

THE EFFECT OF DEMOGRAPHIC TRANSITION AND HUMAN CAPITAL QUALITY ON ECONOMIC GROWTH IN INDONESIA

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Abstract

This study aims to analyze the effect of demographic transition and human capital quality on Indonesia's economic growth within the framework of the economic growth theory proposed by Robert Solow (1956). Demographic transition is characterized by changes in the population age structure, particularly the increase in the proportion of the productive-age population, which has the potential to create a demographic bonus. However, the impact of the demographic bonus on economic growth largely depends on the quality of human resources. The variables used in this study include the population aged 0–14 years, 15–64 years, 65+ years, and the Human Development Index (HDI) as a proxy for human capital quality, with economic growth as the dependent variable. This study employs Indonesian time series data from 1990–2024 and applies the Autoregressive Distributed Lag (ARDL) approach to identify both short-run and long-run relationships among variables. The results indicate that, in the long run, an increase in the productive-age population has a positive and significant effect, while HDI has a negative and insignificant effect on Indonesia's economic growth, whereas the non-productive-age population tends to have a negative effect. In the short run, the effects of the variables are fluctuating, reflecting the adjustment process toward long-run equilibrium. These findings confirm that the success of demographic transition in promoting economic growth does not occur automatically, but requires improvements in human capital quality so that the demographic bonus can be optimally utilized to achieve sustainable economic growth.

Keywords: demographic transition, demographic bonus, human capital, economic growth, ARDL.

INTRODUCTION

Economic growth remains a primary indicator for evaluating a country's development performance, as it reflects the economy's ability to continuously increase the output of goods and services (Marcal et al., 2024). An increase in real Gross Domestic Product (GDP) indicates an expansion of economic activity associated with labor productivity, investment, and the quality of human capital (Ivić, 2024). Over the past several decades, Indonesia has demonstrated relatively stable economic growth, although certain periods experienced contractions due to the 1998 Asian Financial Crisis and the COVID-19 pandemic in 2020 (World Bank, 2025a). These fluctuations suggest that national economic growth is influenced by dynamic structural factors, including changes in population composition and the quality of human capital.

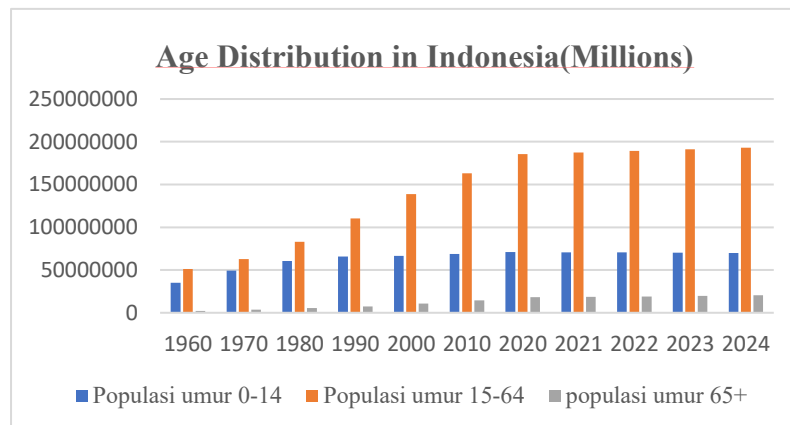


Figure 1. Population (Millions of People) 1990-2024

Changes in the population age structure have become an important issue in the modern economic development literature. Indonesia is currently experiencing a demographic transition characterized by an increasing proportion of the working-age population relative to the non-working-age population (Coale, 1987). This condition creates an opportunity for a demographic dividend, which has the potential to enhance national productivity through the expansion of the labor force and increased production capacity (Setiawan, 2019). Population data indicate that the number of working-age individuals has continued to rise, reaching more than 193 million people in 2024 (World Bank, 2025b), while the elderly population has also increased significantly (World Bank, 2025c). The growth of the working-age population can serve as a source of economic growth when supported by adequate labor quality. However, without sufficient human capital development, the demographic dividend may instead become a social and economic burden, leading to higher unemployment, greater income inequality, and lower labor productivity (Wardani, 2024).

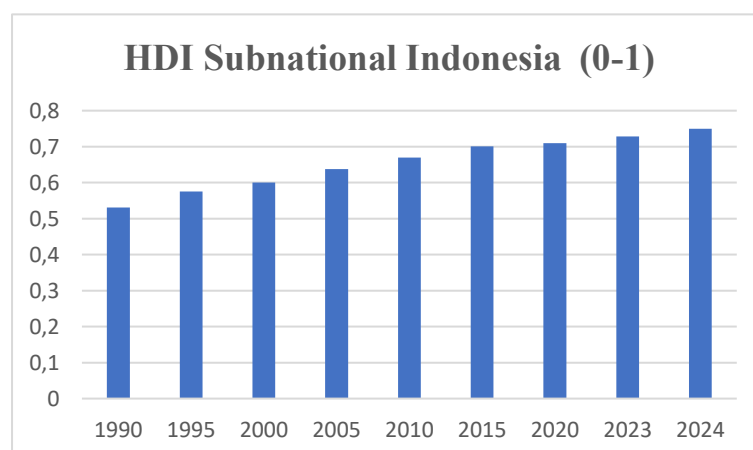


Figure 2. Human Development Index 1990-2024

Human capital quality is a strategic factor in determining the successful utilization of the demographic dividend. Endogenous growth theory emphasizes that education, health, and skills are the key components that drive long-term productivity and economic innovation (Romer, 1994). The improvement in Indonesia's Human Development Index (HDI) during the 1990–2024 period indicates significant progress in human development, particularly in the areas of education

and health (Global Data Lab, 2023). However, these improvements have not been fully accompanied by proportional increases in labor productivity and economic competitiveness across the country. Disparities in educational quality, workforce skills, and the mismatch between labor competencies and labor market demands continue to pose major challenges to Indonesia's economic development (Arwani et al., 2023).

Studies on the relationship between demographic transition and economic growth have expanded considerably; however, the empirical findings remain inconclusive. Several studies have found that an increase in the working-age population positively affects economic growth through the expansion of the labor force and improvements in aggregate productivity (Bawazir & Nor, 2023; Cruz & Ahmed, 2018). In contrast, other studies suggest that increases in both youth and old-age dependency ratios can hinder economic growth due to the rising social and fiscal burdens imposed on the government (Chishti, 2022; Thanh Trong et al., 2024). Research on human capital quality has also produced mixed results, particularly regarding the effectiveness of the Human Development Index (HDI) in promoting long-term economic growth in developing countries (Arwani et al., 2023; Wardani, 2024). Another limitation of previous studies is the lack of research that simultaneously integrates population age structure and human capital quality variables using both short-run and long-run analytical approaches, especially within the context of Indonesia.

