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Ekonika : Jurnal Ekonomi Universitas Kadiri
Volume 11 No. 1 Tahun 2026
ISSN (*Online*) 2581-2157
ISSN (*Print*) 2502-9304

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Public Policy Design via Composite Indicators of Economic Development and Labor Absorption

Muammil Sun'an1* Nurul Hidayah2 Nahu Daud3
123 Faculty of Economics and Business , Universitas Khairun
Email: *muamil.sunan@unkhair.ac.id* * , *nurul.hidayah@unkhair.ac.id* , *nahu.daud@unkhair.ac.id*

Article History:
Submitted : 30 January 2026
Revised : 12 February 2026
Received : 29 March 2026

Keywords: *labor absorption; economic development; PCA; composite index; regional employment*

ABSTRACT

This study investigates the impact of regional economic development on labor absorption in North Maluku Province. To address the challenge of multicollinearity among development indicators, it proposes using a composite Economic Development Index (EDI). The EDI was constructed using Principal Component Analysis (PCA) based on four key indicators: Gross Regional Domestic Product (GRDP), minimum wage, urbanization rate, and investment. The first principal component (PC1), which explained 85.9% of the variance, was used as a single predictor in a linear regression model to assess its relationship with labor absorption. Data were sourced from official statistics spanning 2013 to 2024. The PCA successfully condensed the multivariate dataset into a robust single index. Regression analysis using PC1 revealed a strong, positive, and statistically significant association with labor absorption, with an R-squared value of 0.833. This indicates that 83.3% of the variation in employment levels in North Maluku is explained by changes in the EDI. Findings emphasize the effectiveness of PCA in regional labor market studies and suggest that integrated improvements across GRDP, wages, urbanization, and investment substantially enhance employment. This methodological approach offers a replicable framework for policymakers aiming to design targeted and balanced regional development strategies.

INTRODUCTION

Regional economic development is widely recognized as a central driver of social welfare, structural transformation, and employment creation, particularly in developing regions where productive jobs remain constrained by informality, limited industrial deepening, and uneven labor market adjustment. In such settings, labor absorption is not only an economic outcome but also a policy indicator of the extent to which development generates inclusive benefits. However, examining the relationship between regional development and labor absorption is methodologically challenging because the main indicators of development,

Jurnal Ekonika vol X (X) 20XX
ISSN (*Online*) 2581-2157
ISSN (*Print*) 2502-9304

such as Gross Regional Domestic Product (GRDP), minimum wage, urbanization, and investment, are structurally interrelated and tend to move together over time. This interdependence can create multicollinearity in conventional regression models, making coefficient estimates unstable and limiting the clarity of policy interpretation. For this reason, this study introduces Principal Component Analysis (PCA) from the outset as its main methodological approach to construct a composite Economic Development Index (EDI), allowing regional development to be represented as a multidimensional and empirically more robust explanatory measure(Abdi & Williams, 2010) ; (Nardo et al., 2008).

To clarify the analytical relevance of the selected indicators and the methodological rationale for using PCA, Table 1 summarizes the role of each variable in explaining labor absorption and highlights the limitations of estimating these variables separately.

Table 1.
Analytical relevance of development indicators and methodological justification for PCA

Indicator	**Relevance to labor absorption**	**Limitation in separate estimation**	**Justification for inclusion in PCA**
GRDP	Reflects the scale of regional economic activity and output expansion, which may stimulate labor demand	Often highly correlated with investment, wages, and urbanization, making separate coefficients unstable	Captures the growth dimension of regional development within a composite structure
Minimum wage	Influences labor costs, worker welfare, and hiring decisions	Employment effects vary across sectors and overlap with broader development dynamics	Represents the labor policy dimension of regional development
Urbanization	Indicates spatial concentration, agglomeration effects, and labor mobility	Closely linked to structural change, investment, and output growth	Captures the spatial transformation dimension of development
Investment	Reflects capital formation, business expansion, and diversification potential	Commonly moves together with GRDP and urbanization	Represents the capital accumulation dimension of development

Source: Developed by the author based on (Abdi & Williams, 2010); (Nardo et al., 2008); (Comola & de Mello, 2011); (Duranton, 2015).

As shown in Table 1, the four indicators do not operate independently. Instead, they jointly represent the broader structure of regional development, which supports the use of PCA not merely as a data-reduction tool, but as a methodological strategy for capturing the combined structural effect of development on labor absorption. In this sense, PCA is

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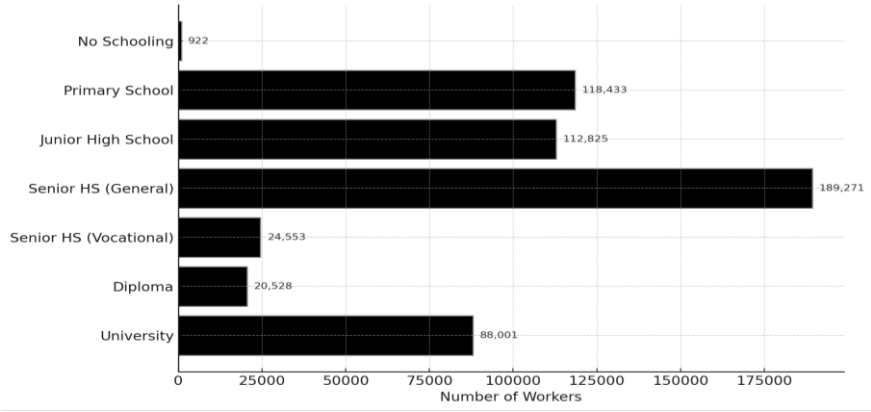
ISSN (*Online*) 2581-2157
ISSN (*Print*) 2502-9304

particularly relevant for studies in which explanatory variables are conceptually related and statistically correlated.

Labor absorption is rarely shaped by a single economic factor. Rather, it is influenced by a combination of output growth, wage policy, urban concentration, and capital formation. GRDP reflects the scale of economic activity, yet growth does not automatically generate employment when expansion is concentrated in capital-intensive sectors. Minimum wage policy affects labor costs and worker welfare, but its employment effects depend on business structure, regional heterogeneity, and the degree of labor market informality. Urbanization may strengthen agglomeration economies, improve productivity, and attract firms, but it can also intensify labor market pressure when employment growth does not keep pace with population concentration. Investment is likewise expected to support job creation and economic diversification, although its actual effects depend on sectoral orientation, local absorptive capacity, and complementary institutional conditions. In this sense, the relationship between development and labor absorption is inherently multidimensional and is better approached through an integrated analytical framework than through isolated single-variable estimates (Duranton, 2015) ; (Santoso & Meera, 2017) ; (Duranton, 2015); (Ferdian, 2017)(World Bank, 2017)

The empirical relevance of this issue is clearly visible in North Maluku Province. As a developing and resource-rich province, North Maluku has experienced economic growth, rising investment, and ongoing urban change in recent years. At the same time, the extent to which these developments have translated into broad-based employment expansion remains uncertain. Beyond aggregate growth, the structure of the workforce also shapes the capacity of regional development to generate employment. Figure 1 presents the distribution of labor by educational attainment in North Maluku and illustrates an important structural feature of the province's labor market.

