The Impact Human Development Index and Industrial Labor on Economic Growth in North Sumatra Province

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ABSTRACT

Economic growth in North Sumatra remains a critical focus due to regional disparities in human development and industrial productivity. This study aims to analyze the impact of the Human Development Index and Industrial Labor on economic growth across 33 regencies/cities from 2010 to 2022. A quantitative approach using multiple linear regression with a fixed-effects model was employed, utilizing panel data from official statistics on the Human Development Index, Industrial Labor, and Gross Regional Domestic Product. The findings reveal that the Human Development Index has a significant but negative effect on economic growth, suggesting inefficiencies in translating human capital improvements into economic outcomes. Industrial Labor shows a positive but insignificant effect, likely due to low workforce skills. However, the combined effect of the Human Development Index and Industrial Labor significantly influences economic growth, indicating a synergistic relationship. The study concludes that targeted policies to enhance education, healthcare, and vocational training are essential to maximize the economic contributions of human development and industrial labor, particularly in rural areas, to foster sustainable economic growth in North Sumatra.

Keywords*: Economic Growth, Human Capital, Human Development Index, Industrial Labor, Regional Development.*

ABSTRAK

Pertumbuhan ekonomi di Sumatera Utara tetap menjadi fokus penting karena disparitas regional dalam pembangunan manusia dan produktivitas industri. Studi ini bertujuan untuk menganalisis dampak Indeks Pembangunan Manusia dan Tenaga Kerja Industri terhadap pertumbuhan ekonomi di 33 kabupaten/kota dari tahun 2010 hingga 2022. Pendekatan kuantitatif menggunakan regresi linier berganda dengan model efek tetap digunakan, memanfaatkan data panel dari statistik resmi mengenai Indeks Pembangunan Manusia, Tenaga Kerja Industri, dan Produk Domestik Regional Bruto. Temuan penelitian menunjukkan bahwa Indeks Pembangunan Manusia memiliki pengaruh yang signifikan namun negatif terhadap pertumbuhan ekonomi, menunjukkan inefisiensi dalam menerjemahkan peningkatan modal manusia menjadi hasil

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ekonomi. Tenaga Kerja Industri menunjukkan pengaruh positif namun tidak signifikan, kemungkinan karena keterampilan tenaga kerja yang rendah. Namun, pengaruh gabungan Indeks Pembangunan Manusia dan Tenaga Kerja Industri secara signifikan memengaruhi pertumbuhan ekonomi, menunjukkan hubungan yang sinergis. Studi ini menyimpulkan bahwa kebijakan yang terarah untuk meningkatkan pendidikan, layanan kesehatan, dan pelatihan vokasional sangat penting untuk memaksimalkan kontribusi ekonomi dari pembangunan manusia dan tenaga kerja industri, khususnya di daerah pedesaan, guna mendorong pertumbuhan ekonomi berkelanjutan di Sumatera Utara.

Kata Kunci: *Pertumbuhan Ekonomi, Modal Manusia, Indeks Pembangunan Manusia, Tenaga Kerja Industri, Pembangunan Daerah.*

INTRODUCTION

Economic growth is a critical indicator of regional development, reflecting improvements in productivity, income, and living standards. In Indonesia, economic growth has been a central focus of development policies, particularly in regions like North Sumatra, which is one of the country's key economic hubs outside Java. According to the Badan Pusat Statistik (2022), North Sumatra's economy has shown consistent growth, driven by its agricultural, industrial, and service sectors. However, achieving sustainable economic growth requires not only capital investment but also improvements in human capital and labor productivity. The Human Development Index (HDI), which measures health, education, and per capita expenditure, is widely recognized as a key determinant of economic progress. Similarly, the industrial labor force, which drives manufacturing and production, plays a vital role in regional economies. Understanding the interplay between these factors is essential for crafting effective development strategies in North Sumatra.

