International Journal of Entrepreneurship and Management Practices IJEMP
EISSN : 2600-8750
Volume 8 Issue 31 (September 2025) PP. 674-693
DOI: 10.35631/IJEMP.831046

INTERNATIONAL JOURNAL OF ENTREPRENEURSHIP AND MANAGEMENT PRACTICES (IJEMP)
www.ijemp.com

AN ANALYSIS OF THE HUMAN DEVELOPMENT NEXUS IN ECONOMIC GROWTH DYNAMICS: REFRAMING AGEING AS OPPORTUNITY

Hu Mingqi[1], Azhan Rashid Senawi[2]*

[1] Faculty of Business & Management, Universiti Teknologi MARA, Malaysia
Email: 2021254756@isiswa.uitm.edu.my

[2] Circular Economy of Logistic & Oprations (CELO) RIG,
Faculty of Business & Management, Universiti Teknologi MARA, Malaysia
Email: azhanrashid@uitm.edu.my

* Corresponding Author

Article Info:

Article history:
Received date: 30.06.2025
Revised date: 21.07.2025
Accepted date: 28.08.2025
Published date: 25.09.2025

To cite this document:

Hu, M., & Senawi, A. R. (2025). An Analysis Of The Human Development Nexus In Economic Growth Dynamics: Reframing Ageing As Opportunity. *International Journal of Entrepreneurship and Management Practices, 8* (31), 674-693.

DOI: 10.35631/IJEMP.831046

Abstract:

Based on the panel data of 31 provincial administrative regions in China from 1990 to 2020, this paper employs the System GMM approach to study the impact of population aging on economic growth, as well as the mediating mechanism and moderating role of the Human Development Index (HDI). The results show that population aging significantly inhibits economic growth, which is consistent with existing international studies. At the same time, HDI can significantly promote economic growth and slow down the negative impact of population aging on economic growth. The intermediary effect test shows that part of the total effect of population aging on economic growth is indirectly realized through HDI, accounting for about 30% of the total impact, indicating that increasing HDI can partially offset the slowdown in growth caused by aging. The GMM estimation result of the system is robust, which has passed the correlation test of AR (1) and AR (2) sequences and the Hansen over-identification test, indicating that the model setting and the selection of instrumental variables are reasonable. The contribution of this paper is to reveal the significance of improving the level of human development in the context of population aging: on the one hand, it expands the theoretical understanding of the impact of population aging on economic growth, and emphasizes the intermediary mechanism of HDI, a comprehensive development indicator; On the other hand, it provides empirical evidence for formulating policies to actively respond to aging, and suggests that the level of human development should be comprehensively improved through education, health care and income distribution policies to alleviate the adverse impact of aging on the economy and achieve long-term sustainable growth.

International Journal of Entrepreneurship and Management Practices IJEMP
EISSN : 2600-8750
Volume 8 Issue 31 (September 2025) PP. 674-693
DOI: 10.35631/IJEMP.831046

Keywords:

Ageing; Economic Growth; Human Development Index (HDI); Panel data; GMM

Introduction

Population aging has become a major challenge of global concern. In China and other developing countries, the proportion of people aged 65 and over has risen rapidly, marking the formal aging of society. This demographic shift has exacerbated problems such as declining labor supply, declining productivity and social security pressures, and the traditional view is that aging will drag down economic growth. For example, bloom et al. (2010) pointed out that as the proportion of the elderly population increases, labor supply, savings and capital accumulation will decline simultaneously, and the potential for economic growth will be limited. Maestas et al. (2023) also found that for every 10% increase in the proportion of people over 60, the per capita GDP growth rate will decrease significantly by about 5.5%, equivalent to an average annual slowdown of 0.3%. These evidence confirm that aging may have a substantial impact on the macro-economy.

