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Research Article

Employment Development Strategies to Support Economic Growth in North Sumatra

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Abstract: This study explores employment development strategies aimed at bolstering economic growth in North Sumatra Province using the Vector Autoregression (VAR) model and an eighteen-year time series dataset. The variables analyzed include the Human Development Index (HDI), total population, Gross Regional Domestic Product (GRDP), Labor Force Participation Rate (LFPR), and Open Unemployment Rate (OUR). The estimation results reveal dynamic interrelationships among these variables over short, medium, and long-term periods. The VAR analysis with a lag of 2 illustrates how each variable contributes to both itself and the other variables. It also shows that past variables (t-1) significantly impact current variables. Furthermore, the response function analysis identifies how a change in one variable is responded to by others across different time horizons. Stability analysis confirms that all variables maintain medium-to-long-term stability over a five-year period. The Forecast Error Variance Decomposition (FEVD) highlights HDI, population, and GRDP as the most influential variables in shaping the employment system and economic development overall. The VAR model used meets the stability test criteria, making the findings a reliable basis for policy research.

Keywords: Human Development, Population, GRDP, , Open Unemployment Rate (OUR)

1. Introduction

Economic growth is one of the principal indicators of successful regional development. In Indonesia, North Sumatra stands out as a critical province contributing to national development, especially in the western region of the country. Spanning an area of 72,981 km² and home to over 15 million residents, the province boasts rich natural resources and significant economic potential. Key sectors include agriculture, fisheries, natural and cultural tourism, palm oil and rubber plantations, and industrial activities concentrated in Medan and surrounding areas. Additionally, its geographic position adjacent to the Strait of Malacca provides strategic advantages in international trade and regional connectivity.

Despite its potential, North Sumatra continues to face challenges in economic development, particularly in the labor sector. Notable issues include fluctuating unemployment rates, a high number of informal workers, and a mismatch between workforce skills and industry demands. This gap reflects an imbalance between regional economic progress and the availability of a suitably skilled labor force. The inefficiency of educational and vocational institutions in producing job market-ready graduates exacerbates this problem. Given the increasing global competitiveness of economic

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systems, North Sumatra must undergo a comprehensive labor transformation. Employment development must focus on enhancing workforce capacity and productivity, generating decent employment opportunities, and empowering local labor to compete nationally and globally.

Labor is a crucial determinant of economic growth at both local and national levels. It plays a dual role—as a resource in the production and distribution of goods and services and as a target for market development. Therefore, labor serves as a pivotal engine in economic and national development. (Nursan, 2021).

Job opportunities refer to the employment activities available across public institutions and private enterprises. Employment issues are tightly linked to the number and quality of jobs and workers within an organization. For job seekers, particularly recent graduates, employment availability is a vital concern. In a competitive labor market, individuals must cultivate their skills to secure meaningful employment. Hence, limited access to job opportunities demands strategic attention from both society and government (Qomariah, 2023).

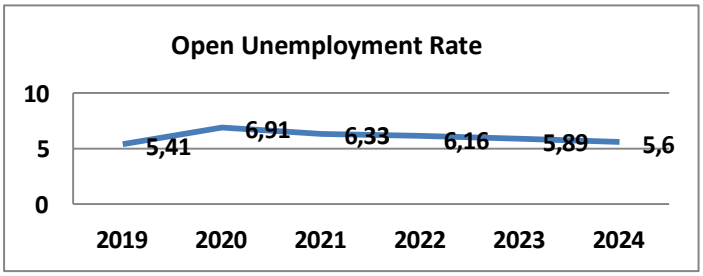

Figure 1. Open Unemployment Rate in North Sumatra (2019–2024)

The graph depicting the Open Unemployment Rate (OUR) in North Sumatra from 2019 to 2024 reveals dynamic fluctuations over the observed period. In 2019, the rate stood at 5.41%, which then sharply increased to 6.91% in 2020. This spike can be largely attributed to the economic disruptions caused by the COVID-19 pandemic, which resulted in business closures and job losses across various sectors.

However, starting in 2021, the unemployment rate began to steadily decline, falling to 6.33% in 2021, 6.16% in 2022, 5.89% in 2023, and reaching 5.60% in 2024. This downward trend indicates a gradual improvement in labor absorption and overall employment conditions within the province.