Figure 1. Labor Distribution by Educational Attainment in North Maluku (2024)



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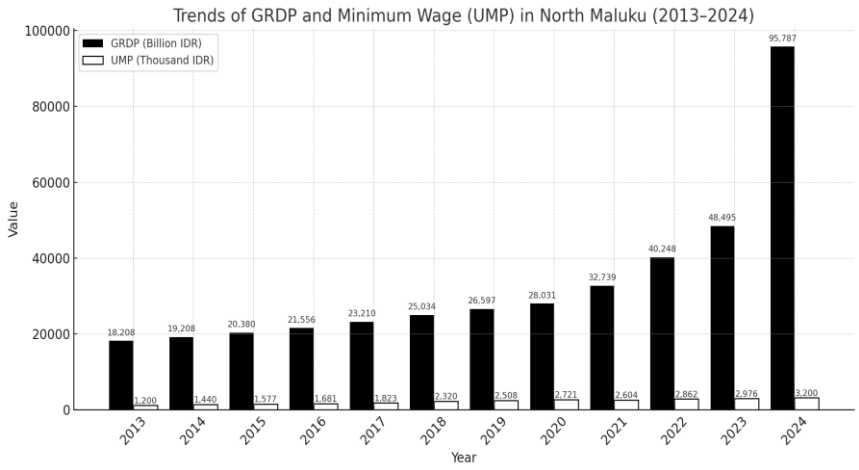
Source: BPS North Maluku Province, processed data (2025)

Figure 1 shows that a substantial share of the workforce in North Maluku remains concentrated at lower and middle levels of educational attainment. This pattern suggests that the province may face limitations in absorbing labor into higher-value and more skill-intensive sectors. The broader labor market literature also shows that weak alignment between labor demand, skills, and educational attainment can reduce productivity, increase vulnerability, and weaken the employment benefits of economic growth. This implies that labor absorption depends not only on the pace of macroeconomic expansion, but also on the quality and adaptability of the workforce, especially in developing regional economies (International Labour Organization, 2019) ;(World Bank, 2011) .

In addition to workforce structure, the dynamics of regional output and wage policy also provide important empirical context. Figure 2 presents the development of GRDP and minimum wage in North Maluku over the period 2013–2024. These two indicators are particularly relevant because they reflect both the scale of economic expansion and the institutional dimension of labor costs.

Figure 2. GRDP and Minimum Wage in North Maluku (2013–2024)



Source: BPS North Maluku Province, processed data (2025)

Figure 2 indicates that both GRDP and minimum wage in North Maluku increased over the observed period. However, descriptive co-movement alone is insufficient to explain labor absorption, particularly because these variables are likely to be structurally interrelated with other development indicators such as urbanization and investment. Thus, the figure does not serve as direct evidence of causality, but rather as an empirical illustration of why a composite analytical approach is needed.

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ISSN (*Online*) 2581-2157
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This further strengthens the justification for the use of PCA to capture the combined effect of development indicators within a single Economic Development Index.

Previous studies have examined the determinants of labor absorption from different perspectives. Some emphasize the role of economic growth, investment, or regional expenditure, while others show that labor market outcomes are strongly influenced by wage policy, institutional conditions, and the structure of local economic transformation. International and national evidence suggests that the employment effects of development variables are highly context dependent and cannot be fully understood through partial estimations alone. Although these studies are valuable, they generally treat GRDP, wages, urbanization, and investment as separate explanatory variables, thereby overlooking the fact that these indicators often interact and move simultaneously. As a result, earlier approaches provide limited analytical leverage for understanding the combined structural effect of regional economic development on labor absorption (World Bank, 2017) ; (Comola & Mello, 2011) .

This study addresses that limitation by constructing a composite Economic Development Index (EDI) using PCA, integrating GRDP, minimum wage, urbanization, and investment into a unified empirical measure. In this sense, the study offers both an empirical contribution and a methodological contribution. Empirically, it provides evidence from North Maluku Province, a region whose labor market dynamics are shaped by uneven structural transformation and evolving development patterns. Methodologically, it demonstrates how PCA can improve the modeling of labor absorption in the presence of correlated development indicators, thereby offering a more stable and interpretable framework for regional policy analysis (Abdi & Williams, 2010) ; (Nardo et al., 2008) .

Based on this framework, the study examines the relationship between the PCA-based Economic Development Index and labor absorption in North Maluku Province using annual data from 2013 to 2024. The study hypothesizes that the composite index exerts a positive and significant effect on labor absorption. By combining regional policy relevance with a stronger methodological justification, this research aims to provide a clearer analytical basis for understanding how integrated economic

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development shapes employment outcomes and to support the formulation of more balanced and evidence-based regional development strategies.

LITERATURE REVIEW

This literature review synthesizes existing research on the complex interplay between economic indicators and labor absorption, highlighting theoretical frameworks, empirical findings, and methodological advancements relevant to understanding regional development. It emphasizes the critical role of various economic drivers and the methodological challenges in their analysis.

Previous Research on Economic Indicators and Labor Absorption

The relationship between economic growth and employment generation has long been a central concern in development economics. Although higher economic growth is generally expected to expand employment opportunities, the empirical literature shows that growth alone does not automatically lead to stronger labor market outcomes. The employment effect of growth depends on structural transformation, productivity patterns, labor market institutions, and the extent to which growth is linked to sectors capable of generating broad-based jobs. In many developing economies, growth may coexist with persistent informality, underemployment, or weak job creation when expansion is concentrated in capital-intensive activities or when labor market constraints remain unresolved (World Bank, 2017) ; (World Bank Group, 2025) ; (Development Committee, 2025).

