



THE RELATIONSHIP BETWEEN POPULATION AGING AND ECONOMIC GROWTH IN EAST JAVA

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ABSTRACT

This study examines the relationship between population aging and economic growth in East Java Province during 2020–2024, with educational attainment as a moderating variable. Population aging represents a demographic transition that may be associated with changes in economic performance through labor productivity, dependency burden, and human capital capacity. This study uses a quantitative approach with balanced panel data from 38 regencies and municipalities in East Java, comprising 190 observations. The data were obtained from official sources, including Statistics Indonesia (BPS), the World Bank, OECD, and the Ministry of Education, Culture, Research, and Technology. Population aging is measured by the old-age dependency ratio, economic growth by the real GRDP growth rate, and educational attainment by mean years of schooling among the population aged 15–64 years. The data were analyzed using panel regression with a Moderated Regression Analysis (MRA) approach estimated through the Panel EGLS Random Effects Model. The results show that population aging has a negative coefficient of -0.361656 but is not statistically significant ($p = 0.1121$), indicating insufficient evidence of a direct relationship with economic growth. The interaction between population aging and educational attainment has a positive coefficient of 0.053348 ($p = 0.0656$), significant at the 10% level but not the 5% level. This indicates that educational attainment may moderate the relationship between population aging and economic growth, although the evidence is weaker than conventional significance. The study highlights education as an important factor in strengthening human capital and addressing demographic transition challenges.

1. INTRODUCTION

Demographic structural changes marked by an increasing proportion of the elderly population have become a significant global phenomenon. Population aging reflects a long-term demographic transition characterized by declining fertility rates and increasing life expectancy, which gradually changes the age structure of populations. Globally, this transition has raised concerns regarding labor supply, productivity, fiscal pressure, and economic sustainability (United Nations, 2020; Lee & Mason, 2017). In Indonesia, the proportion of the elderly population has increased from 7.0% in 2000 to 11.2% in 2024, indicating that Indonesia has entered a period of accelerated demographic aging. East Java has become one of the provinces experiencing a relatively rapid aging process, with the proportion of elderly residents exceeding the national average and reflecting a more advanced stage of demographic transition (BPS East Java, 2024). This condition creates new challenges for regional economic development, particularly because an increasing elderly population may affect labor productivity, dependency burden, consumption patterns, and investment dynamics.

The aging phenomenon in East Java is particularly relevant because the province has one of the largest populations in Indonesia and consists of 38 regencies and municipalities with diverse demographic and economic characteristics. The increase in the elderly population is accompanied by changes in the age structure of the labor force. Although the working-age population remains the dominant demographic group, the gradual increase in the old-age dependency ratio indicates that a growing number of elderly people may depend on a relatively smaller productive population. This demographic shift has important implications for regional economic performance because changes in labor availability and productivity may influence economic growth dynamics.

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The implications of population aging are highly relevant to regional economic growth, including in provinces with large populations such as East Java. In the long term, an aging age structure may slow economic growth if it is not accompanied by adaptive human resource development policies (Bloom et al., 2010). However, the economic consequences of aging may differ across regions depending on differences in human capital quality, labor market conditions, and economic structures. Therefore, examining how population aging relates to economic growth at the regional level is important, particularly by considering factors that may reduce potential negative consequences, such as educational attainment (OECD, 2023; UNDP Indonesia, 2022).

East Java provides an important context for studying the relationship between demographic transition and economic growth because of its substantial regional heterogeneity. Economic growth across regencies and municipalities in East Java shows different patterns due to variations in industrial development, agricultural dependence, infrastructure availability, and human resource quality (BPS East Java, 2024). Urban areas such as Surabaya, Sidoarjo, and Gresik generally demonstrate stronger economic performance due to industrial and service-sector activities, while several rural areas remain more dependent on agriculture and have relatively lower economic capacity. These differences suggest that the economic implications of population aging may not be uniform across regions and require analysis using regional panel data approaches.