The novelty of this study lies in the integration of demographic transition variables and human capital quality within a single empirical framework to explain Indonesia's economic growth using the Autoregressive Distributed Lag (ARDL) approach. This study not only examines the effects of the young population (0–14 years), working-age population (15–64 years), and elderly population (65 years and above) on economic growth, but also incorporates the Human Development Index (HDI) as an indicator of human capital quality within the same analytical framework. The ARDL approach enables the identification of both short-run and long-run relationships simultaneously, thereby providing a more comprehensive understanding of Indonesia's economic dynamics during the demographic transition period.

The theoretical contribution of this study lies in strengthening the economic development literature that recognizes demographic structure and human capital quality as important determinants of long-term economic growth. This research extends demographic transition theory and human capital theory by providing empirical evidence from a developing country currently experiencing a demographic dividend. The practical contribution of this study lies in its policy implications for the government, particularly in formulating development strategies focused on improving labor quality, strengthening education and healthcare systems, and managing the ageing population in a sustainable manner. Enhancing human capital quality and optimizing the productive workforce are essential prerequisites for ensuring that the demographic dividend contributes to inclusive and sustainable economic growth in Indonesia.

LITERATURE REVIEW AND HYPOTHESIS FORMULATION

1. Economic Growth Theory

Economic growth refers to the process of increasing a country's productive capacity, which is reflected in the long-term growth of national output. Classical growth theory identifies capital accumulation, labor, and technological progress as the primary determinants of economic growth. Solow (1956) explained that economic growth is influenced by capital accumulation and labor force growth, while endogenous growth theory emphasizes the importance of human capital quality and innovation in promoting sustainable economic productivity (Romer, 1994). Stable economic growth reflects a country's ability to manage its resources efficiently, thereby enhancing the welfare and living standards of its population.

The endogenous growth approach places greater emphasis on the quality of human capital as a strategic factor of production. Education, health, and workforce skills play essential roles in enhancing productivity and a country's capacity for innovation (Mankiw, 2011). Countries with

high-quality human capital tend to possess stronger economic competitiveness than those with lower levels of human capital development. This relationship indicates that economic growth is influenced not only by the quantity of labor available but also by the quality of the workforce itself.

2. Demographic Transition Theory

Demographic transition theory explains the shift in population structure from high birth and death rates to low birth and death rates as a consequence of economic and social development (Coale, 1987). This transition results in an increasing proportion of the working-age population, a phenomenon commonly referred to as the demographic dividend. A demographic dividend can create opportunities for economic growth when the expansion of the working-age population is accompanied by job creation, improvements in education, and enhanced labor productivity (Siburian et al., 2025).

An increase in the working-age population has the potential to stimulate economic growth through the expansion of the labor force and national production capacity. Research by Cruz and Ahmed (2018) demonstrates that the demographic dividend contributes positively to economic growth in developing countries through improvements in productivity and domestic investment. Similarly, Bawazir and Nor (2023) found that the working-age population has a significant impact on economic growth, as this age group serves as the primary driver of economic activity and household consumption.

The young and elderly population groups possess economic characteristics that differ significantly from those of the working-age population. Young individuals tend to increase the economic dependency burden because they are generally not yet capable of generating income independently (Chishti, 2022). Likewise, the elderly population may exert downward pressure on economic growth due to rising social expenditures and declining labor productivity (Thanh Trong et al., 2024). An imbalanced population age structure can lead to higher fiscal burdens for the government and reduce long-term economic efficiency.

3. Human Capital Theory

Human capital theory explains that investments in education, health, and skills can enhance individual productivity, thereby contributing to national economic growth (Becker, 1994). Human capital is viewed as an economic asset that improves labor efficiency and innovative capacity. Improvements in human capital quality enable the workforce to adapt to technological advancements and changes in the global economic structure.

The Human Development Index (HDI) is widely used as an indicator of human capital quality, reflecting achievements in the dimensions of education, health, and a decent standard of living. An increase in HDI indicates improvements in human resource quality that have the potential to enhance economic productivity. Arwani et al. (2023) found that HDI has a positive effect on economic growth, as better human capital quality can improve production efficiency and national competitiveness. Similarly, Wardani (2024) demonstrated that improvements in human capital quality make a positive contribution to long-term economic growth in Indonesia.

4. Relationship Between Demographic Transition and Economic Growth

The relationship between demographic transition and economic growth can be explained through changes in the population age structure, which influence national productivity. An increase in the working-age population can expand production and consumption capacity, thereby stimulating economic growth. This condition creates opportunities for higher domestic savings, increased investment, and capital accumulation, provided that the labor market is able to absorb the workforce effectively (Setiawan, 2019).

However, this relationship does not always produce positive outcomes, as the effectiveness of the demographic dividend depends heavily on the quality of human resources and the economic policies implemented by the government. Countries that fail to improve workforce quality tend to face rising unemployment and greater social inequality, even when they have a

large working-age population (Setiawan, 2019). Moreover, a demographic structure dominated by non-working-age groups can increase the dependency ratio and exert downward pressure on long-term economic growth.

5. Relationship Between Human Capital and Economic Growth

Human capital quality is closely associated with economic growth through its role in enhancing labor productivity and production efficiency. Better education and healthcare enable workers to generate higher levels of output while also improving their ability to adapt to technological changes (Romer, 1994). Improvements in human capital quality also foster innovation, which has become a crucial driver of modern economic growth.

Empirical studies indicate that countries with higher levels of human development tend to experience more stable and sustainable economic growth. The Human Development Index (HDI) serves as an important indicator for evaluating human capital quality because it reflects the ability of individuals to access education, healthcare services, and a decent standard of living (UNDP, 2025). The positive relationship between HDI and economic growth suggests that human development is a fundamental component of long-term economic development.

6. Hypothesis Formulation

Population age structure is one of the demographic factors that can influence economic growth through changes in the composition of productive and non-productive populations. The young population group (0–14 years old) is generally still in the dependency stage; therefore, an increase in its proportion may raise the dependency ratio and reduce the allocation of resources for productive activities. Munir and Shahid (2021) found that the youth dependency ratio has a significant negative effect on economic growth in South Asian countries. Similarly, Abbas et al. (2024), in their study of SAARC countries, reported that the non-productive young population negatively affects economic growth because it does not yet generate economic output and tends to increase the consumption burden on society.