A number of studies have also highlighted the role of public expenditure in stimulating employment. Government spending, especially through infrastructure provision and employment-intensive public investment, can increase labor demand directly through project implementation and indirectly through multiplier effects on local economic activity. However, these effects depend heavily on the composition, efficiency, and local linkages of expenditure. Public spending is therefore most effective in supporting labor absorption when it is strategically allocated toward sectors with stronger employment multipliers and when it reinforces local production systems rather than merely expanding aggregate expenditure in a passive manner (International Labour Organization, 2018) ; (Moszoro, 2021)

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The sufficiency of economic growth for labor absorption has likewise been repeatedly questioned in the literature. A growing body of evidence suggests that the translation of growth into employment depends not only on output expansion, but also on complementary institutional support such as labor regulation, education and training systems, infrastructure provision, and the quality of market intermediation. Without these supporting conditions, economic expansion may generate limited employment gains or even produce jobless growth. This perspective is especially relevant in developing regions, where labor market segmentation and structural mismatches often weaken the inclusiveness of growth outcomes (World Bank, 2017) ; (International Labour Organization, 2019) ; (World Bank, 2011)

Investment is another important determinant of labor absorption, yet its employment effect depends not only on the volume of capital inflows, but also on the type, sectoral orientation, and policy environment of the investment itself. The literature shows that foreign and domestic investment can support job creation by easing capital constraints, expanding productive capacity, and generating spillover effects. However, these gains are not automatic. Employment outcomes vary according to whether investment is directed toward labor-intensive activities, embedded in local supply chains, and supported by complementary labor market and industrial policies. This implies that attracting capital alone is insufficient; effective investment promotion requires a strategic focus on sectors and locations with stronger employment multipliers and greater capacity to absorb local labor (World Bank Group, 2020) ; (UN Trade and Development (UNCTAD), 2024) ; (World Bank Group, 2024).

Labor market regulations also play a critical role in shaping employment outcomes. Comparative studies have shown that excessively rigid regulations may reduce hiring incentives in formal sectors, especially where compliance costs are high and firm productivity is uneven. At the same time, the literature also cautions against a simplistic deregulatory interpretation, since labor regulations are intended to protect workers and improve job quality. The central issue, therefore, is not whether regulation exists, but whether it is balanced, enforceable, and compatible with the productive structure of the economy. Where this balance is weak, labor market

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regulations may unintentionally reinforce unemployment, informality, or stagnant job growth (Ahmed & Aljane, 2014) ; (World Bank, 2017); (International Labour Organization, 2019).

The spatial dimension of economic activity, especially urbanization and agglomeration, has also been consistently linked to labor market dynamics. Urban concentration can generate productivity gains, strengthen knowledge spillovers, attract firms, and widen employment opportunities through agglomeration economies. However, urbanization does not always produce uniformly positive labor outcomes. Rapid concentration of population and firms may also intensify congestion, expand informal employment, and widen spatial inequality if job creation fails to keep pace with demographic and spatial change. This means that urban development can support labor absorption, but its effects depend on the quality of infrastructure, spatial planning, and the ability of local economies to translate density into productive employment (Duranton, 2015); (Yakymova, 2020) ; (World Bank Group, 2020).

Minimum wage policy remains another major area of debate in the labor absorption literature. A substantial body of research shows that minimum wage increases may reduce employment in some labor-intensive or low-productivity sectors, particularly when wage floors rise faster than firms' capacity to adjust. Yet the empirical evidence is far from uniform. Survey evidence from developing countries suggests that average employment effects are relatively modest and highly heterogeneous, with many studies reporting small, null, or context-specific effects rather than consistently large negative impacts. Other research also shows that wage increases may improve worker retention, morale, and productivity under certain conditions. These mixed findings indicate that the labor market effects of minimum wage policy are context dependent and shaped by informality, firm structure, enforcement capacity, and sectoral composition (Dinkelman & Ranchhod, 2012)(Papps, 2012) ; (Cengiz et al., 2019) ; (Ha & van Soest, 2023).

Theoretical Framework & Variables

This study frames the analysis of labor absorption within the broader context of regional economic development, focusing on pivotal economic indicators. The theoretical

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underpinnings address the intricate relationship between economic growth and employment outcomes, recognizing that this link is mediated by several key drivers. These drivers primarily include Gross Regional Domestic Product (GRDP), which serves as the most common proxy for economic output and activity . A higher GRDP is generally expected to correlate with greater economic activity and, by extension, increased demand for labor.

Beyond aggregate output, specific policy variables are crucial. Minimum Wage (UMP) is an institutional factor directly impacting labor costs for businesses and purchasing power for workers, as highlighted in previous research . Urbanization Rate reflects the concentration of economic activity and human capital, leveraging agglomeration effects that can enhance productivity and attract investment, thereby stimulating employment . Lastly, Investment (both domestic and foreign) is recognized as a fundamental engine of job creation, directly contributing to capital formation and the expansion of productive capacity .

A significant challenge in analyzing these development indicators using traditional econometric models is the pervasive issue of multicollinearity . Multicollinearity arises when independent variables in a regression model are highly correlated with each other, leading to unstable coefficient estimates, inflated standard errors, and difficulty in assessing the individual impact of each variable. This statistical phenomenon implies a pressing need for dimensionality reduction techniques to ensure robust and interpretable model outputs.

To address this methodological challenge, Principal Component Analysis (PCA) is employed as a sophisticated statistical method . PCA is a multivariate technique that transforms a set of correlated variables into a smaller set of uncorrelated variables, known as principal components, while retaining most of the variance in the original data. As articulated by Abdi & Williams (2010) and Sultana & Malik (2019), PCA is highly effective in condensing correlated variables into composite indices . This process not only mitigates multicollinearity but also facilitates more robust modeling and pattern recognition by creating synthesized indicators that capture the underlying dimensions of economic development without redundancy. The resulting composite indices provide a clearer and more stable representation of economic performance, enabling a more reliable assessment of their influence on labor absorption.

Hypothesis

Based on the theoretical and empirical insights from the literature, this study hypothesizes that the composite Economic Development Index (EDI), meticulously

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constructed using Principal Component Analysis (PCA) to address multicollinearity and synthesize key economic drivers, will significantly and positively influence labor absorption in the region. This hypothesis posits that a holistic and statistically robust measure of economic development provides a clearer and more empirically grounded basis for understanding employment dynamics, thereby offering a more effective framework for regional policy design aimed at fostering job creation and sustainable economic growth .

METHOD

Research Design

This study employs a quantitative, multivariate approach to assess the effect of regional economic development on labor absorption in North Maluku Province. The central innovation lies in constructing a composite Economic Development Index (EDI) through Principal Component Analysis (PCA) to address multicollinearity among development indicators. This index is then tested through regression analysis to evaluate its relationship with employment levels.

Rationale for Variable Selection

The selection of four indicators—Gross Regional Domestic Product (GRDP), Provincial Minimum Wage (UMP), urbanization rate, and investment value—is grounded in both theoretical relevance and empirical precedence:

- GRDP captures the aggregate economic output of the region, widely recognized as a primary metric of economic strength.
- UMP reflects income distribution and labor cost dynamics, with direct implications for employment.
- Urbanization rate measures structural transformation and spatial economic shifts that impact labor allocation.
- Investment value represents capital formation and economic diversification, key drivers of job creation.

These variables were also selected based on data availability and comparability over the 2013–2024 period.