Regional economic growth in East Java over the past two decades has been influenced by a combination of physical capital accumulation, human resource quality, labor conditions, and demographic transition (BPS East Java, 2024). In the context of endogenous economic growth theory, Mankiw, Romer, and Weil (1992) explain that human capital plays a central role in promoting long-term output, meaning that improvements in education contribute directly to economic growth through increased labor productivity (Mankiw et al., 1992). Therefore, educational attainment may become an important factor in determining how regions respond to demographic changes.

Educational attainment as an indicator of human capital is believed to mitigate the potential negative effects of population aging by improving workers' skills, extending productive years, and expanding employment opportunities for older people (OECD, 2023). In East Java, educational attainment has shown continuous improvement, with the average years of schooling among the working-age population increasing from 8.5 years in 2000 to 11.3 years in 2024 (BPS East Java, 2024). This improvement indicates increasing investment in human capital, which theoretically enhances productivity and economic adaptability (Barro & Lee, 2013). However, educational attainment remains unevenly distributed among regencies and municipalities, creating differences in human resource capacity across regions.

The variation in educational conditions further strengthens the importance of examining education as a moderating variable. Several areas, such as Surabaya and Malang, have relatively higher concentrations of educated workers and better human capital conditions, whereas other regions, such as Sampang and Situbondo, experience comparatively lower educational achievements (BPS East Java, 2024). These differences may influence the ability of regions to adapt to population aging. Regions with better educational attainment may have greater capacity to maintain productivity, encourage older population participation, and reduce the potential economic burden associated with demographic transition (UNDP Indonesia, 2022).

In the context of population aging, education becomes increasingly important because it can extend productive participation among older individuals and improve their ability to adapt to technological and economic changes. Higher educational attainment may enable older workers to remain engaged in formal and informal economic activities, thereby reducing the potential negative implications of demographic aging (OECD, 2023). Therefore, analyzing whether education moderates the relationship between population aging and economic growth is particularly relevant in East Java, where demographic transition occurs alongside significant differences in regional economic and educational characteristics.

Previous research in Indonesia by Sari and Putra (2018) has explored the relationship between population aging and economic growth at the national aggregate level. However, these studies have generally not examined the role of educational attainment as a moderating variable within regions characterized by substantial demographic and economic heterogeneity, such as East Java. Since demographic aging and economic performance may vary considerably among regions, provincial-level analysis using regency and municipality panel data provides a more comprehensive understanding of this relationship.

The research gap lies in the limited number of quantitative studies integrating population aging and educational attainment into a single model of regional economic growth. This study addresses this gap by examining the relationship between population aging and economic growth in East Java during the 2020–2024 period, while also analyzing the moderating role of educational attainment. This approach contributes to the literature on demographic transition, human capital, and regional economic development

by providing empirical evidence from a province experiencing both rapid aging and substantial regional disparities.

Based on these issues, this study aims to analyze the relationship between population aging and economic growth in East Java and to examine the role of educational attainment as a moderating variable. The findings are expected to provide academic contributions by enriching discussions on the interaction between demographic change and human capital development. From a policy perspective, this study may provide input for the East Java Provincial Government in designing education, employment, and aging-related policies that support productive aging and sustainable regional economic growth.

2. METHODS

Research Type and Approach

This study employs a quantitative approach using an explanatory research design to examine the relationship among population aging, economic growth, and educational attainment as a moderating variable. This approach was selected because it enables empirical testing of the proposed hypotheses using numerical data and statistical estimation techniques (Sugiyono & Lestari, 2021).

Research Location

This research was conducted in East Java Province, Indonesia, involving all 38 regencies and municipalities as the units of analysis. The study uses secondary panel data covering the period from 2020 to 2024, resulting in a balanced panel dataset consisting of 190 observations.

Population, Sample, and Sampling Technique

The population of this study consists of all regencies and municipalities in East Java Province that provide complete information regarding population aging, educational attainment, and economic growth indicators during the observation period. Since the population consists of all 38 regencies and municipalities, this study applies a census or total population sampling technique. This approach was selected to capture regional variations in demographic, educational, and economic characteristics across East Java.