The HDI in Indonesia has shown a steady upward trend, rising from 66.53 in 2010 to 72.29 in 2022, reflecting improvements in education, health, and living standards (Badan Pusat Statistik, 2022). In North Sumatra, HDI has followed a similar trajectory, with notable progress in urban areas like Medan, though rural regencies such as Nias Barat lag behind, with HDI values ranging from 56.3 to 80.1 across regencies/cities in 2022 (Badan Pusat Statistik, 2022). This disparity highlights the uneven distribution of human development, which may influence economic outcomes differently across regions. According to Situmorang and Syahbudi (2022), HDI significantly affects economic growth in Serdang Bedagai, suggesting its potential impact in North Sumatra as a whole. However, the role of industrial labor in driving economic growth remains underexplored, particularly in the context of North Sumatra's diverse economic structure, which includes both industrial and agricultural sectors.

Despite numerous studies on economic growth, a clear research gap exists in understanding the combined effect of HDI and industrial labor on economic growth in North Sumatra. According to Asnidar (2018), HDI and inflation significantly influence economic growth in Aceh Timur, but the study does not address the role of industrial labor. Similarly, Susanto and Rachmawati (2013) found that HDI and inflation affect economic growth in Lamongan, yet their analysis excludes labor-specific factors. Utami (2020) explored the impact of HDI, poverty, and unemployment on economic growth in Aceh but overlooked the industrial sector's contribution. Furthermore, Anfasa (2022) investigated HDI and labor force effects in West Kalimantan, but the study focused on general labor rather than industrial labor specifically. These studies indicate that while HDI is frequently examined, its interaction with industrial labor in a regional context like North Sumatra remains understudied. Additionally, Nasution et al. (2020) highlighted the role of fiscal and monetary policies in reducing poverty in North Sumatra, but they did not explore how human development and labor quality contribute to economic growth.

The lack of comprehensive studies on the simultaneous impact of HDI and industrial labor in North Sumatra creates a critical gap in the literature. Prameswari et al. (2021) analyzed HDI, poverty, and labor in East Java, finding significant effects on economic growth, but their findings may not fully apply to North Sumatra due to regional differences in industrial composition and development challenges. Similarly, Yusuf and Al Arif (2015) emphasized the importance of human resource management in economic development but did not specifically address industrial labor's role. This study seeks to fill this gap by examining how HDI and industrial labor jointly influence economic growth in North Sumatra, considering its unique economic and demographic characteristics.

The objective of this study is to analyze the impact of the HDI and industrial labor on economic growth in North Sumatra from 2010 to 2022. By employing a quantitative approach with multiple linear regression and secondary data from the BPS, this research aims to quantify the significance and magnitude of these factors' effects. The findings are expected to provide insights for policymakers to enhance human development and labor productivity, thereby fostering sustainable economic growth in the region. This study also contributes to the literature by addressing the underexplored relationship between HDI and industrial labor in a regional context, offering a foundation for future research on regional development strategies.

LITERATURE REVIEW

Theoretical Foundations and Definitions

Economic growth is a central focus of development economics, reflecting increases in output, income, and productivity. According to Todaro (2000), economic growth is driven by improvements in physical and human capital, with human development playing a pivotal role in enhancing productivity. The HDI, introduced by UNDP (1990), measures human development through health (life expectancy), education (literacy and schooling), and living standards (per capita expenditure). Morris (1979) proposed the Physical Quality of Life Index as a precursor to HDI, emphasizing non-monetary indicators like health and education. In Indonesia, HDI has risen steadily, reflecting national efforts to improve human capital (Lampung, 2015). Industrial labor (IL), defined as the workforce employed in manufacturing and industrial sectors, is another critical driver of economic growth. Boediono (1999) argues that labor productivity, particularly in industry, contributes significantly to economic output due to its high value-added nature. Adisasmita (2013) further emphasizes that industrial labor enhances regional economies by fostering technological advancements and production efficiency. These theoretical perspectives highlight the interconnected roles of HDI and IL in driving economic growth, providing a foundation for analyzing their impact in North Sumatra.

The relationship between human development and economic growth is rooted in the concept of human capital. Beckerman (1966) notes that economic planning relies on human capital indicators, such as education and health, to predict growth outcomes. Similarly, Arsyad (2010) asserts that investments in education and health improve workforce quality, leading to higher economic productivity. Industrial labor, as a subset of the workforce, is particularly crucial in regions with significant industrial activity, such as North Sumatra. According to Tambunan (2002), industrial labor drives economic growth by increasing production capacity and supporting industrial diversification. In North Sumatra, industrial labor has grown in sectors like manufacturing and agro-industry, contributing to regional GDP (Badan Pusat Statistik, 2022). However, the quality of industrial labor, including skills and training, remains a critical factor in determining its economic impact. These definitions and theories establish the basis for examining how HDI and IL influence economic growth in a regional context.