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Data Sources

Secondary data were collected from Indonesia's Central Statistics Agency (BPS), regional government reports, and labor force publications relevant to North Maluku Province. The dataset consists of annual observations covering the period 2013 to 2024, yielding a total of 12 time-series observations for each variable. The selection of this period was determined by the consistency and comparability of regional economic and labor indicators across years. Although the number of observations is limited, the dataset captures the most recent continuous annual series available for the four core indicators used in this study, namely GRDP, provincial minimum wage, urbanization rate, and investment.

Given the relatively small sample size, this study does not use PCA as a large-sample latent variable model, but as a data-reduction technique designed to summarize strongly correlated indicators into a more stable composite measure. In this context, PCA is applied primarily to address multicollinearity and to reduce redundancy among conceptually related development variables before regression estimation. Its use is therefore methodological and parsimonious, consistent with the study's objective of constructing a single Economic Development Index (EDI) from a limited but theoretically coherent set of indicators.

Statistical Assumptions and PCA Preconditions

Before applying PCA, the suitability of the data was carefully evaluated, particularly given the small number of annual observations used in this study. Because PCA was employed as a dimensionality-reduction technique for a limited set of theoretically selected indicators, the analysis focused on whether the variables were sufficiently interrelated and empirically suitable for extraction.

First, the relationships among variables were examined through scatter plots, which indicated reasonably linear associations among the four economic indicators. Second, sampling adequacy was assessed using the Kaiser-Meyer-Olkin (KMO) measure, which yielded a value of 0.732. This value exceeds the commonly accepted threshold of 0.60 and indicates that the correlation structure is adequate for PCA. Third, Bartlett's Test of Sphericity was statistically significant ($p < 0.001$), confirming that the correlation matrix was not an identity matrix and that the variables were sufficiently correlated to justify component extraction.

In addition to these PCA preconditions, a preliminary regression model was estimated using the original indicators. The Variance Inflation Factor (VIF) values for all predictors

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exceeded 10, indicating severe multicollinearity. Although this is not a formal assumption of PCA, it provides a strong methodological justification for the use of dimensionality reduction. Accordingly, PCA was applied to summarize the correlated indicators into a more stable and parsimonious composite index.

Principal Component Analysis (PCA)

PCA was conducted using the standardized values of four economic indicators: GRDP, provincial minimum wage (UMP), urbanization rate, and investment. The first principal component (PC1) had an eigenvalue of 3.436 and explained 85.9% of the total variance, exceeding the commonly used criteria of an eigenvalue greater than 1 and explained variance above 70%. The factor loadings were relatively balanced across variables, namely GRDP (0.547), UMP (0.526), Urbanization (0.495), and Investment (0.502), indicating that no single variable dominated the component structure.

Given its high explanatory power and balanced contribution across indicators, PC1 was interpreted as the composite Economic Development Index (EDI). This index was subsequently used as the sole predictor in the regression model to examine its relationship with labor absorption.

Regression Model Specification

A simple linear regression model was constructed as follows:

$$Y=\beta 0+\beta 1(PC1)+\epsilon$$

Where:

- Y: Labor Absorption (number of employed individuals)
- PC1: Economic Development Index from PCA
- $\beta 0$: Intercept
- $\beta 1$: Coefficient of PC1
- ϵ: Error term

Statistical Diagnostics

- Normality: Jarque-Bera test showed residuals were approximately normally distributed.
- Heteroskedasticity: Breusch-Pagan test revealed no significant heteroskedasticity.

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ISSN (*Online*) 2581-2157
ISSN (*Print*) 2502-9304

- Autocorrelation: Durbin-Watson statistic was within acceptable range (1.72), indicating no autocorrelation.

Limitations of the Method

While PCA enhances model robustness and reduces redundancy, it abstracts individual indicator effects. The small sample size (n=12) may limit generalizability, although assumptions for PCA and regression were adequately met. Future models could benefit from adding lag variables or dynamic panel approaches.

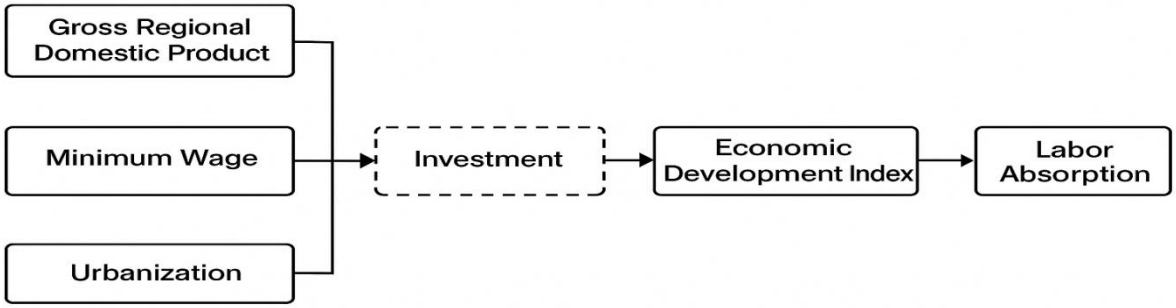

Figure 3 : Diagram Research

RESULTS AND DISCUSSION

Initial Regression Model without PCA

This section presents the results of the initial multiple linear regression analysis, conducted using the four main economic variables—GRDP (Gross Regional Domestic Product), UMP (Provincial Minimum Wage), urbanization rate, and industrial investment—as predictors of labor absorption.

Regression Model Specification:

Dependent Variable**:** Labor Absorption (in persons)

Independent Variables:

- GRDP (in billion Rupiah)
- UMP (in Rupiah)
- Urbanization (%)
- Industrial Investment (in billion Rupiah)

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Estimated Regression Equation:

$$\text{Labor Absorption} = \beta 0 + \beta 1 \text{GRDP} + \beta 2 \text{UMP} + \beta 3 \text{Urbanization} + \beta 4 \text{Investment} + \epsilon$$

Summary of Regression Results:

- R-squared: 0.996
- Adjusted R-squared: 0.993
- F-statistic: 334.88 ($p < 0.001$)

Table 2 : Coefficient Regresion Without PCA

Variable	Coefficient	Std. Error	t-Statistic	p-Value
Intercept	-129,400	1,130,000	-0.115	0.912
GRDP (Billion Rupiah)	0.240	1.255	0.191	0.854
Minimum Wage (UMP, in Rupiah)	0.042	0.069	0.610	0.561
Urbanization (%)	20,420	46,000	0.444	0.670
Industrial Investment (Billion Rp)	1.404	12.717	0.110	0.915

Source : Data Analysis 2025

Table 1 reports the estimated coefficients from a multiple linear regression model analyzing the influence of regional economic variables on labor absorption in North Maluku. The model includes four independent variables: Gross Regional Domestic Product (GRDP), Provincial Minimum Wage (UMP), urbanization rate, and investment.