Data Type and Data Collection Technique

The data used in this study are secondary data obtained from the following sources:

1. Statistics Indonesia (Badan Pusat Statistik/BPS) of East Java and Indonesia (2020–2024);
2. World Bank and OECD for global comparative data;
3. The Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia.

Data were collected through documentation from various official publications issued by BPS and international institutions. The data were obtained in the form of annual reports, online databases, and other statistical publications. This study analyzes three main variables:

- a. **Independent variable (X): Population aging**, measured using the old-age dependency ratio, calculated as the number of people aged ≥ 60 years relative to the working-age population.
- b. **Dependent variable (Y): Economic growth**, measured by the real growth rate of Gross Regional Domestic Product (GRDP).
- c. **Moderating variable (Z): Educational attainment**, measured by the mean years of schooling of the working-age population (15–64 years).

Data Analysis

The data were analyzed using panel data regression with a Moderated Regression Analysis (MRA) approach. The estimation was performed using EViews statistical software. The panel model selection procedure involved the estimation of the Common Effects Model (CEM), Fixed Effects Model (FEM), and Random Effects Model (REM), followed by the Lagrange Multiplier (LM) test to determine the most appropriate model specification.

Common Effects Model (CEM)

The Common Effects Model (CEM), also known as the Pooled Least Squares model, is the most basic method for analyzing panel data. This model assumes that there are no individual- or time-specific effects, so all cross-sectional and time-series units are treated equally. The basic CEM equation is as follows (Ghozali, 2016):

$$Y_{it} = \alpha + \beta X_{it} + \varepsilon_{it}$$

where:

Y_{it} = dependent variable

α = intercept

β = regression coefficient

X_{it} = independent variable

ε_{it} = error term

In this study, the CEM is used as a baseline model for comparison with more complex estimation methods.

Fixed Effects Model (FEM)

The Fixed Effects Model (FEM) assumes that differences among individuals can be captured through differences in the intercepts. This model is appropriate when individual-specific effects are correlated with the independent variables. The FEM equation is expressed as follows (Ghozali, 2016):

$$Y_{it} = \alpha + \beta X_{it} + \varepsilon_{it}$$

where α_i represents the specific effect for each cross-sectional unit.

FEM eliminates potential bias arising from omitted variables that remain constant over time. In this study, the FEM produces coefficients similar to those of the CEM while providing greater capacity to capture unobserved heterogeneity.

Random Effects Model (REM)

The Random Effects Model (REM) assumes that individual-specific effects are random and uncorrelated with the explanatory variables. This model is appropriate when regional differences are considered random components of the model.

The REM equation is expressed as follows (Ghozali, 2016):

$$Y_{it} = \alpha + \beta X_{it} + \varepsilon_{it}$$

where μ_i represents the individual-specific error component.

Lagrange Multiplier Test (LM Test)

The Lagrange Multiplier (LM) test, developed by Breusch and Pagan, is used to select between the CEM and REM. The hypotheses tested are as follows (Ghozali, 2016):

H₀: There is no individual effect, indicating that the CEM is more appropriate.

H₁: There is an individual effect, indicating that the REM is more appropriate.

Moderated Regression Analysis (MRA)

Moderated Regression Analysis (MRA) is used to examine the moderating effect of educational attainment on the relationship between population aging and economic growth. The MRA model in this study is formulated as follows (Sugiyono & Lestari, 2021):

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 Z_{it} + \beta_3 (X_{it} \times Z_{it}) + \varepsilon_{it}$$

where:

Y_{it} = economic growth

X_{it} = population aging

Z_{it} = educational attainment

$X_{it} \times Z_{it}$ = interaction between population aging and educational attainment

Multiple Linear Regression Test

To analyze the data, a panel data regression model was employed with the following equation:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 Z_{it} + \beta_3 (X_{it} \times Z_{it}) + \varepsilon_{it}$$

where:

Y_{it} = economic growth of regency/municipality i in year t

X_{it} = population aging

Z_{it} = educational attainment

$X_{it} \times Z_{it}$ = interaction (moderation)

ε_{it} = error term

Hypothesis Testing

Partial Test (t-Test)

The t-test was conducted to evaluate the statistical significance of each explanatory variable in the regression model. The hypothesis testing was performed at significance levels of 5% and 10% considering the exploratory nature of the moderation analysis.