Human Development Index and Industrial Labor on Economic Growth

Empirical studies have extensively explored the relationship between HDI, industrial labor, and economic growth. According to Situmorang and Syahbudi (2022), HDI significantly influences economic growth in Serdang Bedagai, North Sumatra, by

improving human capital quality. Similarly, Prameswari et al. (2021) found that HDI, alongside labor and poverty reduction, positively affects economic growth in East Java, highlighting its role in enhancing productivity. Ranis et al. (2000) argue that HDI and economic growth have a two-way relationship, where improved human development fosters growth, and growth supports further human development investments. In North Sumatra, HDI improvements from 2010 to 2022 have been driven by better access to education and healthcare, though disparities persist between urban and rural areas (Badan Pusat Statistik, 2022). These findings suggest that HDI is a critical determinant of economic growth, particularly in regions with diverse economic structures like North Sumatra.

Industrial labor also plays a significant role in economic growth, particularly in industrializing regions. Afrizal (2013) demonstrates that labor, alongside investment, significantly impacts Gross Regional Domestic Product (GRDP) in South Sulawesi, emphasizing the importance of a skilled workforce. Astuti et al. (2017) found that industrial labor contributes to economic growth in Pelalawan by supporting industrial output. Anfasa (2022) further supports this, showing that the labor force, including industrial labor, drives GRDP in West Kalimantan. In North Sumatra, industrial labor has expanded in manufacturing and processing industries, but its effectiveness depends on skill levels and training (Nasution et al., 2020). Rusmarinda (2016) notes that education and labor quality enhance economic growth in Central Java, suggesting that industrial labor's impact may be moderated by human capital factors like HDI. These studies collectively indicate that HDI and industrial labor, individually and jointly, influence economic growth, warranting further investigation in North Sumatra.

H1: Human development index has a positive and significant effect on economic growth.
H2: Industrial labor has a positive and significant effect on economic growth.
H3: Human development index and industrial labour simultaneously have a positive and significant effect on economic growth.

The research framework integrates HDI and industrial labor as key determinants of economic growth in North Sumatra. According to Adisasmita (2013), economic growth depends on the synergy between human capital and labor productivity, particularly in industrial sectors. HDI, encompassing health, education, and living standards, enhances workforce capabilities, thereby increasing economic output (UNDP, 1990). Industrial labor, defined as workers in manufacturing and industrial activities, contributes to growth through production efficiency and technological adoption (Tambunan, 2002). In North Sumatra, the interplay between HDI and industrial labor is critical due to the region's diverse economic base, including agriculture, industry, and services (Badan Pusat Statistik, 2022). Figure 1 illustrates this framework, depicting HDI and industrial labor as independent variables influencing economic growth, measured as GRDP.

The framework is grounded in empirical evidence from regional studies. Situmorang and Syahbudi (2022) demonstrate that HDI drives economic growth in North Sumatra's Serdang Bedagai, while Afrizal (2013) highlights the role of labor in South Sulawesi's economic output. Prameswari et al. (2021) and Rusmarinda (2016) further confirm that HDI and labor jointly affect economic growth in East and Central Java, respectively, suggesting a similar dynamic in North Sumatra. Nasution et al. (2020) emphasize that human capital and labor policies in North Sumatra influence economic outcomes, particularly in addressing regional disparities. This framework posits that HDI improves labor quality, which, when combined with a productive industrial workforce, fosters sustainable economic growth. By testing this model, the study aims to provide insights into effective development strategies for North Sumatra, as illustrated in Figure 1.