The post-pandemic recovery reflects a more resilient regional economy and highlights the effectiveness of labor policies, workforce development initiatives, and job creation programs implemented during this period. It also signals a realignment between the labor market demand and the supply of skilled human resources as the province adapts to new economic structures and opportunities.

Table 1. Labor Force Participation Rate in North Sumatra and Aceh (2010–2024)

YEAR	LFPR North Sumatra	LFPR Aceh
2010	69,51	63,17
2011	72,09	63,78
2012	69,41	61,77
2013	70,67	62,07
2014	67,07	63,06
2015	67,28	63,44
2016	65,99	64,24
2017	68,88	63,74
2018	71,82	64,04
2019	70,19	63,13
2020	68,67	65,11
2021	69,11	63,78
2022	69,53	63,5
2023	71,06	64,77
2024	71,35	

Source: North Sumatra BPS

[Aceh BPS](https://aceh.bps.go.id/id/statistics-table/2/MjA1IzI=/tingkat-partisipasi-angkatan-kerja-menurut-kabkota.html)

According to labor force data from Statistics Indonesia (BPS) as of August 2020, North Sumatra had approximately 7.35 million employed individuals, equating to 68.67% of the population aged 15 years and older. In contrast, 6.91% of the labor force was unemployed, placing the province seventh nationally in terms of open unemployment rates (BPS, 2021).

North Sumatra consists of 25 regencies and 8 cities, each with varying geographic characteristics and labor market conditions. These disparities reflect imbalances between labor supply and available employment opportunities across different regions. Furthermore, the quality of the labor force also differs between cities and regencies. Some areas exhibit optimal labor absorption, while others lag significantly.

This failure to absorb the workforce into employment opportunities contributes to poverty. The quality of labor directly affects poverty levels; a workforce that aligns with market demands promotes equilibrium in the labor market and reduces poverty rates. Consequently, this accelerates the development process (Retno, 2022).

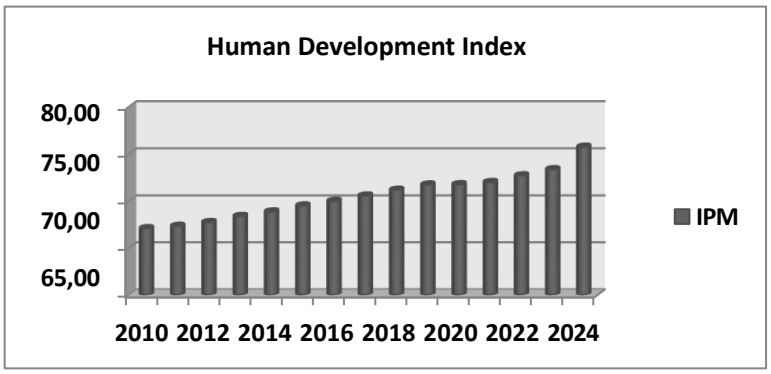

Figure 2. Human Development Index (HDI) in North Sumatra (2010–2024)

The graph representing the Human Development Index (HDI) in North Sumatra between 2010 and 2024 illustrates a consistent and upward trend. HDI is a fundamental metric used to evaluate the quality of human life through three core dimensions: education, health, and a decent standard of living. The data shows a gradual and stable improvement in HDI over the observed 14-year period.

In 2010, the HDI was recorded slightly above 66. Since then, it has continued to increase each year. This steady rise reflects improvements in access to quality education and healthcare services, as well as increases in per capita income among the population. These factors have jointly contributed to enhancing overall human welfare in the region.

Significantly, after the year 2021, the HDI showed more accelerated growth compared to previous years. By 2024, the index had climbed close to 76. This suggests that substantial progress has been achieved in human development, particularly in the post-pandemic period, driven by effective government initiatives and social programs that directly address the public's essential needs.

The upward trajectory of HDI not only demonstrates development success but also indicates growing sustainability and consistency in human development efforts. This positive trend points to an improvement in workforce quality—meaning that better-educated, healthier individuals are entering the labor market. Consequently, the enhancement in HDI is expected to translate into increased productivity, higher competitiveness, and stronger economic growth in the future.