The decision criteria are:

1. If the probability value (*p-value*) is lower than the selected significance level, the variable is considered statistically significant.
2. If the probability value (*p-value*) is higher than the selected significance level, there is insufficient statistical evidence to confirm a significant relationship.

3. RESULTS AND DISCUSSIONS

Results

Research Data Description

This study analyzes panel data from 38 regencies and municipalities in East Java over the 2020–2024 period, comprising a total of 190 observations. The dependent variable is the logarithm of economic growth (Log Economic Growth), while the independent variables include population ageing and educational attainment as a moderating variable.

Comparison of CEM, FEM, and REM

Table 1. Comparison of CEM, FEM, and REM

Aspect	CEM	FEM	REM
Population Ageing Coefficient	0.071699	0.071699	0.052642
Education Coefficient	0.003680	0.003680	0.247616
R-squared	0.205691	0.205691	0.059539
Durbin-Watson	0.307359	0.307359	2.233979
Prob.	0.9572	0.9572	0.0792

Source: Processed Data, 2025.

Based on Table 1, the REM was selected as the model for this study, considering several aspects related to the role of educational attainment as a moderating variable. First, the REM is more appropriate when the 38 regencies and municipalities included in the cross-sectional units are regarded as samples drawn from a larger population. Second, the individual effects across regencies and municipalities are assumed to be random and uncorrelated with the independent variables. Third, the education coefficient under the REM (0.247616) is more substantial and has a higher level of statistical significance (prob. = 0.0792) than those under the CEM and FEM (0.003680, prob. = 0.9572). Fourth, the REM accounts for unobserved heterogeneity across regions. Fifth, the Durbin-Watson statistic under the REM is 2.233979, which is close to 2 and indicates no apparent autocorrelation problem. Sixth, the population ageing variable is significant across all models, while the education variable demonstrates a more meaningful effect under the REM.

Lagrange Multiplier Test

The Lagrange Multiplier (LM) test is used to examine the presence of individual effects or unobserved heterogeneity in panel data models by comparing the more restrictive CEM with the more flexible REM. The null hypothesis (H_0) states that there are no individual effects, or that the variance of the individual effects is equal to zero, thereby supporting the use of the CEM. Conversely, the alternative hypothesis (H_1) states that individual effects exist, or that the variance of the individual effects is not equal to zero, thereby recommending the use of the REM. The decision is based on the probability value (*p-value*) of the test statistic. If the *p-value* is lower than the specified significance level, typically 0.05, H_0 is rejected, indicating that the REM is preferred to the CEM.

Table 2. Lagrange Multiplier Test

Test	Cross-section	Time	Both
Breusch-Pagan	277.6968(0.0000)	0.149781(0.6987)	277.8466(0.0000)
Honda	16.66424(0.0000)	-0.387016(--)	11.50973(0.0000)
King-Wu	16.66424(0.0000)	-0.387016(--)	4.837381(0.0000)
Standardized Honda	17.36435(0.0000)	-0.095039(--)	8.106151(0.0000)
Standardized King-Wu	17.36435(0.0000)	-0.095039(--)	2.439306(0.0074)
Gourieroux, et al.*	--	--	277.6968(< 0.01)

Note: The numbers in parentheses represent the **probability values (p-values)**.

Mixed chi-square asymptotic critical values:

Significance Level	Critical Value
1%	7.289
5%	4.321
10%	2.952

Source: Processed Data, 2025.

Based on the LM test results, the Breusch–Pagan test statistic for both effects (*Both*) is 277.8466, with a *p-value* of 0.0000. This provides strong evidence for rejecting the null hypothesis that there are no individual effects in the model. The finding indicates that the random effects model is more appropriate than the pooled OLS model for analyzing the relationships among the variables.