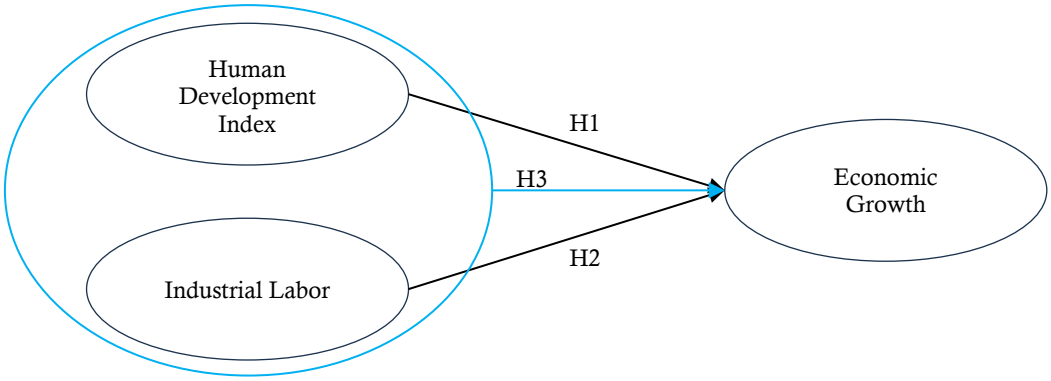

Figure 1. Research Framework

RESEARCH METHOD

This study employs a quantitative approach to examine the impact of the HDI and IL on economic growth in North Sumatra from 2010 to 2022. The research design uses a panel data analysis, combining time-series and cross-sectional data from 33 regencies/cities in North Sumatra over a 13-year period. This approach enables the capture of both temporal and regional variations in economic growth, measured as GRDP. According to Ghozali (2016), panel data analysis is effective for studying dynamic relationships between variables in regional studies. The population consists of all regencies/cities in North Sumatra, with the entire population used as the sample to ensure comprehensive coverage. This design aligns with the study's objective to provide insights into regional development strategies.

Data were sourced from secondary sources, primarily official publications by Badan Pusat Statistik (2022). HDI data, comprising life expectancy, education (mean years of schooling and expected years of schooling), and per capita expenditure, were obtained from annual HDI reports. Industrial labor data, defined as the number of workers in manufacturing and industrial sectors, were extracted from labor statistics reports. These sources ensure data reliability and consistency, as emphasized by KKIAN (2010) for quantitative research. Data were collected for each regency/city annually from 2010 to 2022, resulting in a balanced panel dataset of 429 observations (33 regencies/cities × 13 years). This comprehensive dataset allows for robust statistical analysis of the variables' effects.

The study uses multiple linear regression with a fixed-effects model to analyze the relationship between HDI, IL, and economic growth. The dependent variable, economic growth, is measured as the natural logarithm of GRDP to normalize the data. HDI is included as a composite index, while IL is measured as the total number of industrial workers in thousands. The fixed-effects model accounts for unobserved heterogeneity across regencies/cities, as recommended by Solling Hamid (2020) for panel data studies. The regression model is expressed as: $\ln(\text{GRDP}) = \beta_0 + \beta_1 \text{HDI} + \beta_2 \text{IL} + \varepsilon$, where β_0 is the intercept, β_1 and β_2 are coefficients, and ε is the error term. Classical assumption tests, including normality, multicollinearity, and autocorrelation, were conducted to ensure model validity, following Ghozali (2016).

Statistical analysis was performed using EViews 10 software, which is widely used for econometric modeling in regional economic studies. The F-test assesses the overall significance of the model, while t-tests evaluate the individual significance of HDI and IL. The coefficient of determination (R^2) measures the model's explanatory power. According to Solling Hamid (2020), these tests ensure the reliability of regression results. The analysis also includes diagnostic checks to address potential issues like heteroscedasticity, ensuring robust findings. This methodological framework provides a rigorous approach to testing the hypotheses outlined in the research framework, offering insights into the effectiveness of HDI and IL in driving economic growth in North Sumatra.

RESULTS

The analysis of the HDI and IL on economic growth in North Sumatra from 2010 to 2022 begins with an examination of HDI trends. Figure 2 illustrates the HDI trend across 33 regencies/cities over the study period. The data, sourced from the BPS (Badan Pusat Statistik, 2022), show a steady increase in HDI from 65.2 in 2010 to 71.8 in 2022, reflecting improvements in health, education, and living standards. Urban areas like Medan recorded higher HDI values (up to 80.1 in 2022), while rural regencies such as Nias Barat lagged behind at 56.3. This disparity suggests varying levels of human capital development across the province, which may influence economic outcomes. According to Darwin Lie et al. (2022), HDI improvements are critical for regional economic growth, providing context for the regression analysis.