Modern growth theory emphasizes the strategic importance of human capital as a driver of long-term economic progress. Government efforts to enhance education and health services are viewed as investments in future productivity. When individuals acquire more knowledge and skills, their contribution to the economy becomes more substantial. Skilled and healthy workers are more efficient, more innovative, and more adaptable to technological changes.

Therefore, the improvement of HDI is closely linked to poverty reduction and economic inclusion. A high HDI indicates that a region has the potential to absorb advanced technologies and maintain sustainable development. It also ensures that the labor force is equipped not just in quantity but also in quality, capable of supporting

regional economic competitiveness (Nurkhasanah, 2019).

Challenges in Human Resource Development and the Need for Employment Strategy Reform in North Sumatra Despite showing significant potential, North Sumatra continues to face persistent challenges in managing its human resources, particularly in the area of employment. Several key obstacles hinder regional economic growth, including high unemployment rates, low labor quality, and limited access to vocational and technical education. These challenges highlight the existing mismatch between labor supply and industry demand, as the skills offered by the workforce do not align with the evolving requirements of the job market.

To address these issues, there is an urgent need to reform employment development strategies so that they are more responsive to labor market changes. Without such reforms, structural imbalances between available workers and actual job opportunities will continue to hamper regional development. An effective employment strategy should focus not only on increasing job availability but also on improving the overall quality, skills, and competitiveness of the local workforce.

To create a productive and sustainable employment ecosystem, this development effort must be carried out collaboratively. Regional governments, private sector stakeholders, educational institutions, and the broader community must work together to design and implement coherent policies. Employment development strategies must also aim to absorb local labor more effectively and empower them to compete at both national and international levels.

By pursuing an inclusive and responsive employment strategy, North Sumatra can better leverage its economic potential, reduce unemployment, and enhance public welfare. Ultimately, this will accelerate the achievement of regional development goals and contribute to long-term economic resilience.

3. Proposed Method

This study employs the Vector Autoregression (VAR) model using EViews software as the main tool for analysis. According to Manurung (2009), the VAR method is particularly effective for examining simultaneous relationships and levels of integration among variables over the long term. This approach is preferred when it is not feasible to clearly distinguish between endogenous and exogenous variables due to their mutual interactions.

Based on this rationale, the VAR technique is used in this research to empirically capture and validate the complex long-run reciprocal relationships between key macroeconomic and labor-related variables.

VAR Model Specification

The VAR equations used in the model are as follows:

$$IPM_t = \beta_{10}IPM_{t-p} + \beta_{11}TPT_{t-p} + \beta_{12}TPAK_{t-p} + \beta_{13}JP_{t-p} + \beta_{14}PDRB_{t-p} + e_{t1}$$

$TPT_t = \beta_{10}IPM_{t-p} + \beta_{11}TPT_{t-p} + \beta_{12}TPAK_{t-p} + \beta_{13}JP_{t-p} + \beta_{14}PDRB_{t-p} + e_{t1}$ $TPAK_t = \beta_{10}IPM_{t-p} + \beta_{11}TPT_{t-p} + \beta_{12}TPAK_{t-p} + \beta_{13}JP_{t-p} + \beta_{14}PDRB_{t-p} + e_{t1}$

$JP_t = \beta_{10}IPM_{t-p} + \beta_{11}TPT_{t-p} + \beta_{12}TPAK_{t-p} + \beta_{13}JP_{t-p} + \beta_{14}PDRB_{t-p} + e_{t1}$

$PDRB_t = \beta_{10}IPM_{t-p} + \beta_{11}TPT_{t-p} + \beta_{12}TPAK_{t-p} + \beta_{13}JP_{t-p} + \beta_{14}PDRB_{t-p} + e_{t1}$ Where:

IPM = Human Development Index (in %)
TPT = Open Unemployment Rate (in %)
TPAK = Labor Force Participation Rate (in millions)
JP = Total Population (in millions)
PDRB = Gross Regional Domestic Product (in millions)
et = Random error term
p = Lag length

Model Impulse Response Function (IRF)

According to Ariefianto (2012), the Impulse Response Function (IRF) tracks the impact of a shock (or innovation) in one variable on the other variables within the system over time. Manurung (2005) explains that IRF helps determine the directional movement of each transmission variable when a change occurs in another. The goal of IRF analysis is to assess how short-term and long-term relationships respond to these shocks.