The working-age population (15–64 years old) has the potential to become a major source of economic growth through higher labor force participation, productivity, and production capacity. An increase in the proportion of the working-age population is often associated with a demographic dividend that can stimulate economic growth when supported by adequate human capital quality and employment opportunities. Bawazir and Nor (2023) found that the working-age population has a positive and significant effect on economic growth in both the short run and the long run. This finding is supported by Cruz and Ahmed (2018), who demonstrated that an increase in the proportion of the working-age population is positively correlated with growth in GDP per capita.

The population aged 65 years and above has the potential to increase the old-age dependency ratio, thereby adding to the economic burden borne by the working-age population. Munir and Shahid (2021) showed that the old-age dependency ratio has a negative effect on economic growth in both the short and long run. Liu et al. (2023) found that population ageing negatively affects economic growth through increased healthcare expenditures, pension costs, and other social welfare burdens. Likewise, Khachatryan et al. (2023) confirmed that a higher elderly dependency ratio can reduce an economy's ability to achieve sustainable growth.

Human capital quality, proxied by the Human Development Index (HDI), is an important factor in enhancing productivity and the economic capacity of society. Improvements in education, health, and living standards can strengthen workforce capabilities while promoting innovation and economic efficiency. Wardani (2024) found that HDI has a positive and significant effect on economic growth. Adiwicaksana and Marseilla (2025) demonstrated that improvements in HDI can increase regional gross domestic product (GRDP) in the long run, while Arwani et al. (2023) found that higher HDI contributes to poverty reduction and improvements in social welfare. These findings indicate that human capital quality plays a crucial role in promoting economic growth.

Based on the theoretical framework and findings from previous studies, the research hypotheses are formulated as follows:

H1: The young population has a negative effect on economic growth in Indonesia in the short run.

H2: The young population has a negative effect on economic growth in Indonesia in the long run.

H3: The working-age population has a positive effect on economic growth in Indonesia in the short run.

H4: The working-age population has a positive effect on economic growth in Indonesia in the long run.

H5: The elderly population has a negative effect on economic growth in Indonesia in the short run.

H6: The elderly population has a negative effect on economic growth in Indonesia in the long run.

H7: The Human Development Index (HDI) has a positive effect on economic growth in Indonesia in the short run.

H8: The Human Development Index (HDI) has a positive effect on economic growth in Indonesia in the long run.

RESEARCH METHODS

This study employs a quantitative approach with an explanatory research design aimed at analyzing the effects of demographic transition and human capital quality on economic growth in Indonesia. The quantitative approach is selected because the study focuses on examining the relationships among variables through statistical and econometric analyses using annual time-series data. The analysis is conducted to identify both short-run and long-run effects of the independent variables on the dependent variable during the observation period from 1990 to 2024.

The object of the study is economic growth as the dependent variable, while the independent variables consist of the young population (0–14 years), the working-age population (15–64 years), the elderly population (65 years and above), and the Human Development Index (HDI). Economic growth is proxied by annual Gross Domestic Product (GDP) growth, whereas the demographic variables are measured based on the population size of each age group. The Human Development Index is used as an indicator of human capital quality because it reflects the dimensions of education, health, and living standards.

This study utilizes annual secondary time-series data covering the period from 1990 to 2024, resulting in a total of 35 observations. The data are obtained from reliable and authoritative sources, namely the World Bank and the Global Data Lab. Economic growth data are derived from Indonesia's annual GDP growth indicator, while data on the young, working-age, and elderly populations are obtained from the World Bank population database. Human Development Index data are sourced from the Global Data Lab, which provides consistent and measurable human development statistics. The use of secondary data enables the study to obtain objective, standardized, and highly reliable information, thereby supporting the accuracy and credibility of the research findings.

Data were collected using the documentation method by accessing official publications and databases available online. The collected data were then organized into annual time-series format and analyzed using EViews version 9. The use of this software facilitates the process of econometric estimation, statistical testing, and interpretation of relationships among the research variables. Data analysis in this study employs the Autoregressive Distributed Lag (ARDL) approach. The ARDL method was selected because it is capable of estimating both short-run and long-run relationships simultaneously and can be applied to data with different orders of integration,

namely $I(0)$ and $I(1)$, provided that none of the variables are integrated at order $I(2)$ (Ghouse et al., 2021). The analysis begins with a stationarity test using the Augmented Dickey–Fuller (ADF) test to determine the integration order of each variable. The next stage involves selecting the optimal lag length based on the Akaike Information Criterion (AIC) in order to obtain the most appropriate estimation model.

Long-run relationship testing was conducted using the ARDL Bounds Testing approach to determine the existence of cointegration among the research variables. The calculated F-statistic value was compared with the critical bounds values at a specified level of significance. If the F-statistic exceeded the upper bound value, the variables were considered to have a long-run relationship.

The ECM was employed to identify the speed of adjustment toward long-run equilibrium following short-run disturbances. This model provides information on how quickly deviations from the long-run equilibrium are corrected, thereby allowing the system to return to its equilibrium path over time.

The short-run relationship is estimated through the Error Correction Model (ECM), which can be expressed as follows:

$$\Delta PE_t = \alpha + \sum_{i=1}^p \gamma_1 \Delta GDP_{t-i} + \sum_{j=0}^q \gamma_2 \Delta PUM_{t-j} + \sum_{k=0}^r \gamma_3 \Delta PUP_{t-k} + \sum_{l=0}^s \gamma_4 \Delta PUT_{t-l} + \sum_{n=0}^v \gamma_5 \Delta HDI_{t-n} + \lambda ECT_{t-1} + \mu_t$$

Δ = Delta, representing the change in value from the previous period (first difference)

PDB_t = Economic Growth

PUM_t = Young Population (Aged 0–14 Years)

PUP_t = Working-Age Population (Aged 15–64 Years)

PUT_t = Elderly Population (Aged 65 Years and Above)

HDI_t = Human Development Index

a_t = Constant Term

$\gamma_1, \gamma_2, \gamma_3, \gamma_4$ = Short-Run Coefficients

ECT_{t-1} = Error Correction Term

μ_t = Residual

The long-run model used in this study is specified as follows:

$$GDP_t = a + \beta_1 PUM_t + \beta_2 PUP_t + \beta_3 PUT_t + \beta_4 HDI_t + \mu_t$$

PDB_t = Economic Growth

PUM_t = Young Population (Aged 0–14 Years)

PUP_t = Working-Age Population (Aged 15–64 Years)

PUT_t = Elderly Population (Aged 65 Years and Above)

HDI_t = Human Development Index

a_t = Constant Term

$\beta_1, \beta_2, \beta_3, \beta_4$ = Long-Run Coefficients

μ_t = Residual

The coefficient of the Error Correction Term (ECT) indicates the speed at which the model adjusts toward long-run equilibrium following a short-run shock. A negative and statistically significant ECT coefficient suggests that the model possesses a valid adjustment mechanism that restores equilibrium in the long run. Classical assumption tests were conducted to ensure that the regression model satisfies the criteria of the Best Linear Unbiased Estimator (BLUE). The normality test was performed using the Jarque–Bera test to examine the distribution of the model residuals. The Breusch–Pagan–Godfrey test was employed to detect heteroskedasticity and verify whether the residual variance remained constant. Autocorrelation was examined using the Breusch–

Godfrey Serial Correlation LM test to identify any correlation among residuals across time periods. Model stability was assessed using the CUSUM and CUSUM of Squares (CUSUMSQ) tests to ensure the consistency of model parameters throughout the study period.