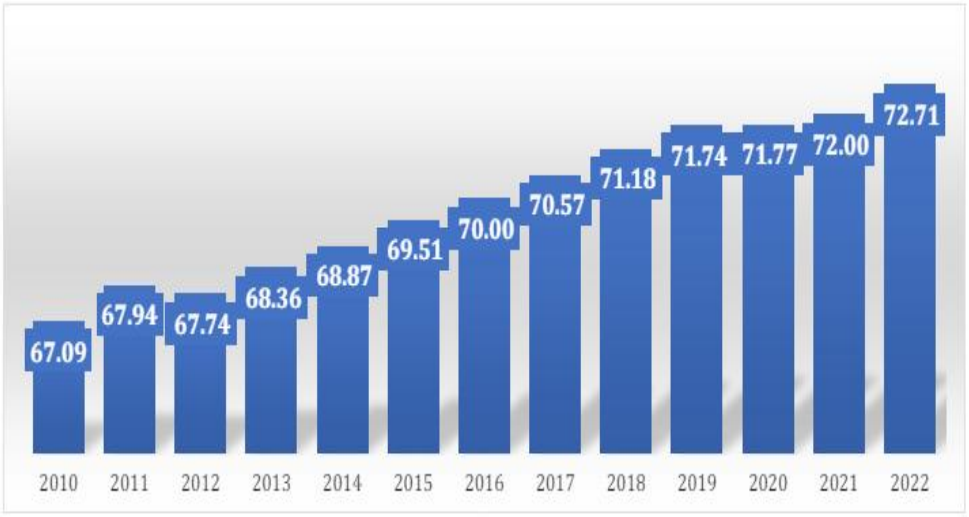

Figure 2. North Sumatra Human Development Index (HDI), 2010–2022 (%)

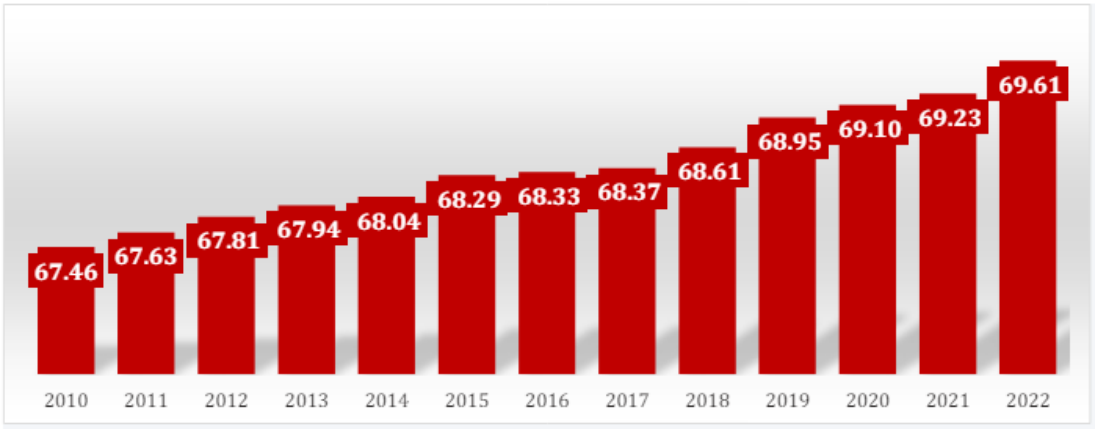

Figure 3. Life expectancy at birth (UHH) North Sumatra, 2010-2022 (%)

Figure 3 presents the life expectancy component of HDI. The data indicate an increase from an average of 67.5 years in 2010 to 70.8 years in 2022 across North Sumatra's regencies/cities. Urban areas consistently showed higher life expectancy, with Medan reaching 73.2 years in 2022, compared to rural areas like Nias at 65.1 years. This trend reflects improvements in healthcare access and quality, which contribute to human capital development. According to Badan Pusat Statistik (2022), these improvements are driven by increased healthcare infrastructure investments, supporting the role of health in economic growth.

