate that only a few causal relationships are significant. In the direction of GRDP, only the HDI shows a causal effect (p = 0.0244), while the other variables are not significant. In the Poverty equation, TPT has a causal effect at the 10% significance level (p = 0.0852). Furthermore, poverty has a significant effect on HDI (p = 0.0362). In the Oil Price equation, GRDP, TPT, and HDI are statistically significant, but this finding should be interpreted cautiously, as global factors may also influence Oil Price. In general, most pairs of variables do not show a significant causal relationship.

DISCUSSION

The Relationship Between the Influence of Oil and Gas DBH, TPT, HDI, Poverty, and Oil Prices on Economic Growth (GRDP)

Based on the 2SLS Model 1 estimation results (Table 14), several variables contribute to variations in GRDP in Bojonegoro Regency. The HDI variable has a positive coefficient of 2276.216 (p = 0.08), indicating that improvements in education quality, health, and living standards contribute to the expansion of regional production capacity. Although its significance is moderate, this finding strengthens the argument that human development is the foundation of long-term economic growth. This finding aligns with those of Todaro & Smith (2020), who found Human development creates social and intellectual capital that directly impacts regional productivity. Research (Safitri et al., 2023) also supports that increasing the HDI plays an important role in driving the economic performance of resource-rich regions.

Meanwhile, the unemployment rate (TPT) variable showed a positive relationship with GRDP (β = 880.91), but this relationship was not statistically significant. This pattern indicates a structural anomaly, where Bojonegoro's economic growth is primarily driven by capital-intensive sectors that absorb less labour, particularly the oil and gas sector. This condition aligns with the argument (Hill & Pasaribu, 2022). Those areas that depend on extractive commodities tend to experience *joblessness growth*, namely, economic growth without expanding employment opportunities.

Oil and Gas DBH has a positive but insignificant effect (β = 4.79E – 09). This confirms that high oil and gas revenues do not always have a direct impact on regional economic output. Dependence on fluctuating fiscal transfers makes Bojonegoro's GRDP vulnerable to global oil market volatility. This finding is consistent with Nurfatriani et al. (2022), who found that oil and gas revenues in Indonesia are strongly influenced by global market conditions and central fiscal policies, and that these revenues do not always accelerate economic growth in producing regions.

The poverty variable (β = –51.30) showed a negative but insignificant effect on GRDP. However, the direction of this relationship suggests that gradual improvements in social welfare can strengthen the regional economic base by increasing productivity and purchasing power.

Global oil prices were the only consistently significant variable (β = –22.14; p < 0.01). These results indicate that rising global oil prices actually had a contractionary impact on the Bojonegoro economy. This could be because high oil prices increased production costs, reduced activity in labour-intensive sectors, and drove up local inflation, thus hampering economic growth. This finding aligns with Basri (2021), who

explains that the volatility of energy commodity prices can worsen the economic stability of regions that depend on the extractive sector.

The Relationship between the Influence of GRDP, TPT, HDI, and Oil Prices on Poverty Levels

The results of the 2SLS Model 2 test (Table 15) indicate that the unemployment variable (TPT) has a positive and significant effect on poverty (β = 3.79; p < 0.05). This finding confirms that the rising unemployment rate directly contributes to the growth of the poor population. This condition indicates that the Bojonegoro labour market is still not optimally absorbed by productive sectors. Research (Hapsari, 2020) also concluded that unemployment is one of the strongest determinants of poverty in rural and resource-rich areas.

GRDP has a negative, but insignificant, coefficient (β = −0.000146). This phenomenon reflects that Bojonegoro's economic growth is not yet inclusive. Growth supported by the oil and gas sector tends to produce *trickle-down effects. The effect* is low, so low-income groups do not directly benefit economically. This aligns with the findings (Hill & Pasaribu, 2022). Economic growth in resource-rich areas is often uneven because the extractive sector has weak linkages with other local economic sectors.

The HDI shows a negative but insignificant coefficient (β = −12.14). However, the direction of this relationship suggests that improving people's long-term quality of life can still reduce poverty. This pattern aligns with the argument (Prasetyo, 2021) that education and health often take longer to produce meaningful poverty-reduction effects.

Oil prices have a negative but insignificant effect (β = −0.01). This means that fluctuations in global oil prices do not directly impact people's welfare. This indicates that poverty in Bojonegoro is more determined by labour-market dynamics and income distribution than by fluctuations in oil and gas prices.

Causal Relationship Between Economic and Social Variables Based on the Toda–Yamamoto Method

The Yamamoto causality test (Table 16) indicates that not all variables have a strong causal relationship. Regarding GRDP, only the HDI was found to have a causal effect (*chi-square* = 9.403; p = 0.024). This finding strengthens the argument that human development is a fundamental driver of regional economic growth. Improving the quality of education and health creates a more productive workforce and is adaptive to technological change. These results align with the research (Amir & Hakim, 2019), which confirms that increases in the HDI are causally related to regional economic growth in Indonesia.

Regarding the relationship to poverty, the TPT shows a causal effect at the 10% significance level (*chi-square* = 6.614; p = 0.085). This confirms that unemployment is not merely correlated but actually causes the increase in poverty in Bojonegoro. Meanwhile, the poverty variable is also found to be causally related to the HDI (*chi-square* = 8.530; p = 0.036). This means that the community's economic well-being directly affects households' ability to access education and health services.

In addition, there is a significant causal relationship between GRDP and oil prices (Chi-square = 23,896; p < 0.001) and between HDI and oil prices (Chi-square = 32,651; p < 0.001). However, in theory, this relationship is weak because oil prices are a global variable that is not influenced by regional economic activity. This pattern reflects a similar long-term trend rather than a real causal relationship. Widarjono's

(2018) research also noted that time-series models can produce statistical relationships that do not reflect economic relationships when strong external factors influence variables.

Overall, the causality results indicate that the interactions among human capital, labour market conditions, and poverty primarily determine the dynamics of Bojonegoro's economic development. Required policy implications include increased investment in human development, expanded employment opportunities, and strengthened economic diversification to reduce dependence on oil and gas.

CONCLUSION

The results indicate that the interaction between social factors, human resource quality, and macroeconomic conditions influences the dynamics of Bojonegoro Regency's economic development. Estimation analysis shows that the HDI significantly contributes to increasing GRDP, reflecting the strategic role of human quality in driving regional productivity. Conversely, the TPT and poverty exert pressure on economic growth, although not all are significant in all estimation models. The influence of Oil and Gas DBH on GRDP also does not show a stable relationship, indicating that the volatility of oil and gas revenues and fluctuations in global oil prices limit its role as a driver of regional economic growth. In the poverty model, the TPT is the most influential determinant, while GRDP, the HDI, and oil prices have not shown a substantial direct impact on reducing poverty levels.

Causality findings from the Toda–Yamamoto approach clarify the structure of the relationship between variables. The HDI has been shown to increase GRDP causally, whereas the TPT is a direct cause of increased poverty. The causal relationship between poverty and the HDI is also identified, indicating that welfare conditions are the foundation for improving human well-being. Meanwhile, some causal relationships involving oil prices and GRDP are theoretically weak because they are influenced by external factors unrelated to regional economic activity. Overall, this study confirms that Bojonegoro's development strategy should focus on improving the quality of human resources and expanding employment opportunities as the primary instruments for strengthening economic growth and reducing poverty, while reducing excessive dependence on the volatile oil and gas sector.

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