The LM test provides comprehensive evidence regarding the presence of random effects in the model. The Breusch–Pagan statistic of 277.8466, with a probability value approaching zero (0.0000), clearly rejects the null hypothesis of no individual effects. This confirms that variation across regencies and municipalities in East Java is statistically significant and should be incorporated into the estimation model. In addition to the Breusch–Pagan test, other LM test variants, including the Honda, King–Wu, and their standardized versions, consistently reject the null hypothesis with very small probability values. The consistency of the results across the various LM tests strengthens the evidence that random effects are present in the data. The Gourieroux et al. test, which is also significant at the 1% level, further supports this conclusion. Therefore, the random effects model is more appropriate than the pooled OLS model for the data analyzed in this study.

The LM test was also conducted by considering the time component. The Breusch–Pagan statistic for the time effect is 0.149781, with a *p-value* of 0.6987, which is not statistically significant at any conventional significance level. This indicates that there is no significant time effect in the model. In other words, there are no factors that vary over time but are common to all regencies and municipalities, such as national economic shocks or national-level policies implemented during the same period, that systematically affect economic growth. The insignificance of the time effect may indicate that economic growth dynamics in East Java during the 2020–2024 period were more strongly influenced by region-specific factors (*cross-sectional effects*) than by temporal factors that were uniform across regions.

Moderated Regression Analysis (MRA)

Table 3. Moderated Regression Analysis

Variable / Keterangan	Coefficient / Nilai	Std. Error / S.D.	t-Statistic / Rho	Prob.
MODEL INFORMATION				
Dependent Variable	LOGPERTUMBUHAN_EKONOMI			
Method	Panel EGLS (Cross-section random effects)			
Date	09/15/25			
Time	20:27			
Sample	2020 2024			
Periods included	5			

Cross-sections included	38			
Total panel (balanced) observations	190			
Variance estimator	Swamy and Arora estimator of component variances			
ESTIMATION RESULTS				
C	25.88315	10.55276	2.452738	0.0151
POPULATION_AGING	-0.361656	0.226556	-1.596321	0.1121
EDUCATION-LEVEL	-2.287846	1.353521	-1.690292	0.0926
Population Aging*Education Level	0.053348	0.028807	1.851938	0.0656
EFFECTS SPECIFICATION				
Cross-section random	0.844639		0.8614	
Idiosyncratic random	0.338776		0.1386	
WEIGHTED STATISTICS				
R-squared	0.078992	Mean dependent var	1.877559	
Adjusted R-squared	0.064137	S.D. dependent var	0.376276	
S.E. of regression	0.364009	Sum squared resid	24.64552	
F-statistic	5.317544	Durbin-Watson stat	2.195304	
Prob(F-statistic)	0.001544			
UNWEIGHTED STATISTICS				
R-squared	0.272792	Mean dependent var	10.63442	
Sum squared resid	161.3912	Durbin-Watson stat	0.335238	

Source: Processed Data, 2025.

Based on the estimation results of the Panel EGLS model using the Moderated Regression Analysis (MRA) approach, this study reveals a complex relationship among population ageing, educational attainment, and economic growth in East Java during the 2020–2024 period. The estimated MRA model shows that the interaction variable between population ageing and educational attainment has a positive coefficient of 0.053348 (standard error = 0.028807; $p = 0.0656$). The coefficient is statistically significant at the 10% level but does not reach the conventional 5% significance threshold, indicating weaker statistical evidence for the moderating role of educational attainment. Therefore, educational attainment may moderate the relationship between population ageing and economic growth, although this effect should be interpreted cautiously. Individually, population ageing has a negative coefficient of -0.361656 but is not statistically significant ($p = 0.1121$), indicating that there is insufficient statistical evidence to confirm a direct relationship between population ageing and economic growth. Meanwhile, educational attainment has a negative coefficient of -2.287846 and approaches statistical significance ($p = 0.0926$). The presence of a positive interaction effect indicates a more complex mechanism underlying the relationship between population ageing and economic growth. The R-squared value of 0.078992 indicates that the model explains approximately 7.9% of the variation in economic growth, while the Durbin–Watson statistic of 2.195304 indicates no apparent autocorrelation problem in the model.