The scope of this study is limited to analyzing the effects of demographic transition and human capital quality on Indonesia's economic growth during the period 1990–2024. This study does not incorporate other macroeconomic factors such as inflation, foreign investment, government expenditure, or international trade. Therefore, the interpretation of the findings is focused specifically on the relationship between demographic variables, human capital quality, and national economic growth.

RESULTS AND DISCUSSION

Descriptive Analysis

Descriptive statistics are used to provide a general overview of the characteristics of the research data based on a total of 35 observations. The variables analyzed include Gross Domestic Product (GDP), the population aged 0–14 years, the population aged 15–64 years, the population aged 65 years and above, and the Human Development Index (HDI). The population variables (0–14, 15–64, and 65+ years) as well as the HDI variable were transformed into their natural logarithmic forms prior to analysis.

The descriptive statistics presented in Table 4.1 indicate that the GDP variable has a mean value of 4.72%, suggesting that the Indonesian economy generally experienced positive growth during the study period. However, the median value is slightly higher at 5.07%, indicating that more than half of the observations recorded economic growth above the average level. A notable feature of the data is the minimum GDP value of -13.13%, which reflects a substantial economic contraction during a particular period, most likely associated with a major economic crisis or the COVID-19 pandemic. The presence of this extreme value contributes to the non-normal distribution of the GDP variable, as evidenced by the Jarque–Bera probability value of 0.000, which is below the 0.05 significance level.

Table 1. Descriptive Statistical Analysis of the Research Data

Description	GDP	0-14 years	15-64 years	65+ years	HDI
<i>Mean</i>	4.723	18.038	18.843	16.370	4.162
<i>Median</i>	5.070	18.030	18.864	16.418	4.172
<i>Maximum</i>	8.220	18.079	19.078	16.843	4.317
<i>Minimum</i>	-13.130	18.002	18.518	15.817	3.972
<i>Std. Dev.</i>	3.612	0.027	0.167	0.294	0.098
<i>Jarque-Bera</i>	434.849	4.104	2.331	2.019	2.280
<i>Probability</i>	0.000	0.128	0.311	0.364	0.319
<i>Observations</i>	35	35	35	35	35

Source: Processed by the author using EViews 9.

Regarding the population age groups, the average proportion of the population aged 0–14 years was 18.04%, while the working-age population (15–64 years) and the elderly population (65 years and above) averaged 18.84% and 16.37%, respectively. These three age-group variables exhibit very small standard deviations, indicating that the population proportions within each age group remained relatively stable throughout the study period. It is noteworthy that the elderly population (65+ years) has the largest standard deviation among the three groups, suggesting a gradual increase in the elderly population over time. All three age-group variables are normally distributed, as indicated by their respective Jarque–Bera probability values, which are greater than 0.05.

The HDI variable has a mean value of 4.16 and a relatively small standard deviation of 0.098, indicating that human development progressed steadily throughout the study period without significant fluctuations. This variable is also normally distributed, with a Jarque–Bera probability value of 0.320. Overall, nearly all variables are normally distributed except for GDP. However, this does not pose a problem in ARDL analysis, since the primary concern is the normality of the model residuals rather than the individual variables themselves. Furthermore, all variables contain complete data for the 35 observations, with no missing values, indicating that the dataset is suitable for further analysis.

Data Analysis Method

Data analysis in this study employs the Autoregressive Distributed Lag (ARDL) approach using annual time-series data covering a 35-year period from 1990 to 2024. The ARDL method is utilized to examine both the short-run and long-run relationships among the research variables, taking into account differences in the stationarity levels of the variables at both the level and first-difference forms. The analytical procedure consists of several stages, including the stationarity test, optimal lag selection, Bounds Test for cointegration, ARDL estimation, classical assumption testing, and the determination of the best-fitting model.

1. Stationarity Test

The stationarity test in this study was conducted using the Augmented Dickey–Fuller (ADF) method. In the ADF test, stationarity is determined based on the probability value, where a variable is considered stationary if its probability value is less than 0.05. The results of the ADF test presented in Table 2 indicate that the variables representing the population aged 65 years and above (65+) and the Human Development Index (HDI) are not stationary at the level form but become stationary after being transformed into their first differences. In contrast, the GDP variable, the population aged 0–14 years, and the population aged 15–64 years are already stationary at the level form.

Table 2. Stationarity Test Using the Augmented Dickey–Fuller (ADF) Method

Variable	Metode	Level/I(0)	Prob.	First Difference/I(1)	Prob.
GDP	ADF	significant	0.0018	significant	0.0000
0-14 years	ADF	significant	0.0210	significant	0.0247
15-64 years	ADF	significant	0.0046	Not significant	0.2105
65+ years	ADF	Not significant	0.9617	Description	0.0023
HDI	ADF	Not significant	0.4601	Description	0.0003

Source: Processed by the author using EViews 9.

The stationarity test was conducted using the Augmented Dickey–Fuller (ADF) test to ensure that the research variables do not contain a unit root at the second-order integration level, I(2). The test results indicate that some variables are stationary at the level form, or I(0), while others become stationary after first differencing, or I(1). No variable was found to be integrated of order two. Therefore, the ARDL model is appropriate for use in this study, consistent with the approach developed by (Brooks, 2014).

2. Optimal Lag Selection

Determining the optimal lag length is an important step in ARDL model estimation to accurately capture short-run dynamics and avoid model specification errors. Lag selection was

carried out by comparing several alternative model specifications using the Akaike Information Criterion (AIC), Schwarz Bayesian Criterion (BIC), and Hannan–Quinn Criterion (HQ). The best model was selected based on the lowest information criterion value. In this study, the maximum lag length considered was four.