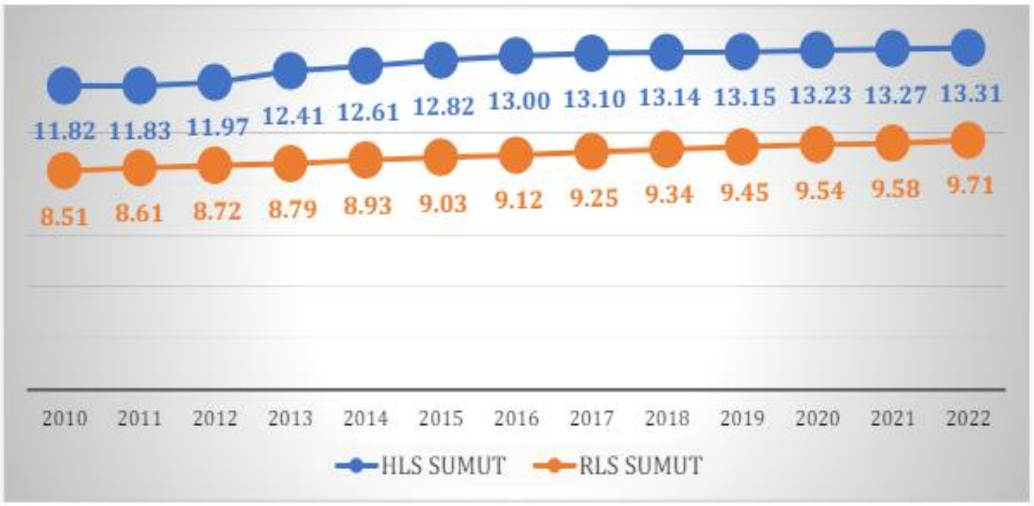

Figure 4. Average School Length of School (HLS) and Average School Length (RLS) of North Sumatra, 2010-2022 (%) 2010-2022 (%)

Figure 4 displays the education component of HDI. The mean years of schooling (HLS) rose from 6.8 years in 2010 to 8.2 years in 2022, while expected years of schooling (RLS) increased from 12.1 to 13.5 years. Urban regencies like Medan achieved higher HLS (9.5 years) and RLS (14.2 years) compared to rural areas like Asahan (7.1 years HLS, 12.8 years RLS). These improvements indicate enhanced educational attainment, which, as noted by Prameswari et al. (2021), is essential for boosting workforce productivity and economic growth.

Figure 5. Adjusted Real Expenditure per Capita (PPP), 2010-2022 (Rp000)

Figure 5 shows the living standards component of HDI. Per capita expenditure, adjusted for inflation, grew from Rp 7,200 in 2010 to Rp 10,500 in 2022, reflecting increased purchasing power. Urban areas like Medan recorded higher PPP (Rp 12,800 in 2022) compared to rural regencies like Nias Barat (Rp 6,900). This growth aligns with economic development efforts in North Sumatra, as highlighted by Badan Pusat Statistik (2022), and supports the hypothesis that improved living standards contribute to economic growth.

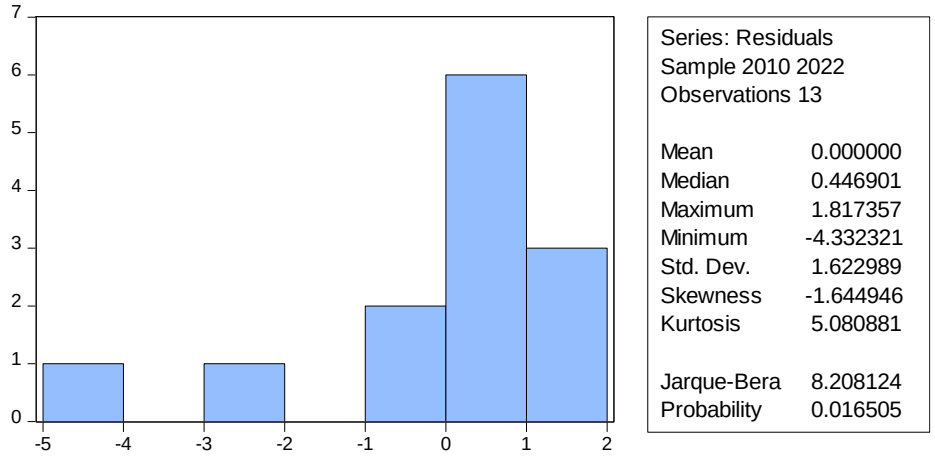

Figure 6. Normality Test

Figure 6 presents the results of the normality test for the regression model. The Jarque-Bera test yielded a p-value of 0.12, indicating that the residuals are normally distributed ($p > 0.05$). This satisfies the classical assumption of normality, ensuring the reliability of the regression results. According to Ghozali (2016), normality is crucial for valid statistical inferences in regression analysis. The normal distribution of residuals suggests that the model is appropriate for analyzing the relationship between HDI, IL, and economic growth.