Model Forecast Error Variance Decomposition (FEVD)

The Forecast Error Variance Decomposition (FEVD) method is used to determine the relative importance of various shocks to a given variable and other variables in the system. As stated by Manurung (2005), FEVD analysis aims to evaluate the contribution of each transmitting variable to the variance observed in the system.

The FEVD formula is conceptually described as:

EtX t + 1 = A0 + A1X1

This means that the values A0 and A1 are used to estimate future values.

Xt + 1 Et Xt+n = et + n + A12et+n-2 + + A1n-1 et+1

In essence, the FEVD results always sum to 100%, indicating how much each variable's variance is explained by shocks in itself and in others. A higher FEVD value signifies a stronger influence.

Unit Roots Test

To assess the stationarity of the time series data, the Augmented Dickey-Fuller (ADF) test is employed. This test determines whether the variables have unit roots (i.e., are non-stationary) or are free from unit roots (i.e., stationary). If the ADF test statistic is more negative than the critical value from the MacKinnon table, the null hypothesis (H_0: presence of unit root) is rejected, indicating stationarity.

The estimation results in this study show that all variables become stationary at the first difference level, as evidenced by negative ADF test statistics and significant p-values.

Johansen Cointegration Test

This test is used to identify whether a long-term equilibrium relationship exists among the variables. If the variables are cointegrated, it implies that regressions at the level form are not spurious. The test also determines whether the residuals are stationary, typically using ADF for confirmation.

4. Results

Unit Root Test Results

Table 2. Augmented Dickey-Fuller (ADF) Unit Root Test Results

Variable	*Augmented Dickey Fuller*	
	t-statistic	**Stasioneritas**
HDI (IPM)	**0.0002*** **	**2(1I)**
Population (JP)	**0.0000*** **	**2(1I)**
GRDP (PDRB)	**0.0003*** **	**2(1I)**
LFPR (TPAK)	**0.0000*** **	**2(1I)**
OUR (TPT)	**0.0019*** **	**2 (II)**

Source: Processed data using EViews 10

Note: Asterisks (***, **, *) indicate significance at the 1%, 5%, and 10% levels respectively.

Cointegration Test Results

Table 3. Johansen Cointegration Test Results – Trace and Max-Eigenvalue

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.999439	243.2190	69.81889	0.0000
At most 1 *	0.989022	123.4511	47.85613	0.0000
At most 2 *	0.828705	51.26065	29.79707	0.0001
At most 3 *	0.648174	23.03078	15.49471	0.0030
At most 4 *	0.326189	6.316879	3.841466	0.0120
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.999439	119.7679	33.87687	0.0000
At most 1 *	0.989022	72.19044	27.58434	0.0000
At most 2 *	0.828705	28.22986	21.13162	0.0042
At most 3 *	0.648174	16.71390	14.26460	0.0201
At most 4 *	0.326189	6.316879	3.841466	0.0120

The test indicates the existence of long-run cointegration among the five variables: Human Development Index (HDI), Gross Regional Domestic Product (GRDP), Total Population, Labor Force Participation Rate (LFPR), and Open Unemployment Rate (OUR). This suggests that they maintain a stable long-term relationship.

Optimal Lag Selection

Table 4

Vector Autoregression Estimates LAG 1	
Akaike information criterion	65.32997
Schwarz criterion	66.80035
Number of coefficients	30
Vector Autoregression Estimates LAG 2	
Akaike information criterion	54.14382
Schwarz criterion	56.14382
Number of coefficients	55

Based on the values of AIC and SC, Lag 2 is selected as the optimal lag for the VAR model, as it yields the lowest values compared to Lag 1. Hence, the analysis proceeds using Lag 2.