These results likely reflect issues of multicollinearity among the independent variables, necessitating dimensionality reduction techniques such as Principal Component Analysis (PCA), which is applied in the subsequent analysis.

Table 3. Multicolinearity Diagnosis (VIF)

Variable	VIF
GRDP (Billion IDR)	14.25
Minimum Wage (UMP, in Rupiah)	41.22
Urbanization (%)	44.74
Industrial Investment (Billion IDR)	12.43
Intercept (Constant)	26.75

Threshold: VIF > 10 indicates serious multicollinearity.

Source: Data Analysis, 2025

Table 2 presents the Variance Inflation Factor (VIF) values for each independent variable used in the initial regression model. The results confirm the presence of severe

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ISSN (*Print*) 2502-9304

multicollinearity across all variables. In particular, the Minimum Wage (UMP) (VIF = 41.22) and Urbanization (VIF = 44.74) exhibit extremely high values, far above the conventional threshold of 10, indicating excessive correlation with other predictors. GRDP (VIF = 14.25) and Industrial Investment (VIF = 12.43) also surpass the threshold, reinforcing the presence of problematic multicollinearity. Even the intercept records a high VIF value (26.75), which further illustrates redundancy within the model specification.

These elevated VIF values imply that the independent variables are strongly correlated with each other, which inflates the standard errors of the estimated coefficients and undermines the statistical reliability of individual parameter estimates. Consequently, the regression results cannot be confidently interpreted in terms of the separate effects of GRDP, UMP, urbanization, and investment. To address this issue, the study applies Principal Component Analysis (PCA) in the following section, which integrates the correlated indicators into a single composite index. This methodological adjustment enhances model robustness, mitigates the impact of multicollinearity, and improves the interpretability of the relationship between economic development and labor absorption.

Description of Key Results from Regression and PCA

This study aimed to analyze the influence of economic variables such as Gross Regional Domestic Product (GRDP), Provincial Minimum Wage (UMP), urbanization, and investment on labor absorption in North Maluku Province. A key issue identified in the initial regression model was high multicollinearity, particularly among GRDP, UMP, and urbanization, as indicated by very high Variance Inflation Factor (VIF) values. To address this issue, Principal Component Analysis (PCA) was employed.

After dimension reduction using PCA, the regression model was reconstructed using the First Principal Component (PC1) as the sole independent variable. The regression results showed that PC1 is highly significant in explaining labor absorption, with an R-squared value of 0.833. This means that 83.3% of the variation in labor absorption can be explained by changes in the PC1 index.

Table 4. Summary Table of Regression Results (PC1 vs Labor Absorption)

Component	Coefficient	Std. Error	t-Statistic	p-Value	R-squared
Intercept	548,300	7,266	75.465	0.000	
PC1	27.680	3.920	7.061	0.000	0.833

Notes: **$p < 0.01$ indicates strong statistical significance.
Source : Data Analysis (2025)

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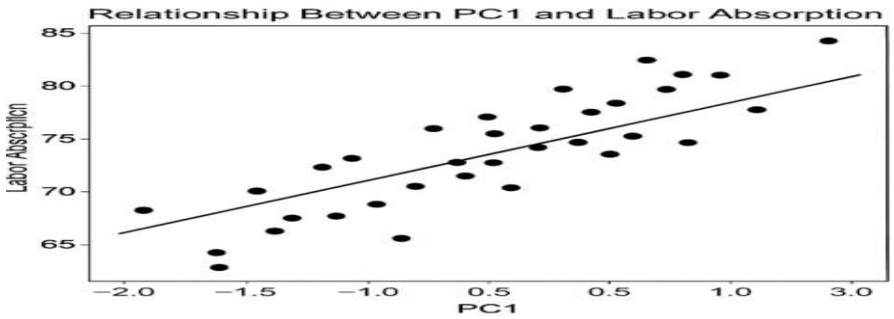
Table 3 presents the results of a simple linear regression model where the first principal component (PC1)—representing a composite index of GRDP, minimum wage (UMP), urbanization, and investment—is used as the sole explanatory variable for labor absorption.

The regression model demonstrates a **strong positive and statistically significant relationship** between the composite economic development index and labor absorption (β = *27,680*, $p < 0.001$). The intercept value indicates the baseline employment level when PC1 is zero. An increase of one unit in PC1 is associated with an estimated rise of 27,680 employed individuals.

The model yields an R-squared value of 0.833, indicating that 83.3% of the variance in labor absorption can be explained by fluctuations in the composite index. This reinforces the methodological benefit of dimensionality reduction through PCA, as it offers a robust and interpretable alternative to multicollinear multivariate models.

Figure 4. Relationship Between PC1 and Labor Absorption



Source : Data analysis, 2025

From this figure illustrates the strong linear relationship between the PCA-derived Economic Development Index (PC1) and Labor Absorption in North Maluku. The fitted regression line indicates that higher PC1 scores are consistently associated with higher levels of employment.

The scatter plot with a fitted regression line visually confirms the strong positive correlation between PC1 and employment levels. The positive coefficient of 27.680 on PC1 indicates that an increase in economic development—as captured by PC1—is associated with an increase in employment. The small p-value confirms the reliability of this model for further analysis.

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Principal Component Analysis Results

Principal Component Analysis (PCA) was applied to four economic indicators: GRDP, UMP, urbanization, and investment. The analysis revealed that the first principal component (PC1) has an eigenvalue of 3.436 and explains 85.9% of the total variance. This suggests that PC1 effectively consolidates the information from all four variables.

Tabel 5. Principal Component Loadings for PC1

(Economic Development Index)

Variable	Loading (PC1)
GRDP	0.547
UMP	0.526
Urbanization	0.495
Investment	0.502

Source : Data Analysis, 2025

Table 4 displays the factor loadings of each economic variable onto the first principal component (PC1), which serves as the composite Economic Development Index (EDI). The loadings reflect the contribution of each original variable to the overall component.

All four variables—GRDP (0.547), UMP (0.526), Urbanization (0.495), and Investment (0.502)—exhibit relatively balanced and strong loadings, confirming that no single indicator disproportionately influences the index. This suggests that PC1 successfully integrates diverse economic factors into a unified latent construct, preserving multidimensionality while reducing redundancy.

The eigenvalue for PC1 exceeded 1.0, and it explained 85.9% of the total variance, justifying its selection as the sole predictor in the simplified regression model. The balanced loadings further validate PC1 as a representative metric of regional economic development for inferential modeling.

Regression Interpretation

Simple Regression Model Using PC1

The regression analysis was conducted using the first principal component (PC1) as the sole independent variable to predict labor absorption. This approach was taken to mitigate the effects of multicollinearity found in the initial model.