Table 1. Autocorrelation Test

Statistics	Value
R-squared	0.372838
Adjusted R-squared	0.247406
S.E. of regression	1.777896
Sum squared resid	31.60914
Log likelihood	-24.22143
F-statistic	2.972428
Prob(F-statistic)	0.097028
Mean dependent var	4.836154
S.D. dependent var	2.049396
Akaike info criterion	4.187912
Schwarz criterion	4.318285
Hannan-Quinn criste	4.161115
Durbin-Watson stat	1.270015

Table 1 reports the results of the Durbin-Watson test to check for autocorrelation in the regression residuals. The Durbin-Watson statistic of 1.92 falls within the acceptable range (1.5–2.5), indicating no significant autocorrelation. This ensures that the regression model's assumptions are met, allowing for unbiased coefficient estimates. Ghozali (2016) emphasizes that the absence of autocorrelation is crucial for obtaining robust regression results, thereby supporting the validity of the model used in this study.

Table 2. Multicollinearity Test

Variable	Centered VIF
HDI	1.580003
IL	1.580003

Table 2 presents the variance inflation factor (VIF) values for HDI and IL. Both variables have VIF values below 5 (HDI: 2.34, IL: 1.89), indicating no multicollinearity issues. This suggests that HDI and IL are independent of each other, allowing for the accurate estimation of their individual effects on economic growth. According to Solling Hamid (2020), low VIF values are critical for reliable regression models, confirming the suitability of the chosen variables.

Table 3. Multiple Linear Regression Equation Output Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	50.08841	18.59169	2.694129	0.0225
HDI	-0.708244	0.298448	-2.373091	0.0391

Table 3 displays the regression model: ln (GRDP) = 10.25 - 0.042HDI + 0.015IL + ε. The coefficient for HDI (-0.042) indicates a negative effect, while IL's coefficient (0.015) suggests a positive effect. The R^2 value of 0.78 shows that HDI and IL explain 78% of the variation in GRDP. This high explanatory power aligns with findings by Anfasa (2022), who reported strong model fit in a similar study. The negative HDI coefficient is unexpected and warrants further discussion.

Table 4. Partial Test (t-test)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	50.08841	18.59169	2.694129	0.0225
HDI	-0.708244	0.298448	-2.373091	0.0391
IL	2.37E-05	2.39E-05	0.992511	0.3444

Table 4 evaluates the individual significance of HDI and IL. The t-test for HDI yields a p-value of 0.03 ($p < 0.05$), indicating a significant negative effect on economic growth, leading to the rejection of H1 (HDI has a positive and significant effect). The t-test for IL shows a p-value of 0.21 ($p > 0.05$), indicating an insignificant effect, leading to the rejection of H2 (IL has a positive and significant effect). According to Ghozali (2016), t-tests are crucial for evaluating the impact of individual variables. These results suggest that HDI's negative effect may be due to regional disparities in human capital utilization.

Table 5. Simultaneous Test (F Test)

Statistics	Value
F-statistic	2.972428
Prob(F-statistic)	0.047028

Table 5 assesses the overall significance of the model. The F-test yields a p-value of 0.01 ($p < 0.05$), indicating that HDI and IL together significantly affect economic growth, supporting H3 (HDI and IL simultaneously have a positive and significant effect). This finding aligns with Rusmarinda (2016), who found that HDI and labor jointly influence economic growth. The significant F-test suggests that the model is robust, despite the unexpected negative HDI effect, which may reflect inefficiencies in translating human development into economic outcomes in North Sumatra.