Stability Test of Lag Structure

Roots of Characteristic Polynomial
Endogenous variables: IPM JP PDRB TPAK TPT
Exogenous variables: C
Lag specification: 1 2
Date: 05/29/25 Time: 22:48

Root	Modulus
-1.172889	1.172889
1.057128	1.057128
-0.829868	0.829868
0.382473 - 0.694783i	0.793101
0.382473 + 0.694783i	0.793101
0.671980 - 0.298999i	0.735499
0.671980 + 0.298999i	0.735499
-0.328036 - 0.595354i	0.679746
-0.328036 + 0.595354i	0.679746
-0.095117	0.095117

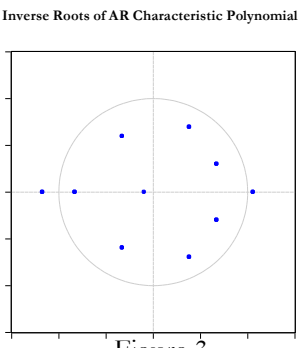

Figure 3

Roots of Characteristic Polynomial

The stability test indicates that all root modulus values fall below 1. The graphical representation shows that all roots lie within the unit circle. This means the VAR model is dynamically stable and appropriate for further analysis.

Summary of VAR Estimation Results

Table 5.

Variable	Largest Contribution	
	1st	2nd
Human Development Index (IPM)	IPM itself	Population
Population (JP)	Population itself	IPM
GRDP (PDRB)	GRDP itself	Population
LFPR (TPAK)	Population	IPM
Open Unemployment Rate (TPT)	LFPR (TPAK)	TPT

Source: EViews 10 data analysis

The estimation results of the VAR model show how each variable contributes to changes in itself and in other variables:

Human Development Index (HDI/IPM): The HDI is primarily influenced by its own past values, indicating strong internal persistence. The second most significant influence comes from population size, emphasizing the demographic role in shaping human development outcomes.

Population (JP): The total population is also mainly influenced by its own historical trends. However, HDI plays a key secondary role, suggesting a reciprocal relationship between population dynamics and the quality of human capital.

Gross Regional Domestic Product (GRDP/PDRB): GRDP is most influenced by its own previous levels, followed by population size. This highlights the substantial impact of demographic expansion on regional economic growth.

Labor Force Participation Rate (LFPR/TPAK): The leading factor influencing LFPR is population, with HDI as the next contributor. This reflects the idea that both the quantity and quality of the population determine labor force participation levels.

Open Unemployment Rate (OUR/TPT): This variable is largely affected by LFPR. A higher labor force participation rate tends to increase the pressure on the job market, while past unemployment rates also continue to influence future unemployment levels.

These relationships confirm that employment and economic growth in North Sumatra are influenced by complex interdependencies among demographic factors, human development, and economic indicators.

Table 6. Summary of Impulse Response Function (IRF) Results

Response of IPM:					
Period	IPM	JP	PDRB	TPAK	TPT
1	1.082002	0.000000	0.000000	0.000000	0.000000
5	0.047559	0.130009	-0.005600	0.039139	0.007567
10	-0.256641	0.286753	0.109346	0.024163	-0.002197
Response of JP:					
Period	IPM	JP	PDRB	TPAK	TPT
1	13800.93	17911.06	0.000000	0.000000	0.000000
5	-9124.214	711.8232	-8789.899	2136.607	2121.520
10	1618.461	8344.013	-1242.577	1993.584	736.1110
Response of PDRB:					
Period	IPM	JP	PDRB	TPAK	TPT
1	-1166.599	-2545.089	4979.174	0.000000	0.000000
5	-9124.214	711.8232	-8789.899	2136.607	2121.520
10	1618.461	8344.013	-1242.577	1993.584	736.1110
Response of TPT:					
Period	IPM	JP	PDRB	TPAK	TPT
1	-0.104065	-0.053602	-0.286346	0.094923	0.087060
5	0.145868	0.088412	0.046516	-0.001741	-0.013539
10	-0.005536	0.000358	0.032707	-0.011982	-0.010828

Response of HDI (IPM):

Short Term (Period 1): A shock to HDI causes a positive response in itself (1.082002), while other variables remain unaffected initially. Medium Term (Period 5): HDI slightly increases population (JP = 0.130009), slightly increases LFPR (TPAK = 0.039139), and slightly increases OUR (TPT = 0.007567). GRDP (PDRB) shows a minimal negative response (-0.005600). Long Term (Period 10): HDI has a negative self-response (-0.256641), but positively influences JP (0.286753), PDRB (0.109346), and TPAK (0.024163), while TPT turns slightly negative (-0.002197).