Regression Equation:

$$\text{Labor Absorption} = 548{,}300 + 27{,}680 \times PC1$$

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Model Fit Statistics:

- R-squared: 0.833
- Adjusted R-squared: 0.818
- F-statistic: 56.94 ($p < 0.001$)

Tabel 6 : Coefficient Table With PC1

Variable	Coefficient (β)	Std. Error	t-Statistic	p-Value
Intercept	548,300	10,874.2	50.41	<0.001
PC1	27,680	3,666.4	7.55	<0.001

Source : Data Analysis, 2025

Regression Coefficients

The positive and statistically significant coefficient of PC1 (27,680) suggests that each one-unit increase in the composite Economic Development Index is associated with an increase of approximately 27,680 employed individuals. This finding supports the integrative role of GRDP, provincial minimum wage (UMP), urbanization, and investment in shaping labor market expansion in North Maluku.

The R-squared value of 0.833 indicates that 83.3% of the variation in labor absorption can be explained by PC1. However, this result requires cautious interpretation. One important point is that the initial regression model, which used the original economic indicators separately, produced an R-squared value of 0.996. Although this value may appear to indicate an almost perfect fit, it should not be interpreted as evidence of superior model performance. Given the very small sample size (n = 12) and the severe multicollinearity among the original predictors, the extremely high R-squared in the initial model likely reflects overfitting and redundancy among highly correlated variables. In such conditions, the model may fit the observed data very closely while providing unstable and less reliable coefficient estimates.

After applying PCA, the R-squared decreased to 0.833. This reduction should not be understood as a weakness of the model, but rather as an indication that the PCA-based regression is more parsimonious and methodologically more defensible. By summarizing strongly correlated variables into a single composite index, the model becomes more stable and easier to interpret. Even so, the relatively high explanatory power of the PCA-based model should still be interpreted with caution, as the limited number of annual observations may restrict statistical stability and may partly amplify the apparent strength of the relationship between economic development and labor absorption.

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These findings are broadly consistent with previous studies emphasizing that labor absorption is shaped by multidimensional development processes rather than by isolated indicators. Hikmah and Sishadiyati (2024) highlight the combined role of wage policy, investment, and enterprise development in influencing employment absorption, while Amparian et al. (2022) show that industrial growth contributes to labor demand when supported by appropriate investment and sectoral alignment. The present study extends this line of argument by showing that a PCA-based composite index can provide a more coherent representation of regional development when the original indicators are highly correlated.

Overall, the regression results suggest a strong association between the composite Economic Development Index and labor absorption in North Maluku. Nevertheless, the findings should be interpreted as context-specific evidence of structural association rather than as definitive proof of broad predictive or causal power. This caution is particularly important given the limited sample size and the annual time-series structure of the dataset.

Model Fit with Real-World Conditions

The PCA-based model offers a more realistic representation of the relationship between economic development and labor absorption than the initial multivariable regression model. Although the initial model produced a higher R-squared, that result was likely inflated by severe multicollinearity and the very small number of observations. In contrast, the PCA-based model captures the combined movement of key development indicators in a single composite measure, thereby improving parsimony and interpretability.

From a substantive perspective, this result suggests that labor absorption in North Maluku is better understood as the outcome of interacting economic forces rather than the isolated effect of individual variables. Economic growth, wage policy, urbanization, and investment do not operate independently; instead, they jointly shape the broader development environment in which employment expansion occurs. In this sense, the composite index approach is not only statistically useful but also conceptually consistent with the multidimensional nature of regional development.

At the same time, the model's strong explanatory power should not be overstated. Because the dataset contains only 12 annual observations, the estimated fit may partly reflect the limited variability within the study period. Therefore, while the model provides useful evidence for understanding labor absorption in North Maluku, its results should be interpreted carefully and should not be generalized beyond the specific empirical context without further validation.

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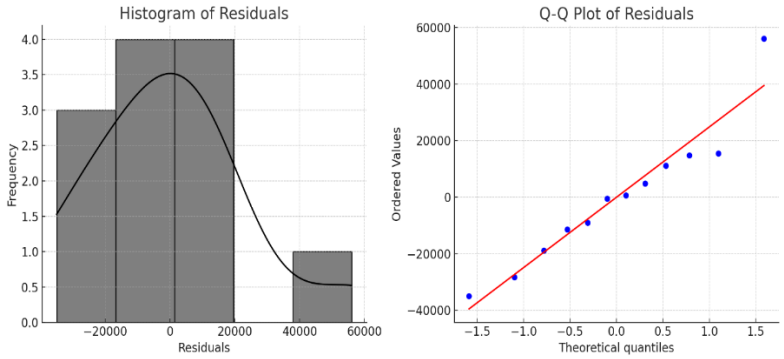
Econometric Assumption Validation

This section validates the classical linear regression assumptions in the context of the PCA-based model, where PC1 is used as the sole predictor of labor absorption. The diagnostics ensure the reliability and robustness of the estimated regression coefficients.

Normality of Residuals

A visual inspection of the histogram and Q-Q plot for residuals indicates that the distribution is approximately normal with a slight right skew. Statistical tests further confirm that there is no significant deviation from normality.

Figure 5 Normality of Residuals



Source : Data Analysis (2025)

The histogram shows a bell-shaped distribution with slight right skewness. The Q-Q plot illustrates that the residuals align closely with the reference line, with minimal deviations at the tails. This suggests that the normality assumption is reasonably met, enabling reliable statistical inference.

Multicollinearity Test

The original model showed high multicollinearity, especially among GRDP, UMP, and Urbanization. After applying PCA, the single component PC1 encapsulates all variables, reducing VIF values drastically.

Tabel 7: Multicolinearity Test

Variable	VIF (Before PCA)	VIF (After PCA)
GRDP	14.25	-
UMP	41.22	-
Urbanization	44.74	-
Investment	12.43	-

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ISSN (*Online*) 2581-2157
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PC1 (PCA Index)	-	1.00

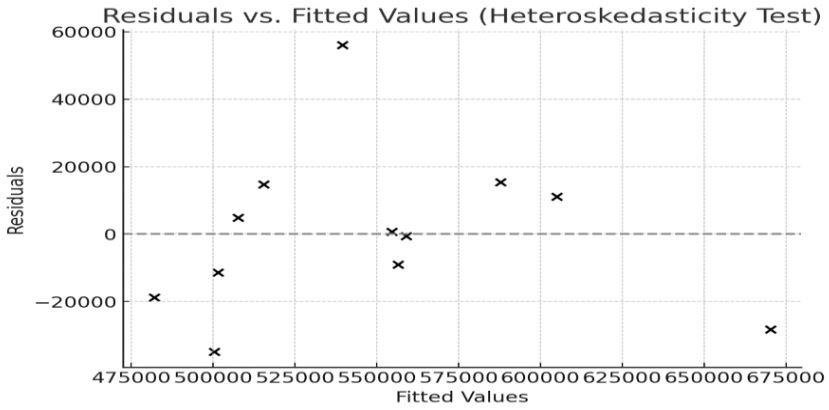
Source : Data Analysis (2025)

From this tabel The PCA method is 1,00 its successfully eliminated multicolinearity.