Table 3. Comparison of Alternative Models Based on the Akaike Information Criterion (AIC)

ARDL Model Specification	AIC	BIC	HQ	Description
ARDL(1, 4, 4, 4, 4)*	4.674	5.691	5.006	Lowest AIC Value
ARDL(1, 3, 4, 4, 4)	4.712	5.684	5.029	Higher AIC Value
ARDL(1, 4, 3, 4, 4)	4.718	5.689	5.035	Higher AIC Value
ARDL(1, 3, 3, 4, 4)	4.719	5.645	5.021	Higher AIC Value

terpilih Note: *Selected optimal lag.

Source: Processed by the author using EViews 9.

Based on the results of the optimal lag selection presented in Table 3, the ARDL(1, 4, 4, 4, 4) model was identified as the best specification because it produced the lowest Akaike Information Criterion (AIC) value, namely 4.674, compared with the alternative model specifications. A lower AIC value indicates that the model provides a better fit in explaining the relationships among the variables while maintaining a lower estimation error. Furthermore, the ARDL(1, 4, 4, 4, 4) model is considered to offer an optimal balance between model parsimony and the ability to capture the underlying dynamics of the data. As a result, it minimizes the risks of both overfitting and underfitting. Therefore, the ARDL(1, 4, 4, 4, 4) specification was selected as the most appropriate model for further analysis in estimating the short-run and long-run relationships among the research variables.

3. Cointegration Test (Bounds Test)

To identify the existence of a long-run relationship among the variables in the ARDL model, a cointegration test was conducted using the Bounds Test approach. This test aims to determine whether a long-run equilibrium relationship exists among the variables and to assess the feasibility of estimating an Error Correction Model (ECM). Cointegration is a fundamental requirement for long-run analysis; if no cointegration relationship is detected, the analysis can only be conducted on the short-run dynamics among the variables.

Table 4. ARDL Bounds Test for Cointegration Results ($\alpha = 5\%$)

Test Statistic	Value
F- statistik Bound-test	11.14043
Lower Bound Critical Value I(0)	2.86
Upper Bound Critical Value I(1)	4.01

Source: Processed by the author using EViews 9.

Based on the results of the Bounds Test for cointegration presented in Table 4.4, the calculated F-statistic is 11.14043. This value exceeds the upper critical bound value, I(1), at the 5% significance level, which is 4.01. Since the F-statistic is greater than the I(1) critical value, the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted. This result indicates the existence of a cointegration relationship, or long-run equilibrium relationship, between the dependent variable and the independent variables included in the model. Therefore, the ARDL model satisfies the necessary condition for estimating long-run relationships and constructing an Error Correction Model (ECM). The presence of cointegration further suggests that, although short-run fluctuations may occur, the variables tend to move together and converge toward a stable long-run equilibrium over time.

4. Model Diagnostic Tests

a. Autocorrelation Test

The autocorrelation test was conducted to ensure that the residuals in the ARDL model are not correlated across time periods. A model that is free from autocorrelation produces efficient parameter estimates and allows for reliable statistical interpretation. The results of the autocorrelation test are presented in Table 5.

Table 5. Results of the Autocorrelation Test

Test Statistic	V	Probabilit
	alue	y
F-statistic	2.	0.1101
	422	

Source: Processed by the author using EViews 9.

The results of the autocorrelation test using the Breusch–Godfrey LM test produced an F-statistic probability value of 0.1101, which is greater than the 5% significance level (0.05). This finding indicates that the null hypothesis of no serial correlation cannot be rejected, suggesting that the model does not suffer from an autocorrelation problem. The Breusch–Godfrey LM test was employed because it is particularly suitable for detecting autocorrelation in regression models and is capable of providing more reliable results, especially in dynamic models that include lagged variables. Therefore, it can be concluded that the residuals are free from serial correlation, indicating that the model satisfies the autocorrelation assumption and produces efficient and reliable parameter estimates.

b. Heteroskedasticity Test

To determine whether heteroskedasticity is present in the ARDL model, a heteroskedasticity test was conducted using the Breusch–Pagan method by comparing the probability value of the F-statistic with the critical significance level of 5%.

Table 6. Results of the Heteroskedasticity Test

Test Statistic	Value	Probability
F-statistic	1.66241	0.1860

Source: Processed by the author using EViews 9.

The results of the heteroskedasticity test produced an F-statistic probability value of 0.1860, which is greater than the 5% significance level (0.05). This result indicates that the null hypothesis of homoskedasticity cannot be rejected, suggesting that the model does not suffer from a heteroskedasticity problem. Therefore, it can be concluded that the estimated ARDL model is free from heteroskedasticity, implying that the variance of the residuals remains constant across observations. As a result, the model satisfies the homoskedasticity assumption required for reliable and efficient parameter estimation.

c. Normality Test

The normality test was conducted to determine whether the residuals of the ARDL model are normally distributed. This test is important because the assumption of residual normality is required to ensure the validity of statistical inference and hypothesis testing. The test was performed by comparing the Jarque–Bera probability value with the critical significance level of 5%.

Table 7. Results of the Normality Test

Test Statistic	Value	Probability
Jarque-Bera	0.138330	0.933173

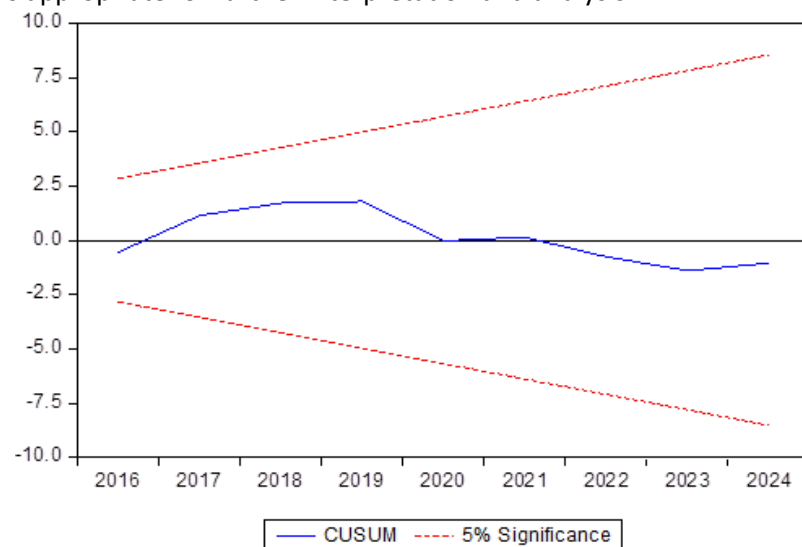
Source: Processed by the author using EViews 9.