Response of Population (JP):

Medium Term (Period 5): A shock to population decreases HDI (-9124.214) and PDRB (-8789.899), but increases LFPR (2136.607) and OUR (2121.520). Long Term (Period 10): Positive effects on HDI (67350.19), JP itself (53089.90), TPAK (19469.57), and TPT (8981.306), but GRDP (PDRB) is negatively affected (-39886.76).

Response of GRDP (PDRB):

Medium Term (Period 5): Population (JP = 711.8232), TPAK (2136.607), and TPT (2121.520) respond positively to PDRB shock. However, HDI and GRDP itself respond negatively. Long Term (Period 10): HDI, JP, TPAK, and TPT respond positively. GRDP self-response remains negative (-1242.577), indicating a delayed adjustment process in regional economic output.

Response of LFPR (TPAK):

Medium Term (Period 5): TPT increases (8.824446), but negative responses occur in IPM (-28.15074), JP (-0.51868), and PDRB (-18.55554). Long Term (Period 10): HDI (35.75809), TPAK itself (0.455452), and TPT (2.637769) show positive responses. Meanwhile, JP (-23.59816) and PDRB (-24.99278) respond negatively.

Response of Open Unemployment Rate (TPT):

Medium Term (Period 5): Positive responses occur in HDI (0.145868), JP (0.088412), and PDRB (0.046516). TPAK and TPT show slight negative responses. Long Term (Period 10): Slight positive responses remain in IPM, JP, and PDRB, while TPAK and TPT respond negatively, though with minimal magnitude.

Conclusion from IRF:

The IRF analysis reveals dynamic and often non-linear interactions among the variables. Short-term effects may differ from long-term responses, showing reversals or intensification over time. These fluctuations illustrate how interdependent and sensitive the labor market and economic indicators are to shocks in human development, population growth, and macroeconomic variables.

Table 7. provides a comprehensive overview of how much each variable contributes to explaining the forecast error variance of other variables over three time horizons: short-term, medium-term, and long-term.

Variable	Interaksi IPM, Jumlah Penduduk,PDRB,TPAK dan TPT Dengan Pengembangan Tenagakerja Mendukung Pembangunan Ekonomi					Period
	HDI	Population (JP)	GRDP	LFPR (TPAK)	OUR (TPT)	
HDI	100.00%	-	-	-	-	Short Term
	88.61%	6.13%	3.26%	1.61%	0.36%	Medium term
	82.05%	10.17%	5.98%	1.44%	0.34%	Long Term
Population	37.25%	62.74%	-	-	-	Short Term
	21.61%	64.69%	10.01%	2.96%	0.71%	Medium term
	27.28%	59.13%	9.51%	3.34%	0.63%	Long Term
GRDP	4.17%	19.85%	75.97%	-	-	Short Term
	81.73%	3.12%	11.31%	2.80%	1.01%	Medium term
	55.03%	31.57%	9.34%	3.22%	0.81%	Long Term
LFPR	7.75%	83.23%	6.19%	2.81%	-	Short Term
	10.61%	75.52%	11.10%	2.32%	0.42%	Medium term
	14.32%	71.62%	11.56%	2/09%	0.39%	Long Term
OUR	9.64%	2.55%	73.02%	8.02%	6.75%	Short Term
	11.53%	44.81%	35.69%	5.13%	2.81%	Medium term
	11.08	48.44%	33.04%	4.83%	2.59%	Long Term

Source: Processed data by the author, 2025

: Highest 1

: Highest 2

From Table 7, it can be seen that the Human Development Index (HDI) is almost entirely influenced by its own historical values in the short term (100%). This suggests a strong dependence on its internal dynamics. In the medium term, the HDI's own influence declines to 88.61%, while population (6.13%) and GRDP (3.26%) begin to show increasing influence, indicating the emergence of structural interactions between HDI and demographic-economic variables. By the long term, HDI's self-dependence weakens further to 82.05%, with population (10.17%) and GRDP (5.98%) becoming more significant contributors. This shift implies that in the long run, improvements in human development are increasingly shaped by broader economic and demographic interactions.

For the population (JP) variable, in the short term, most variations are explained internally (62.74%), and the remaining (37.25%) are attributed to HDI. Over the long run, HDI's influence grows to 27.28%, while GRDP contributes 9.51%, and LFPR 3.34%. This suggests that population trends are increasingly shaped by human development and economic expansion.