The MRA results indicate that the effect of population ageing on economic growth is not entirely direct but may depend on the level of educational attainment. The positive interaction coefficient suggests that in regions with higher levels of educational attainment, the negative effect of population ageing on economic growth may be reduced or potentially become positive. This mechanism can be explained through several potential pathways. First, higher educational attainment may extend individuals' productive

participation, allowing older people with higher levels of education to remain engaged in economic activities. Second, education may facilitate better adaptation to technological changes, thereby helping maintain the productivity of older workers. Third, regions with higher educational attainment tend to have more diversified economic structures and may therefore demonstrate greater resilience to demographic changes.

Discussion

The Effect of Population Ageing on Economic Growth in East Java during the 2020–2024 Period

The findings indicate that population ageing is negatively associated with economic growth; however, this relationship is not statistically significant (coefficient = -0.361656 ; $p = 0.1121$). Therefore, the results provide insufficient statistical evidence to confirm a direct relationship between population ageing and economic growth during the observed period. The negative coefficient suggests that an increasing proportion of elderly population tends to be associated with lower economic growth, which is consistent with demographic transition theories emphasizing the potential decline in labor supply and increasing dependency burden. Bloom et al. (2010) argue that population ageing may reduce economic growth through declining labor productivity, reduced labor-force participation, and increasing social expenditure. However, the insignificant relationship found in this study suggests that the economic implications of population ageing in East Java may depend on specific regional conditions, including labor-market structure, productivity capacity, migration patterns, health conditions, and economic composition. A holistic and integrated approach is therefore essential, given the complexity of the relationship between demographic factors and regional economic performance. This finding further emphasizes that the impact of population ageing cannot be examined in isolation but should be considered in interaction with other factors.

One possible explanation for the insignificant relationship is that East Java still maintains a relatively large working-age population, allowing labor supply to remain sufficient despite the increasing proportion of elderly residents. Furthermore, the economic contribution of older populations may vary depending on their productivity, health status, and opportunities to participate in economic activities. Older individuals with better health and skills may continue contributing through formal employment, self-employment, or informal economic activities, thereby reducing the potential negative consequences of population ageing. In addition, internal migration and differences in regional development may influence the observed relationship. More developed areas, such as Surabaya, Sidoarjo, and Gresik, have stronger industrial and service sectors that may absorb labor more effectively, while other regions with different economic structures may experience different demographic-economic dynamics (BPS East Java, 2024).

This finding differs from several empirical studies conducted in developed countries, where population ageing has been shown to significantly reduce economic growth due to declining labor supply and increasing dependency costs (Bloom et al., 2010). The difference may be explained by variations in demographic transition stages, labor-market institutions, healthcare systems, and economic structures. In developing regions such as East Java, the impact of population ageing may not immediately appear because demographic changes occur alongside improvements in education, labor participation, and economic diversification. Therefore, population ageing should not be viewed as a deterministic constraint on economic growth, but rather as a demographic condition whose economic consequences depend on the capacity of regions to adapt through human capital development and appropriate policy interventions.

Educational Attainment as a Moderator of the Relationship between Population Ageing and Economic Growth in East Java during the Same Period

The interaction variable between population ageing and educational attainment shows a positive coefficient of 0.053348 ($p = 0.0656$), which provides limited statistical support for the moderation hypothesis. Although significant at the 10% level, this evidence remains weaker than the conventional 5% significance threshold. From a theoretical perspective, this finding is consistent with human capital theory, which suggests that investment in education can increase labor productivity, including among older workers. When educational attainment is relatively high, older people may possess skills that enable them to remain engaged in productive economic activities, thereby reducing the potential negative effects of population ageing on economic growth. However, the significance observed only at the 90% confidence

level indicates that this moderating effect is relatively weak and may be influenced by other factors not included in the model.

The negative coefficient of educational attainment as a main effect raises important questions regarding the underlying mechanism. One possible explanation is a mismatch between educational qualifications and labor market requirements, or the inability of the regional economy to optimally absorb educated workers. In the context of East Java, an increase in average years of schooling may not necessarily be accompanied by improvements in educational quality that are aligned with industrial needs, and therefore may not contribute significantly to economic growth. An alternative explanation is the existence of a time lag between investment in education and its effects on economic growth, whereby the benefits of education may only materialize over the long term.