The results of the normality test using the Jarque–Bera statistic produced a probability value of 0.933173, which is greater than the 5% significance level (0.05). This result indicates that the residuals of the research model are normally distributed. Therefore, it can be concluded that the estimated ARDL model satisfies the normality assumption, implying that the residuals follow a normal distribution and that the statistical tests conducted within the model are valid and reliable.

d. Model Stability Test

To determine whether the ARDL model remains stable throughout the observation period, stability tests were conducted using the CUSUM Test and the CUSUM of Squares (CUSUMSQ) Test. These tests are intended to assess the stability of the model parameters over the study period and to determine whether the estimated model is consistent and free from structural changes. Based on Figure 8, the results of the CUSUM Test indicate that the CUSUM line remains within the 5% critical bounds (5% significance level). This finding suggests that the research model is stable throughout the observation period and does not experience any significant parameter instability. Therefore, the estimated ARDL model demonstrates satisfactory parameter stability.

Similarly, based on Figure 9, the results of the CUSUM of Squares (CUSUMSQ) Test show that the CUSUMSQ line also remains within the 5% critical bounds. This result indicates that the variance of the model residuals is stable and that no structural breaks occurred during the study period. Consequently, it can be concluded that the estimated ARDL model satisfies the stability requirement and is appropriate for further interpretation and analysis.



Source: Processed by the author using EViews 9

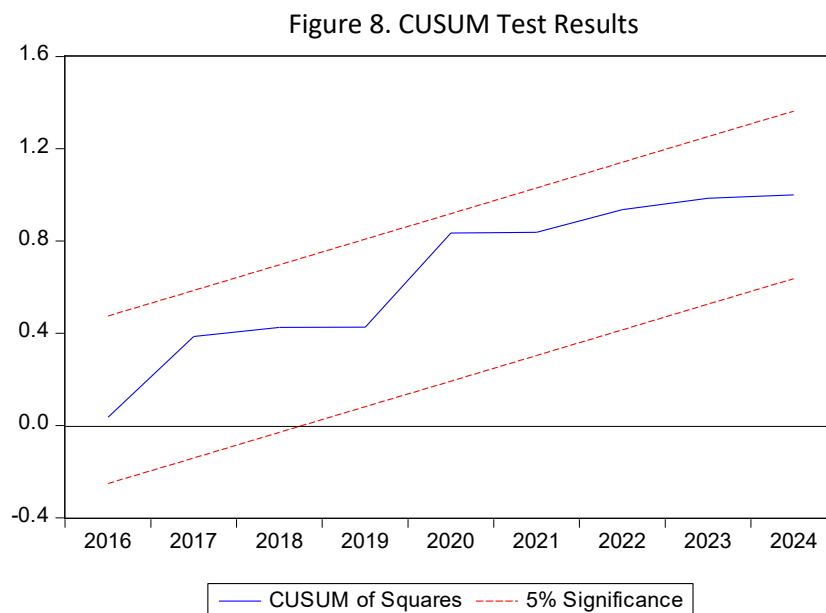


Figure 9. Results of the CUSUM of Squares (CUSUMSQ) Test

5. Parameter Significance Test

The estimation results of the ARDL(1, 4, 4, 4, 4) model indicate that the Error Correction Term (ECT), or CointEq(-1), has a coefficient value of -1.689436 and is statistically significant at the 5% significance level, with a probability value of 0.0000. The negative and significant ECT coefficient indicates the existence of an adjustment process from short-run disequilibrium toward long-run equilibrium.

The coefficient value of -1.689436 implies that approximately 168.94% of the short-run disequilibrium is corrected and adjusted back toward the long-run equilibrium within one period. This adjustment speed can be considered relatively high, particularly because the data used in this study are annual observations. Furthermore, an ECT coefficient with an absolute value greater than one suggests the presence of an overshooting phenomenon, whereby the adjustment process temporarily exceeds the equilibrium point before eventually converging back to the long-run equilibrium.

These findings indicate that the model exhibits a valid long-run relationship among the variables and possesses a strong adjustment mechanism in responding to short-run shocks.

a. t-Statistic Test of the Short-Run Model

The estimation results of the Error Correction Model (ECM) for the short-run model, presented in Table 10, are intended to analyze the short-run adjustment dynamics and the speed of adjustment toward long-run equilibrium between the independent variables and the dependent variable in this study. The short-run estimation results are evaluated using the t-statistic to determine the individual significance of each explanatory variable in influencing economic growth. The following section presents the estimation results of the short-run model based on the t-statistic values.

Table 10. Results of the t-Statistic Test for the Short-Run Model

Variable	Coefficient	t-statistik	Prob.	Description
LN0-14	-4404.529	-1.535	0.1556	Not significant
LN0-14(-1)	7511.925	1.791	0.1035	Not significant
LN15-64	-12201.848	-1.722	0.1158	Not significant
LN15-64(-1)	55975.471	2.454	0.0340	significant

LN15-64(-2)	-3393.512	-0.182	0.8590	Not significant
LN15-64(-3)	-14693.102	-1.386	0.1957	Not significant
LN65+	-52.496	-0.072	0.9437	Not significant
LN65+(-1)	1286.960	0.561	0.5865	Not significant
LN65+(-2)	-1925.463	-0.821	0.4303	Not significant
LN65+(-3)	2093.357	1.335	0.2113	Not significant
LNHDI	944.427	2.245	0.0485	significant
LNHDI(-1)	717.942	3.623	0.0047	significant
LNHDI(-2)	541.719	2.416	0.0363	significant
LNHDI(-3)	547.694	2.758	0.0202	significant
CointEq(-1)*	-1.689	-7.662	0.0000	significant

Source: Processed by the author using EViews 9

The short-run ARDL estimation results indicate that not all demographic transition and human capital quality variables have a significant effect on Indonesia's economic growth. At the 5% significance level, the variables found to have a significant impact are the working-age population aged 15–64 years at the first lag (LN15-64(-1)), the Human Development Index (LNHDI) along with its first to third lags, and the Error Correction Term (ECT). In contrast, the population aged 0–14 years and the population aged 65 years and above, both in the current period and across most of their lagged values, do not exhibit a statistically significant effect on economic growth.

The population aged 0–14 years demonstrates an inconsistent relationship and is not statistically significant. This finding suggests that the young population continues to function primarily as a non-productive group that requires substantial investment in education and healthcare, meaning that its contribution to economic growth cannot yet be realized in the short run. This result is consistent with the findings of de Pereira & Charvet (2025) who argue that the economic benefits of the young population only emerge once individuals enter the working-age group and possess adequate human capital quality.