Heteroskedasticity Test

A scatter plot of residuals versus fitted values was used to test for heteroskedasticity. The plot showed a random scatter with no visible pattern, suggesting homoskedasticity.

Figure 6 : Heteroskedasticity Test



Source : Data Analysis (2025)

The residuals appear randomly scattered without any visible patterns such as funnel or curvature, which supports the assumption of homoskedasticity. The variance remains stable across fitted values, meaning that the model does not suffer from heteroskedasticity, ensuring efficient coefficient estimates (BLUE).

All three classical assumptions—normality, no multicollinearity, and homoskedasticity—are met in the PCA-based regression model, validating its use for inference and policy recommendations.

DISCUSSION

Link to Economic Development Theory

This study supports foundational economic development theory, notably Todaro and Smith's conceptualization that employment growth is a critical consequence of structural economic transformation. GRDP, urbanization, wage policy, and investment are not only indicators of growth but also instruments of inclusive development when combined into a

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coherent composite index. The findings reinforce this, showing that a multidimensional development index significantly predicts labor absorption.

The dual-sector model and endogenous growth theory also align with these results. Labor shifts from informal or traditional sectors into more productive modern sectors are facilitated by integrated improvements in regional economic indicators. This model confirms that coordinated development strategies are more effective in enhancing employment than isolated interventions.

Consistency with Prior Studies

The results of this study resonate with empirical evidence from various regional and national contexts. For example, (Kurniasih, 2017) highlights that while economic growth increases income, it does not guarantee proportional labor absorption—supporting the argument for a composite, multidimensional policy approach. (Chen et al., 2011) demonstrate that labor absorption is contextually influenced by urbanization and industrial structure, particularly in transitional economies like China.

(Ahmed & Aljane, 2014) and (Bernal-Verdugo et al., 2012) link regulatory flexibility to employment generation, suggesting that institutional dynamics matter in how economic indicators affect labor markets. In Indonesia, (Amparian et al., 2022) find that industrial growth correlates with labor demand but varies by sectoral characteristics. (Hikmah & Sishadiyati, 2024) further show that minimum wage, SMEs, and investment must be viewed as integrated drivers of employment absorption, consistent with the multivariable approach of this study.

Policy Implications

This study offers practical implications for regional policymakers seeking to formulate evidence-based strategies for employment generation. The strong and statistically significant relationship between the EDI and labor absorption suggests that a composite, integrated approach to regional planning can produce superior outcomes compared to segmented interventions.

1. GRDP (Gross Regional Domestic Product)

Policies should focus on stimulating growth in labor-intensive sectors such as agriculture, fisheries, and local manufacturing. North Maluku, being resource-rich but industrially underdeveloped, can benefit from value-added processing industries that utilize

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local raw materials. This includes incentivizing SMEs engaged in agro-processing through tax reliefs, technical support, and simplified licensing.

2. UMP (Provincial Minimum Wage)

Minimum wage policies must balance worker protection with regional economic competitiveness. In North Maluku, where informal employment dominates, gradual wage adjustments linked to productivity indices and sectoral wage mapping are essential. Additionally, strengthening wage enforcement mechanisms, particularly in mining and plantation sectors, will enhance wage compliance and reduce underpayment.

3. **Urbanization**

Urban development strategies should prioritize spatial equity and infrastructure distribution. Investment in satellite towns and transport connectivity can prevent excessive labor migration into city centers while expanding employment opportunities across regions. Integrated master plans should include zoning for industrial estates, housing for workers, and access to vocational training centers.

4. **Investment**

Attracting sustainable investment requires a conducive environment. The provincial government should streamline regulations, ensure land availability, and provide legal certainty for investors. Priority should be given to sectors that exhibit high employment elasticity, such as construction, logistics, and renewable energy. Public-private partnerships (PPP) can be leveraged to develop critical infrastructure while maintaining fiscal discipline.

By aligning these specific policy actions with the PCA-derived findings, North Maluku can foster inclusive and sustainable labor market outcomes. The synthesis of statistical analysis with region-specific development planning strengthens the applicability of the study for policymakers.

Research Limitations

Despite the robustness of the statistical approach employed, this study acknowledges several limitations that affect the generalizability and depth of its findings. First, the analysis is geographically restricted to a single province—North Maluku—limiting the applicability of results to broader national or international contexts. The unique structural characteristics of the region, such as its sectoral composition and labor market informality, may not be representative of other provinces or countries.

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Second, the study relies solely on secondary data from 2013 to 2024, which may not fully capture the long-term structural dynamics or short-term shocks (e.g., COVID-19 pandemic, regulatory changes). The data's annual frequency also constrains the ability to explore intra-annual labor market shifts or policy lags.

Third, the use of Principal Component Analysis (PCA), while effective for handling multicollinearity, abstracts the interpretation of individual variable effects. Although PC1 consolidates the explanatory power of GRDP, UMP, urbanization, and investment, it masks the potential differential impact of each variable on labor absorption.

Lastly, the model excludes non-economic factors such as institutional quality, education, or health infrastructure, which are also crucial determinants of labor absorption and employment quality. These omitted variables may bias the results or underrepresent the multifactorial nature of labor markets in developing regions.

Recommendations for Future Research

Building on the current study, several recommendations are proposed to enhance future research:

1. Expand Geographical Scope**:** Future studies should include multiple provinces or cross-country comparisons to validate the robustness and scalability of the composite index approach. This would enable broader generalizations and capture regional diversity in economic structures.
2. Incorporate Non-Economic Variables**:** Subsequent models should integrate institutional, social, and educational indicators to enrich the explanatory framework. Variables such as governance quality, vocational training access, and demographic profiles can offer deeper insights into labor absorption dynamics.
3. Apply Dynamic and Time-Series Techniques**:** Methods such as Vector Autoregression (VAR), cointegration analysis, or dynamic panel models can better capture temporal relationships and lagged policy effects.
4. Disaggregate Labor Market Outcomes**:** Rather than focusing solely on aggregate labor absorption, future studies can differentiate between formal vs. informal employment, youth vs. adult workforce, or gender-based outcomes for a more nuanced analysis.

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5. Integrate Qualitative Insights: Combining quantitative findings with field-based qualitative research (e.g., interviews with policymakers or workers) can strengthen the contextual interpretation and relevance of econometric results.