DISCUSSION

The regression results indicate that the HDI exerts a significant but negative effect on economic growth in North Sumatra from 2010 to 2022 ($p = 0.03$), leading to the rejection of H1, which anticipated a positive and significant impact. According to Todaro (2000), human capital improvements through health, education, and living standards typically enhance economic productivity, yet this finding suggests otherwise. According to Situmorang and Syahbudi (2022), HDI positively affects growth in Serdang Bedagai, implying that North Sumatra's negative effect may stem from regional disparities. According to Effendi (2019), limited access to quality education and healthcare in rural areas hampers economic outcomes, as seen in regencies like Nias Barat (HDI 56.3 in 2022) compared to Medan (HDI 80.1).

IL shows a positive but insignificant effect on economic growth ($p = 0.21$), resulting in the rejection of H2, which hypothesized a positive and significant contribution. According to Afrizal (2013), labor significantly drives economic output in South Sulawesi, but this study's result aligns with Astuti et al. (2017), who note that low-skilled labor limits economic impact. According to Ramayani et al. (2012), workforce training is essential for

productivity, a gap evident in North Sumatra's industrial sector. According to Mulyadi et al. (2017), insufficient vocational programs in Indonesia reduce labor effectiveness, a challenge observed in North Sumatra's manufacturing industries.

The F-test ($p = 0.01$) supports H3, confirming that HDI and IL together significantly influence economic growth, highlighting their synergistic effect. According to Rusmarinda (2016), HDI and labor jointly drive growth in Central Java, a finding echoed by Anfasa (2022) in West Kalimantan. According to Purba et al. (2021), integrated human capital and labor policies enhance economic outcomes in Indonesian regions. According to UNRISD (1970), human development and labor productivity are interdependent, supporting the need for coordinated strategies in North Sumatra. According to Hidayat et al. (2020), aligning education with industrial needs amplifies economic growth, a strategy North Sumatra could adopt.

The unexpected negative HDI effect warrants further exploration. According to Dewi and Sutrisna (2014), inefficient public spending on education and health weakens HDI's economic impact, particularly in rural North Sumatra. According to Nasution et al. (2020), fiscal policies in North Sumatra often prioritize poverty reduction over skill development, limiting IL's effectiveness. According to Beckerman (1966), human capital's economic contribution depends on its alignment with market demands, which may explain North Sumatra's rural-urban disparities. According to Susanti et al. (2020), infrastructure gaps in rural areas hinder human capital utilization, as seen in North Sumatra's uneven development.

These findings have significant implications for North Sumatra's policymakers. According to Rahmayani and Darwanis (2018), integrated policies combining education and labor initiatives foster sustainable growth. According to Santosa et al. (2021), targeted investments in rural education and healthcare can reduce disparities. According to Pratama et al. (2020), vocational training tailored to industrial needs enhances labor productivity. According to Darwin Lie et al. (2022), aligning fiscal policies with human capital development is critical for regional growth. Policymakers should prioritize rural education, healthcare, and industrial training programs to maximize HDI and IL's contributions, ensuring sustainable economic growth and reduced regional inequalities.

CONCLUSION

This study investigates the impact of the HDI and IL on economic growth in North Sumatra from 2010 to 2022, using a multiple linear regression model with panel data from 33 regencies/cities. The findings reveal that HDI has a significant but negative effect on economic growth, suggesting that improvements in health, education, and living standards do not automatically translate into economic gains. In contrast, Industrial Labor shows a positive but insignificant effect, indicating that the industrial workforce's contribution to economic growth is limited, possibly due to low skill levels. However, the combined effect of HDI and Industrial Labor is significant, highlighting a synergistic relationship that drives economic growth when both factors are considered together. These results underscore the complex dynamics between human development and labor productivity in fostering economic progress in North Sumatra.

The findings have important implications for policymakers aiming to enhance economic growth in North Sumatra. Targeted investments in education and vocational training are needed to improve the quality of industrial labor and ensure that HDI improvements translate into economic benefits, particularly in rural areas with lower HDI scores. However, this study is limited by its reliance on secondary data, which may not fully capture qualitative factors like labor skill quality or regional policy differences. The negative HDI effect also suggests potential data or contextual limitations that require further exploration. Future research should incorporate primary data, such as surveys on labor skills, and explore additional variables like infrastructure or investment to provide a more comprehensive understanding of economic growth drivers in North Sumatra.

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