The working-age population aged 15–64 years does not have a significant effect on economic growth in the current period. However, the first lag of this variable exhibits a positive and statistically significant effect, indicating that the benefits of the demographic dividend require time before contributing optimally to economic activity and national output formation. This finding supports the demographic dividend theory, which argues that an increase in the proportion of the working-age population can become a source of economic growth when accompanied by adequate productivity and human capital quality (de Pereira & Charvet, 2025). Meanwhile, the second and third lagged values do not show statistically significant effects.

The population aged 65 years and above, both in the current period and across all lagged values examined, does not have a significant effect on economic growth. This result suggests that population ageing has not yet become a major factor influencing Indonesia's economic growth dynamics, given that the country's population structure continues to be dominated by the working-age population.

In contrast to the demographic variables, the Human Development Index (HDI) demonstrates a positive and statistically significant effect in the current period as well as up to the third lag. This finding highlights that improvements in education, health, and living standards enhance labor productivity and economic efficiency. The result supports the Human Capital Theory proposed by Becker (1964) and is consistent with the findings of Lutz et al., (2018) who argue that human capital quality plays a more substantial role in promoting economic growth than demographic age structure changes alone.

The negative and statistically significant coefficient of the Error Correction Term (ECT) confirms the existence of an adjustment mechanism toward long-run equilibrium and indicates

the presence of a cointegrating relationship among economic growth, population age structure, and the Human Development Index. The ECT coefficient, which exceeds one in absolute value, suggests that the adjustment process occurs rapidly through an overshooting mechanism before converging back to the long-run equilibrium.

Overall, the short-run estimation results indicate that human capital quality, proxied by the Human Development Index, is the most consistent determinant of Indonesia's economic growth. Meanwhile, the effect of demographic transition is only evident through the working-age population at the first lag. These findings imply that the demographic dividend does not automatically generate higher economic growth unless it is supported by improvements in human capital quality. Therefore, human capital quality emerges as the more dominant factor in driving Indonesia's economic growth in the short run.

b. t-Statistic Test of the Long-Run Model

Based on the ARDL estimation results, the significance of the long-run parameters was evaluated using the t-test to determine the effects of each independent variable, namely demographic transition variables (population aged 0–14 years, population aged 15–64 years, and population aged 65 years and above) and human capital quality (HDI), on economic growth in Indonesia. Parameter significance testing was conducted at the 5% significance level by comparing the calculated t-values (t-statistics) with the critical t-value, as well as by comparing the corresponding p-values with the 5% significance threshold.

To determine the critical t-value, the degree of freedom was calculated based on the total number of observations (35) minus the maximum lag length and the number of estimated parameters. Based on 29 degrees of freedom and a 5% significance level under a two-tailed test, the critical t-value was found to be ± 2.045 . A variable is considered statistically significant if the absolute value of its t-statistic exceeds the critical t-value and its probability value is less than 0.05.

Tabel 11. Hasil Uji t-statsistik Model Jangka Panjang

Variable	Coefficient	t-statistik	Prob.	Description
C	-5809.793	-1.493	0.1661	significant
LN0-14	-474.607	-2.118	0.0602	Not significant
LN15-64	1504.402	2.463	0.0335	significant
LN65+	-852.994	-2.491	0.0319	significant
LNHDI	-465.574	-1.405	0.1902	Not significant

Source: Processed by the author using EViews 9

Based on the long-run ARDL estimation results, the long-run equation for Gross Domestic Product (GDP) employed in this study is specified as follows:

$$GDP_t = -5809.793 + -474.607 LN014_t + 1504.402 LN1564_t + -852.994 LN65_t + -465.574 LNHDI_t \dots\dots\dots(1)$$

This model is classified as a semi-log model because the dependent variable is not expressed in natural logarithmic form, whereas the independent variables are transformed using natural logarithms. To obtain comparable interpretations across variables, the estimated regression coefficients are subsequently transformed into elasticity measures. According to Gujarati (2006), elasticity can be calculated using the following formula:

$$E_{y,x} = \frac{\partial y}{\partial x} \times \frac{x}{y} \dots\dots\dots(2)$$

Thus, for a Lin–Log specification, the elasticity is given by:

$$Y = \beta_0 + \beta_1 \ln X \dots\dots\dots (3)$$

Taking the partial derivative with respect to X yields:

$$\frac{\partial Y}{\partial X} = \beta_1 \cdot \frac{1}{X} \dots\dots\dots (4)$$

Substituting the partial derivative into the elasticity formula yields the following expression:

$$E_{y,x} \approx \frac{\beta_1}{Y} \dots\dots\dots (5)$$

Interpretation of the Long-Run ARDL Model:

1. Constant Term (C). The constant term (C) has a coefficient of -5809.793 with a probability value of 0.1661, which is greater than the 5% significance level. Therefore, the coefficient is not statistically significant. Mathematically, when all independent variables are held constant, long-run economic growth (GDP) is estimated at -5809.793. However, from an economic perspective, the constant term has limited practical interpretation because a situation in which all independent variables are equal to zero is unlikely to occur in reality.
2. Young Population (Aged 0–14 Years). The young population variable (0–14 years) has a coefficient of -474.607, but it is not statistically significant, with a t-statistic of -2.118 and a probability value of 0.0602, which exceeds the 5% significance level. This result suggests that an increase in the proportion of the young population tends to reduce economic growth by 474.607 units; however, this effect cannot be empirically confirmed at the 5% significance level. The finding indicates that the young population has not yet contributed directly to productive economic activities because most individuals in this age group are still engaged in education and have not yet entered the labor market.
3. Working-Age Population (Aged 15–64 Years). The working-age population variable (15–64 years) has a coefficient of 1504.402 and is statistically significant, with a t-statistic of 2.463 and a probability value of 0.0335, which is below the 5% significance level. This implies that an increase in the proportion of the working-age population leads to an increase in economic growth of 1504.402 units, ceteris paribus. The result indicates that a larger working-age population enhances labor force capacity, productivity, and production activities, thereby promoting long-run economic growth. This finding supports the demographic dividend theory, which argues that a higher proportion of working-age individuals can become a source of economic growth when accompanied by adequate employment opportunities and human capital quality.
4. Elderly Population (Aged 65 Years and Above). The elderly population variable (65 years and above) has a coefficient of -852.994 and is statistically significant, with a t-statistic of -2.491 and a probability value of 0.0319, which is below the 5% significance level. This finding indicates that an increase in the proportion of the elderly population reduces economic growth by 852.994 units, ceteris paribus. The result suggests that population ageing decreases the proportion of productive workers and increases the dependency ratio. Consequently, it may raise economic burdens through higher healthcare expenditures, social security costs, and elderly welfare needs, thereby exerting a negative impact on long-run economic growth.