More recently, however, views have begun to emphasize the potential opportunities of aging. Some developed countries (such as Japan and Germany) actively develop the "silver haired economy", make up for the impact of labor aging by improving human capital and technological innovation, and make the elderly population a new driving force for economic development (OECD, 2022; who, 2022). In the context of the gradual fading of the demographic dividend, if can improve the quality of human resources and give full play to the role of the elderly group, the aging society may not necessarily be an economic burden, but may turn into a new opportunity to promote industrial upgrading and expand domestic demand. This suggests that it is necessary to examine the relationship between population aging and economic growth from a new perspective, and to explore what factors can regulate or affect the direction and intensity of this relationship.

The human development index (HDI) provides an important framework for assessing a country's comprehensive development level. HDI, which consists of three indicators of life expectancy, education and per capita income, is a comprehensive measure of health, education and living standards (DP, 2023). Unlike the development view that only focuses on economic indicators, HDI embodies the development concept of "people oriented", which comprehensively measures the quality of the population and the level of welfare, and is widely used to evaluate long-term development performance. Existing research shows that higher levels of human development are often accompanied by better health care, higher human capital and stronger social innovation. These factors help to improve labor productivity and enhance the social participation of the elderly population, which may reduce the "burden effect" of aging. However, there is still a lack of sufficient empirical research at home and abroad on the role of HDI in alleviating the impact of aging on economic growth. In China, there are large differences in the level of human development among regions, which leads to different effects of aging on the economy (Ni et al. 2014). Therefore, it is necessary to explore how the introduction of HDI will change the relationship between population aging and economic growth, so as to provide a basis for formulating differentiated strategies to cope with aging.

Volume 8 Issue 31 (September 2025) PP. 674-693
DOI: 10.35631/IJEMP.831046
This paper aims to fill the above research gaps, focusing on the mediating and regulatory role of HDI in the process of population aging affecting economic growth. On the one hand, should build an analytical framework to test the intermediary mechanism of population aging indirectly affecting economic growth through HDI On the other hand, The interaction term ($Age_{it} \times HDI_{it}$) is introduced to test the moderating effect of HDI on the aging growth relationship, where both Aging and HDI are mean-centered to mitigate multicollinearity. The study will use the data of 31 provincial administrative regions in mainland China from 1990 to 2020, and use the systematic GMM method to overcome the problems of endogenous and dynamic bias, in order to get reliable conclusions. This study not only enriches the theoretical understanding of the economic effects of aging in academia, but also has practical significance for China's policy practice of actively dealing with aging and achieving high-quality development.

Literature Review

In the global development landscape of the twenty-first century, population ageing has become a major challenge that cannot be ignored, with far-reaching implications for countries' economic structures, social welfare systems and sustainable development strategies.(Hu and Azhan, 2024). A large number of multinational empirical studies and theoretical literature show that the change of population age structure will affect economic growth in many ways, and its impact is complex and multi-dimensional. On the one hand, the traditional theory of population economics believes that population aging will generally have a negative impact on economic growth. Aging leads to a relative reduction in labor supply and an increase in the average age of the labor force, which will reduce labor productivity. At the same time, the decline in household savings rate and the rise in medical and pension expenditure will also squeeze investment and consumption, thus weakening the momentum of economic growth. Bloom et al. (2003) and Faruqee and Muhleisen (2003) pointed out that the decline of labor force and savings are the main channels for aging to drag down growth. Subsequently, many empirical studies have verified the significant negative correlation between aging and economic growth. For example, Lee and Shin (2019) found that when the proportion of the elderly population rises to a higher level, its inhibitory effect on per capita GDP growth will increase significantly, showing a non-linear negative impact pattern, based on data from 1960 to 2014 in 142 countries. Maestas et al. (2016, 2023) used state panel data to provide direct evidence that population aging between 1980 and 2010 has reduced the growth rate of per capita GDP in the United States by about 0.3%s annually. Similarly, in studies of a global sample, population aging has been shown to significantly slow the growth trajectory of most economies (kotschy and bloom, 2023). Over all, without intervention, the adverse effects of population aging on economic growth have become a common challenge for countries.