These findings also provide important implications for theories of demographic transition and economic growth. Although population ageing is generally assumed to have a negative effect on economic growth, the findings suggest that this effect is not deterministic and may be moderated by other factors, such as the quality of human capital. In the context of East Java, which is experiencing an accelerated ageing process, investment in quality education may serve as a strategy to mitigate the potential negative effects of demographic transition.

Based on the findings, several policy implications can be considered. First, local governments need to develop education policies that focus not only on improving access but also on relevance and quality. Educational curricula should be aligned with labor market requirements and the economic potential of each region so that graduates acquire skills relevant to regional development needs. Second, specific programs are needed to empower educated older adults through skills training, access to business capital, and incentives for those who remain economically active. Such programs can utilize the experience and knowledge of educated older adults to support their positive contribution to the economy.

Third, labor market policies should be designed to facilitate the participation of older workers, particularly those with higher levels of education. Flexible working hours, opportunities for part-time employment, and the elimination of age-based discrimination in recruitment may improve the utilization of human capital among older workers. Fourth, the government needs to develop a comprehensive monitoring system to identify gaps between educational outcomes and industry requirements, thereby enabling education and labor policies to become more effectively integrated.

4. CONCLUSION

Based on the results of the analysis, this study concludes that the Random Effects Model (REM) is an appropriate estimation model for examining the relationship between population ageing, educational attainment, and economic growth in East Java during the 2020–2024 period. The Lagrange Multiplier (LM) test supports the presence of individual effects across regencies and municipalities, with the Breusch–Pagan statistic of 277.8466 (p -value = 0.0000), indicating that the random effects specification is more suitable than the pooled OLS model.

Regarding the first research objective, the findings show that population ageing has a negative coefficient of -0.361656 ; however, the relationship is not statistically significant ($p = 0.1121$). This result indicates that the study does not provide sufficient statistical evidence to confirm a direct relationship between population ageing and economic growth during the observed period. Nevertheless, the negative coefficient suggests a tendency that increasing population ageing may be associated with lower regional economic growth, which highlights the importance of considering demographic transition within broader economic and social contexts.

Regarding the second research objective, the findings indicate that educational attainment may play a moderating role in the relationship between population ageing and economic growth. The interaction variable between population ageing and educational attainment has a positive coefficient of 0.053348 ($p = 0.0656$), which is statistically significant at the 10% level but does not reach the conventional 5% significance threshold. Therefore, this finding provides limited statistical evidence that higher educational attainment may help reduce the potential negative association between population ageing and economic growth. The weaker significance level suggests that this moderating role should be interpreted cautiously.

The findings imply that investment in education remains relevant as part of strategies to address demographic transition, particularly because educational attainment shows a positive interaction with population ageing in the empirical model. Policies focusing on lifelong learning, skills development, and opportunities for productive participation among older individuals may support regional adaptation to population ageing. However, these policies should consider differences in demographic, economic, and educational characteristics across regencies and municipalities in East Java.

Future studies are encouraged to incorporate additional moderating factors, such as technology, health conditions, and innovation, as well as employ more advanced econometric approaches, such as dynamic panel models, to further examine the evolving relationship between demographic transition and economic growth.