5. Human Development Index (HDI) The Human Development Index (HDI) variable has a coefficient of -465.574, but it is not statistically significant, with a t-statistic of -1.405 and a probability value of 0.1902, which exceeds the 5% significance level. This result suggests that an increase in HDI tends to reduce economic growth by 465.574 units; however, the effect is not statistically significant and therefore cannot be empirically verified. The finding indicates that improvements in human development, reflected through education, health, and living standards, have not directly translated into long-run economic growth during the study period. This may imply that improvements in human capital quality need to be accompanied by higher productivity, greater job creation, and the economy's ability to absorb skilled labor in order to generate a meaningful contribution to long-term economic growth.

c. Uji F-statistik

To evaluate the overall adequacy of the regression model, an F-statistic test was conducted to determine whether the independent variables jointly have a significant effect on the dependent variable. This test assesses the overall significance of the model by examining whether all explanatory variables collectively contribute to variations in economic growth. The results of the F-statistic test are presented in the following table.

Table 4.12. Results of the F-Statistic Test

Description	Value
F-Statistic	3.434458
Prob. (F-Statistic)	0.030466

Source: Processed by the author using EViews 9

Based on the results of the F-statistic test presented in Table 4.12, the calculated F-statistic is 3.434458 with a probability value of 0.030466. At the 5% significance level ($\alpha = 0.05$), the probability value is lower than 0.05, leading to the rejection of the null hypothesis (H_0). This result indicates that the independent variables, namely the young population (0–14 years), the working-age population (15–64 years), the elderly population (65 years and above), and the Human Development Index (HDI), jointly have a statistically significant effect on economic growth (GDP).

Furthermore, the F-statistic exceeds the critical F-value, indicating that the regression model employed in this study is statistically valid for explaining the relationship between the independent variables and the dependent variable. These findings suggest that changes in population age structure and the quality of human development collectively contribute to variations in economic growth throughout the study period. Therefore, the ARDL model is considered appropriate and capable of explaining the simultaneous effects of demographic transition and human capital quality on economic growth in Indonesia.

DISCUSSION

The ARDL estimation results indicate that the population aged 0–14 years does not have a significant effect on Indonesia's economic growth in either the short run or the long run. This finding reflects the fact that the young population is not yet directly involved in productive economic activities, as individuals in this age group are generally still pursuing education and are not actively contributing to economic output. An increase in the proportion of the young population tends to raise the dependency ratio, meaning that its economic benefits cannot be realized immediately. This finding is consistent with demographic transition theory, which suggests that the economic benefits of changes in population age structure emerge only when the proportion of the working-age population increases and the dependency ratio declines. The result is also in line with the findings of Munir & Shahid (2021) and Chishti (2022), who reported that a high youth dependency ratio tends to hinder economic growth.

The working-age population aged 15–64 years exhibits a positive and significant effect on economic growth in the long run, although its effect in the current period is not statistically significant. This finding suggests that the economic benefits of an expanding working-age population require time to materialize through labor market absorption and productivity improvements. A population structure dominated by working-age individuals creates opportunities for greater production capacity, savings, and investment, all of which serve as important drivers of economic growth. The result supports the demographic dividend theory, which argues that a larger proportion of working-age individuals can stimulate economic growth through higher productivity, savings, and investment (Nuriman et al., 2025). This finding is also consistent with previous studies by Cruz & Ahmed (2018), Bawazir and Nor (2023), and Nuriman et al. (2025), which found that the working-age population contributes positively to economic growth.

The elderly population aged 65 years and above does not exhibit a significant effect in the short run but has a negative and statistically significant impact on economic growth in the long run. An increase in the elderly population may reduce the proportion of productive workers and raise the old-age dependency ratio. Population ageing leads to higher healthcare expenditures, social protection costs, and pension obligations, which may reduce the resources available for productive investment. This finding is consistent with demographic transition theory, which suggests that a growing elderly population can diminish the economic benefits previously generated by the demographic dividend (Lee, 2017). The result is further supported by Chisti (2022), Liu et al (2023), and Thanh Trong et al. (2024), who found that population ageing has a negative impact on economic growth.

The Human Development Index (HDI) is found to have a positive and statistically significant effect on economic growth in the short run, but no significant effect in the long run. Improvements in education, health, and living standards are capable of directly enhancing labor productivity and economic activity. The consistent significance of HDI across several lag periods indicates that the benefits of human development are not only realized in the current period but also persist into subsequent periods. This finding supports Human Capital Theory, which argues that investments in education, health, and skills enhance productivity and economic output (Becker, 1964). The result is also consistent with the findings of Bawazir and Nor (2023), Wardani (2024), and Adiwicaksana & Yesica Marseilla (2025) who reported that improvements in human capital quality contribute positively to economic growth. The absence of a significant long-run effect suggests that the benefits of human development require complementary factors, such as employment opportunities, productive investment, and sufficient economic capacity, in order to be transformed into sustainable economic growth (Index & Nasution, 2021).

CONCLUSION

This study aims to analyze the effects of demographic transition and human capital quality on economic growth in Indonesia using the Autoregressive Distributed Lag (ARDL) approach. The findings reveal that demographic variables and human capital quality exert different effects in the short run and the long run. In the short run, the population aged 0–14 years and the population aged 65 years and above do not have a significant effect on economic growth. The working-age population (15–64 years) exhibits a positive and significant effect only at the first lag, indicating that the economic benefits of an increasing working-age population require an adjustment period before contributing to economic growth. In contrast, the Human Development Index (HDI) is found to have a positive and significant effect on economic growth, both in the current period and across several lagged periods, highlighting the importance of human capital quality in stimulating economic activity.

The long-run estimation results indicate that the working-age population has a positive and significant effect on economic growth, whereas the elderly population has a negative and

significant effect. These findings suggest that the demographic dividend remains an important opportunity for Indonesia, while the growing elderly population may become a challenge to future economic growth. The young population and the Human Development Index do not exhibit significant long-run effects. Overall, the results emphasize that the successful utilization of demographic transition depends not only on changes in population age structure but also on the ability to improve human capital quality and create productive employment opportunities. Therefore, integrated development policies that combine demographic management, human capital development, and the strengthening of productive economic sectors are essential to support sustainable economic growth in Indonesia.

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