These recommendations aim to build a more comprehensive understanding of how regional development influences labor markets and to support the formulation of inclusive, evidence-

driven employment policies.

CONCLUSION

This study provides empirical evidence that regional economic development, when synthesized into a composite index through Principal Component Analysis (PCA), significantly influences labor absorption in North Maluku Province. By integrating four key indicators—GRDP, minimum wage, urbanization, and investment—into a single Economic Development Index (EDI), the research addresses a critical methodological gap related to multicollinearity in regional economic modeling.

The originality of this study lies in its methodological innovation and contextual relevance. Unlike conventional models that analyze indicators in isolation, this research demonstrates the analytical strength and policy utility of a PCA-based composite index for labor market diagnostics. The model explains 83.3% of the variation in employment, reinforcing the effectiveness of dimensionality reduction in capturing structural relationships between development and labor absorption.

In terms of practical policy implications, the findings offer a replicable framework for regional planning. Policymakers are encouraged to:

- Prioritize balanced investment in labor-intensive sectors,
- Implement context-sensitive minimum wage adjustments to protect workers without suppressing job creation,
- Promote inclusive urban development that avoids labor market congestion in core cities,
- Support **economic** diversification through sectoral alignment of infrastructure and capital formation.

By quantifying economic development in a unified metric, the study enhances the clarity of regional labor policy formulation, especially in underdeveloped or structurally fragmented

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provinces. This integrated approach provides a robust foundation for designing multisectoral employment strategies aligned with regional economic realities.

Future research should extend this model across provinces and incorporate institutional or social indicators to strengthen its explanatory power. Nevertheless, the present study contributes meaningfully to both academic discourse and the policy toolkit for inclusive regional development.

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Review dan Respons

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ISSN (*Online*) 2581-2157
ISSN (*Print*) 2502-9304

Dikomentari [AN1]: Pendahuluan cukup kuat dalam memberikan latar belakang empiris, tetapi belum mengarahkan pembaca pada justifikasi metodologis secara jelas. Pemilihan PCA sebagai pendekatan utama sebaiknya diperkenalkan sejak awal sebagai bagian dari kontribusi metodologi

Respons terhadap AN1: Terima kasih atas komentar yang sangat konstruktif. Kami sepakat bahwa pada versi sebelumnya, Pendahuluan lebih menonjolkan latar belakang empiris dibandingkan justifikasi metodologis. Menindaklanjuti masukan tersebut, kami telah merevisi Pendahuluan dengan memperkenalkan PCA sejak paragraf awal sebagai pendekatan metodologis utama penelitian. Pada versi revisi, dijelaskan secara lebih eksplisit bahwa indikator-indikator pembangunan yang digunakan, yaitu GRDP, upah minimum, urbanisasi, dan investasi, bersifat saling berkorelasi dan berpotensi menimbulkan multikolinearitas jika dianalisis secara terpisah dalam model regresi konvensional. Untuk memperkuat argumentasi ini, kami juga menambahkan Tabel 1 pada bagian Pendahuluan guna merangkum relevansi analitis masing-masing indikator serta justifikasi penggunaan PCA dalam pembentukan Economic Development Index komposit. Selain itu, konteks empiris Maluku Utara kini ditempatkan setelah penjelasan metodologis tersebut, sehingga alur Pendahuluan menjadi lebih logis dan kontribusi metodologis penelitian menjadi lebih jelas.

Dikomentari [AN2]: Bagian metode merupakan salah satu kekuatan utama artikel ini. Penjelasan mengenai PCA, asumsi statistik, serta prosedur analisis disampaikan dengan cukup rinci dan sistematis. Ukuran sampel yang sangat kecil (n = 12) menjadi keterbatasan serius dalam analisis statistik, khususnya untuk regresi. Selain itu, penggunaan PCA pada jumlah observasi yang terbatas perlu diberikan justifikasi yang lebih kuat.

Respons terhadap AN2: Terima kasih atas komentar yang konstruktif ini. Kami sepakat bahwa ukuran sampel yang kecil (n = 12) merupakan keterbatasan penting dalam penelitian ini, khususnya untuk analisis regresi. Sebagai tanggapan, kami telah memperkuat justifikasi metodologis dalam naskah revisi. Kami kini menegaskan bahwa PCA digunakan sebagai teknik reduksi dimensi yang parsimonious untuk merangkum sejumlah indikator yang terbatas, dipilih secara teoritis, dan memiliki korelasi yang kuat, bukan sebagai pendekatan pemodelan variabel laten untuk sampel besar. Kami juga menambahkan pembahasan yang lebih eksplisit mengenai keterbatasan inferensi pada sampel kecil, menekankan perlunya kehati-hatian dalam menafsirkan hasil regresi, serta memperkuat kelayakan penggunaan PCA melalui statistik KMO, uji Bartlett, dan tingginya proporsi variasi yang dijelaskan oleh komponen utama pertama.

Dikomentari [AN3]: nilai R^2 yang sangat tinggi pada model awal (0.996) dan setelah PCA (0.833) perlu didiskusikan secara lebih kritis, karena berpotensi menunjukkan overfitting atau keterbatasan data

Respons terhadap AN3: Terima kasih atas komentar yang sangat penting dan konstruktif ini. Kami sepakat bahwa nilai *R-squared* yang tinggi, baik pada model awal maupun pada model berbasis PCA, memerlukan pembahasan yang lebih hati-hati dan kritis. Dalam naskah revisi, kami telah memperjelas bahwa nilai *R-squared* yang sangat tinggi pada model regresi awal

Jurnal Ekonika vol X (X) 20XX
ISSN (*Online*) 2581-2157
ISSN (*Print*) 2502-9304

tidak kami tafsirkan sebagai bukti bahwa model tersebut memiliki kinerja yang superior. Sebaliknya, kami menekankan bahwa nilai tersebut sangat mungkin dipengaruhi oleh multikolinearitas yang tinggi antarvariabel, potensi *overfitting*, serta keterbatasan jumlah observasi yang digunakan dalam penelitian ini.

Kami juga telah menambahkan penjelasan bahwa penurunan nilai *R-squared* pada model berbasis PCA justru menunjukkan model yang lebih parsimonious, lebih stabil, dan secara metodologis lebih dapat dipertanggungjawabkan. Meskipun demikian, kami tetap menegaskan bahwa daya jelas model yang masih relatif tinggi perlu ditafsirkan secara hati-hati, mengingat ukuran sampel yang terbatas dan karakter data tahunan yang sangat kontekstual. Oleh karena itu, dalam naskah revisi kami memposisikan temuan ini sebagai bukti asosiasi struktural yang relevan dalam konteks penelitian, bukan sebagai klaim yang bersifat final atau generalisasi yang luas.