On the other hand, some studies focus on the neutral or positive effects of aging on the economy and its conditions. According to the endogenous growth theoretical model, the increase in life expectancy means that the labor force can have more years of work and innovation, which has a positive effect on long-term economic growth (Prettner, 2013). Prettner (2013) built an endogenous growth model to prove that in the context of population aging, as long as the extension of life expectancy is accompanied by the improvement of health level and the increase of human capital, the impact of aging on long-term growth can turn positive. Some studies also emphasize that the impact of aging depends on the stage of economic development and the institutional environment. Pan and Chang (2021) studied 27 Asian economies and found that aging significantly dragged down growth in high-income economies, but may

Volume 8 Issue 31 (September 2025) PP. 674-693
DOI: 10.35631/IJEMP.831046

promote growth in low-income economies, which often offset the decline in labor motivation caused by aging through mechanisms such as increasing female labor force participation. Nguyen et al. (2024)'s research on the seven ASEAN countries shows that institutional quality and human capital accumulation can effectively buffer the negative impact of aging on economic growth and enhance social innovation and resilience. It can be seen that the impact of aging on the economy is not one size fits all, and its effect is regulated by the development level and response measures of various countries.

In the case of China, existing research focuses on the direct impact of aging on the labor market and macro-economy, and less on possible regulatory factors. Some scholars estimate that if other factors are not taken into account, changes in the age structure of the population alone could reduce China's long-term economic growth by about 1% (Cai Fang et al. 2017).China's economic development agenda, aiming to promote the modernization process with Chinese characteristics and achieve common prosperity for all(Li Shuang et al.2025). However, some studies have begun to explore possible ways to improve human capital and reform the retirement system to alleviate the impact of aging. For example, Ni et al. (2014) pointed out that differences in human development levels between regions in China will exacerbate the imbalance caused by aging: in areas with higher human development levels, the negative impact of aging on the economy is relatively weak. Li Hong and Li Jie (2017) analyzed the impact of aging from the perspective of HDI, believing that improving human development indicators such as education and health care will help to reduce the slowdown in economic growth caused by aging. The empirical study by Wang and Jiang (2020) further supports this: through grouping regression of provincial data in China, they found that the negative impact of aging on economic growth was significantly weakened in areas with better health, higher education and higher income. Generally speaking, the literature at home and abroad suggests that should pay attention to the heterogeneity of the impact of population aging, especially the important role that factors such as the level of human development may play in it.

To sum up, existing studies provide an important basis for understanding the relationship between population aging and economic growth, but there are still shortcomings. First, there is a lack of a systematic analysis framework on how the level of comprehensive development (such as HDI) can intervene in the process of aging affecting economic growth. Second, there are still few empirical tests on whether and how HDI regulates the economic effects of aging. Third, the measurement methods used in most studies do not adequately control endogenous and dynamic effects, which may lead to bias. Therefore, based on the existing literature, this paper will introduce HDI as an intermediary and regulatory variable, and adopt the improved dynamic panel GMM method to further explore the mechanism and dynamic effects of population aging on economic growth.

Theoretical Mechanisms and Research Hypotheses – Heading 2 (TNR, 12, Bold, Italic, Capitalize Each Word)

The mechanism of population aging affecting economic growth. The change of population age structure affects the macro-economy through multiple channels. Traditional mechanisms include labor supply channels (changes in the number and quality of labor force), savings and investment channels (life cycle effects lead to a decline in the savings rate and a slowdown in capital formation), and fiscal burden channels (rising pension and medical expenditure crowd out development funds). Specifically, with the deepening of population aging, the proportion of working age population has declined, and labor shortage has pushed up wage costs and

EISSN : 2600-8750
Volume 8 Issue 31 (September 2025) PP. 674-693
DOI: 10.35631/IJEMP.831046
reduced the willingness of enterprises to invest. The consumption tendency of the elderly is higher than that of savings, and the reduction of capital supply affects long-term production capacity. In response to pension and medical expenditure, the government has raised taxes or squeezed productive expenditure such as education and infrastructure, which has a negative impact on economic growth. Based on this, the hypothesis is put forward:

H1: there is a significant negative correlation between population aging and economic growth.