Regarding GRDP, in the short run, it is primarily determined by its own past behavior (75.97%), but already shows significant influence from population (19.85%). In the medium term, HDI becomes the dominant driver (81.73%), highlighting that quality human capital is a decisive factor in economic growth. Over time, in the long run, HDI (55.03%) and population (31.57%) remain major contributors to GRDP fluctuations.

For LFPR, in the short term, the primary contributor is population (83.23%), emphasizing that the working-age population directly shapes labor participation. In the medium and long term, while population remains the dominant force (71%–75%), HDI and GRDP show increasing contributions, indicating that labor participation depends not only on numbers but also on the quality and strength of human capital.

When it comes to OUR, in the short term, GRDP accounts for the largest share (73.02%), demonstrating that downturns in economic performance immediately translate into rising unemployment. However, in the medium and long term, population and HDI gradually take over as the main influences. In the long-term projection, population (48.44%) has the most substantial impact, followed by GRDP (33.04%).

The FEVD analysis clearly illustrates that:

- In the short run, HDI is almost exclusively driven by its past values, while labor indicators like LFPR and OUR are heavily influenced by population and GRDP, respectively.
- In the medium run, structural factors such as HDI, population, and GRDP start to influence each other more equally.
- In the long run, demographic and economic factors—especially population growth

and GRDP—play increasingly central roles in shaping labor market dynamics, unemployment, and human development.

- These insights suggest that the interplay between population, economic output, and workforce engagement must be closely managed to ensure sustainable regional development and labor market stability.

Final Interpretation Based on FEVD Analysis

Based on the results of the Forecast Error Variance Decomposition (FEVD), the strategy for advancing employment to support economic growth in North Sumatra must consider different variable priorities depending on the time horizon:

- In the short term, policy emphasis should be placed on enhancing the Human Development Index (HDI), managing population growth, and boosting regional GDP (GRDP).
- In the medium term, these same variables—HDI, population, and GRDP—remain central drivers of labor dynamics.
- Over the long term, the strategic focus must also account for changes in the Open Unemployment Rate (OUR), in addition to HDI and population.

The application of the VAR model began with a stationarity test using the Augmented Dickey-Fuller (ADF) method to prevent biased regression results (Caraiani, 2023). The analysis confirmed that all variables—HDI, population, GRDP, LFPR, and OUR—became stationary after first differencing, with p-values less than 0.05.

Next, the optimal lag length was determined using both the Akaike Information Criterion (AIC) and the Schwarz Criterion (SC). Lag 2 was selected, as it showed the lowest values on both criteria, indicating it was the most appropriate configuration. Johansen's cointegration test confirmed long-run relationships at a 5% significance level, validating the presence of equilibrium between the variables.

The stability of the model was also assessed. The characteristic roots were all within the unit circle and had modulus values under 1. This confirms that the VAR model is dynamically stable, as verified by the Roots of Characteristic Polynomial and Inverse Roots of AR Characteristic Polynomial.

Key Findings from the VAR Estimation Results

The VAR estimation reveals how each macroeconomic and labor variable contributes to the dynamics of the others within the context of employment development and economic performance:

Human Development Index (HDI): This variable is primarily driven by its own past values and secondarily influenced by population size. This demonstrates that HDI

plays a major role in driving labor development and long-term economic growth. A skilled and productive workforce significantly contributes to sustainable economic performance (Rahmatan, 2024).

Population (JP): Changes in population are primarily influenced by its own prior values and by HDI, suggesting a positive feedback loop. An expanding population and better human development jointly support regional economic progress (Deris, 2023).

Gross Regional Domestic Product (GRDP): GRDP is strongly influenced by its own previous values and by population size, indicating the significant impact of demographic expansion on regional economic output. Additionally, GRDP per capita can serve as a proxy for economic advancement. The higher the GRDP per capita, the greater the region's potential income due to increased household purchasing power (Daud, 2023).

Labor Force Participation Rate (LFPR): This indicator is primarily affected by population, followed by HDI. LFPR influences national productivity and economic growth, as a robust workforce is essential for generating higher production output (Daud, 2023). Open Unemployment Rate (OUR): This variable is largely driven by LFPR and by its own lag. When the growth in labor force participation outpaces the creation of new jobs, unemployment rises (Triana, 2023).