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6. REFERENCES

- Asian Development Bank. (2022). *Asian development outlook 2022: Mobilizing taxes for development*. Asian Development Bank.
- Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Sage Publications.
- Badan Pusat Statistik Provinsi Jawa Timur. (2024). *Produk Domestik Regional Bruto Kabupaten/Kota di Jawa Timur Menurut Lapangan Usaha 2019–2023*. Surabaya: BPS Provinsi Jawa Timur.
- Badan Pusat Statistik Provinsi Jawa Timur. (2024a). *Provinsi Jawa Timur dalam angka 2024*. Badan Pusat Statistik Provinsi Jawa Timur.
- Badan Pusat Statistik Provinsi Jawa Timur. (2024b). *Statistik daerah Jawa Timur 2024*. BPS Jawa Timur.
- Barro, R. J., & Lee, J. W. (2013). A new data set of educational attainment in the world, 1950–2010. *Journal of Development Economics*, 104, 184–198. <https://doi.org/10.1016/j.jdeveco.2012.10.001>
- Bloom, D. E., Canning, D., & Sevilla, J. (2004). The Effect of Health on Economic Growth: A Production Function Approach. *World Development*, 32(1), 1–13. <https://doi.org/10.1016/j.worlddev.2003.07.002>
- Bloom, D. E., Canning, D., & Fink, G. (2010). Implications of population ageing for economic growth. *Oxford Review of Economic Policy*, 26(4), 583–612. <https://doi.org/10.1093/oxrep/grq038>
- Canning, D., & Pedroni, P. (2008). The effect of demographic change on economic growth in the European Union. *Economics Letters*, 99(3), 525–530.
- Ghozali, I. (2016). *Aplikasi analisis multivariate dengan program IBM SPSS 23*. Badan Penerbit Universitas Diponegoro.
- Hanushek, E. A., & Woessmann, L. (2020). Education, knowledge capital, and economic growth. Dalam *The economics of education* (pp. 171–182). Academic Press.
- Lee, R., & Mason, A. (2017). *Population aging and the generational economy: A global perspective*. Edward Elgar Publishing.
- Lee, R., & Mason, A. (2017). Cost of aging. *Finance & Development*, 54(1), 7–9. International Monetary Fund.
- Mankiw, N. G., Romer, D., & Weil, D. N. (1992). A contribution to the empirics of economic growth. *The Quarterly Journal of Economics*, 107(2), 407–437. <https://doi.org/10.2307/2118477>

- Nugroho, Y. (2021). Pengaruh penuaan penduduk terhadap pertumbuhan ekonomi Indonesia. *Jurnal Ekonomi dan Pembangunan*, 29(1), 45–60.
- Organisation for Economic Co-operation and Development. (2023a). *Ageing and employment policies: Indonesia*. OECD Publishing.
- Organisation for Economic Co-operation and Development. (2023b). *Pensions at a glance 2023: OECD and G20 indicators*. OECD Publishing.
- Pratama, A., & Rachmawati, D. (2023). Moderasi pendidikan dalam pengaruh penuaan penduduk terhadap pertumbuhan ekonomi daerah. *Jurnal Ekonomi Regional*, 15(2), 101–118.
- Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of Political Economy*, 94(5), 1002–1037. <https://doi.org/10.1086/261420>
- Sari, D. P., & Putra, A. (2018). Pengaruh penuaan penduduk terhadap pertumbuhan ekonomi di Indonesia. *Jurnal Ekonomi dan Pembangunan*, 26(2), 157–174.
- Sugiyono, S., & Lestari, P. (2021). *Metode penelitian komunikasi: Kuantitatif, kualitatif, dan cara mudah menulis artikel pada jurnal internasional*. Alfabeta.
- Susilowati, D., Adianita, H., & Trifandha, S. (2025). Pearson correlation study: Unveiling the relationship between demographic, economic, and health factors in East Java. *Gorontalo Development Review*, 8(1), 125–135.
- Susilowati, D., Adianita, H., Ekonomi, F., & Bojonegoro, U. (2024). Pengaruh jumlah penduduk dan pertumbuhan ekonomi (produk domestik regional bruto) terhadap upah minimum. *Ekonomi, Bisnis, dan Kewirausahaan*, 7, 372–377. <https://doi.org/10.37600/ekbi.v7i1.1402>
- United Nations. (2020). *World population ageing 2020*. United Nations, Department of Economic and Social Affairs, Population Division.
- United Nations Development Programme Indonesia. (2022). *Indonesia human development report 2022: Advancing regional development*. UNDP Indonesia.
- United Nations. (2023). *World Social Report 2023: Leaving No One Behind in an Ageing World*. United Nations Department of Economic and Social Affairs.
- World Bank. (2023a). *Indonesia economic prospects: Investing in people*. World Bank.
- World Bank. (2023b). *Indonesia economic prospects: Pathways to middle-class prosperity*. World Bank.