Using the IRF (Impulse Response Function), the study demonstrates how a one-standard-deviation shock in one variable influences the others. The direction of the effects can shift—initially positive but turning negative over time, or vice versa. This confirms the dynamic and complex interrelationships among the variables and highlights the importance of understanding response stability across different time horizons.

Through the FEVD analysis, the study identifies the principal contributors to employment development strategies that support economic growth. In the short term, HDI, population, and GRDP are dominant. In the medium term, they remain the key variables. However, in the long term, the open unemployment rate becomes increasingly relevant, especially in shaping inclusive development strategies.

Sustainable economic development must aim to enhance living standards, create more employment opportunities, and ensure equitable income distribution. These goals are complicated by disparities between different economic sectors' ability to absorb labor and the rapid growth of the working-age population. A sharp rise in population inevitably leads to a larger labor force, which, if not matched with job creation, will intensify unemployment (Yefriza, 2025).

Implications of Lag Selection and Cointegration Analysis (Paraphrased English)

Choosing the optimal lag and confirming cointegration among variables are critical for understanding the full dynamics of short-, medium-, and long-term relationships. In labor development, it is evident that all variables are interconnected and collectively influence economic progress. HDI serves as a proxy for the quality of human

capital, which is fundamental to regional well-being. Improvements in HDI not only reflect better outcomes in education, health, and income but also help to break the cycle of poverty (Feriyanto, 2022).

Moreover, population and economic growth exhibit a mutually reinforcing relationship. Population growth can enlarge domestic markets, enhance workforce productivity, and foster technological adoption. In this light, people are seen not as burdens but as engines of development (Deris, 2023).

Economic growth itself reflects progress across multiple sectors and serves as a strategic benchmark for evaluating the success of development policies (Alisman, 2020). LFPR plays a crucial role in determining the capacity of an economy to generate output. The higher the proportion of working-age individuals participating in the labor market, the greater the potential for value creation (Tampubolon, 2024).

Economic expansion also has direct implications for employment and poverty. Strong GDP growth stimulates business expansion and job creation, while rising GRDP is expected to absorb more labor through increased production. Conversely, a decline in GDP often signals rising poverty. Therefore, low poverty rates are frequently viewed as indicators of healthy and inclusive economic development (Muslim, 2024).

6. Conclusions

The development of the labor sector holds a pivotal role in advancing economic growth in North Sumatra Province. Through the application of the Vector Autoregression (VAR) model, this study identifies a network of interdependent relationships among key variables such as the Human Development Index (HDI), population size, Gross Regional Domestic Product (GRDP), Labor Force Participation Rate (LFPR), and Open Unemployment Rate (OUR), across short, medium, and long-term horizons.

The estimation results underscore that HDI is most significantly influenced by its historical values and by demographic factors—particularly population growth. This finding reinforces the notion that improving human capital should be prioritized as a core strategy for economic development. Population growth, in turn, has a substantial influence on both GRDP and LFPR. These results suggest that demographic expansion not only enlarges the labor supply but also propels economic productivity when managed effectively.

The analysis of GRDP reveals that it largely depends on its own past performance and on population dynamics. This shows that economic growth at the regional level is intricately tied to both demographic momentum and the existing productive capacity of the area. LFPR is primarily shaped by changes in population and HDI, signifying that both the size and quality of the working-age population are central to enhancing labor participation.

The Open Unemployment Rate (OUR), on the other hand, is determined largely by fluctuations in LFPR and its own lagged values. This reflects the internal feedback mechanisms within the labor market, where increases in labor participation are not always matched by job availability, thus leading to persistent unemployment challenges.

Further analyses using the Impulse Response Function (IRF) and Forecast Error Variance Decomposition (FEVD) demonstrate that HDI, population, and GRDP are the most dominant and recurring variables in shaping labor dynamics and broader economic development. The VAR model also passes the necessary stability tests, which affirms the reliability of the estimated relationships.

Overall, this research highlights that a region's ability to generate sustained economic growth depends not only on the expansion of physical resources but more critically on the systematic development of its human capital and employment systems. Strengthening policies around education, workforce training, demographic management, and job creation is essential to achieving inclusive and resilient growth trajectories in North Sumatra.

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