The mediating role of HDI. In addition to directly affecting economic growth, population aging can also indirectly affect economic performance by changing the level of human development in a country or region. On the one hand, aging societies are usually accompanied by an increase in life expectancy and an improvement in the health of residents (which is an important part of the HDI health dimension). But on the other hand, the reduction of labor force and the increase of upbringing burden may restrict the increase of per capita income and education investment (HDI's income and education dimension). Therefore, the net effect of aging on HDI is uncertain. However, it can be expected that if the growth of per capita income caused by aging slows down or public resources shift from education to pension, the improvement of HDI will be restrained, which will drag down long-term growth in the case of insufficient accumulation of human capital. Conversely, if a society still maintains education investment and health improvement (that is, HDI continues to increase) in the process of aging, the negative impact of aging on the economy will be partially offset. In other words, HDI may play an intermediary role in the process of aging affecting economic growth: aging first affects the level of human development, and then affects economic growth. Based on the intermediary effect analysis framework proposed by Baron and Kenny, a three-step regression is constructed to test: (1) aging significantly affects economic growth; (2) Aging significantly affects HDI; (3) After controlling HDI, the impact of aging on economic growth is weakened, and HDI itself has a significant effect on growth. If the above conditions are met and the indirect effect is significant, it can be judged that HDI has some mediating effect in it. Make assumptions accordingly:

H2: HDI plays an intermediary role in the relationship between aging and economic growth

The regulatory effect of HDI. In addition to the intermediary mechanism, HDI itself has a regulatory function on the economic impact of aging. The higher the comprehensive development level of a country, the more calm it is in the face of the impact of aging. On the one hand, high HDI means a healthier and better educated work force, with less decline in labor productivity even as the age structure ages. At the same time, the high level of medical security extends the healthy life span of the elderly and can make long-term economic contributions. On the other hand, high HDI is often accompanied by a better social security and innovation environment, which transforms the burden of the elderly population into new consumer demand and "silver economy" opportunities, thus hedging some negative effects. Therefore, it can be expected that in areas with higher HDI, the negative effect of population aging on economic growth will be smaller. On the contrary, in the lower stage of HDI development, the impact of aging is more serious. This inference is also supported by existing research. The United Nations human development report 2023 points out that the continuous improvement of healthy life span and education years not only helps to provide high-quality labor supply, but also promotes the participation of the elderly in social innovation and knowledge economy activities, thus creating new growth momentum. Nguyen et al. (2024) also found that in

Volume 8 Issue 31 (September 2025) PP. 674-693
DOI: 10.35631/IJEMP.831046
societies with sound institutions and abundant human capital, the negative correlation between aging and economic growth has been greatly weakened. In the Chinese context, the analysis of Wang and Jiang (2020) shows that the adverse impact of aging on economic growth in high HDI provinces is significantly lower than that in low HDI provinces. Based on the above discussion, the following assumptions are put forward:

H3: HDI plays a significant regulatory role in the relationship between population aging and economic growth.

Methodology

This paper selects panel data from 31 provincial regions (excluding Hong Kong, Macao, Taiwan) in mainland China from 1990 to 2020. China has undergone rapid demographic and economic changes since the 1990s, making this period ideal for studying aging effects. Data sources include the China Statistical Yearbook, World Bank Database, and UNDP reports, ensuring data authority and comparability. Missing data are filled using linear interpolation and other methods. The balanced panel data from 1990-2020 consist of 961 observations.

Economic growth (dependent variable) is measured as a percentage of the growth rate of GDP per capita. The degree of population aging (independent variable) is often expressed by the elderly dependency ratio or the proportion of people aged 65 and over. In view of the availability of population structure data in various regions of China, this paper takes the dependency ratio of the elderly population (that is, the ratio of the population aged 65 and over to the population aged 15-64) as the aging index, and if necessary, uses the proportion of the population aged 65 and over in the total population as an alternative index to test the robustness. The human development index HDI (intermediary/moderating variable) was calculated following the methodology of the United Nations development program, including dimensions of Health (life expectancy), education (average years of schooling and expected years of schooling) and income (GNI per capita conversion). Considering the characteristics of provincial data, the income index of per capita GDP in each province is calculated after purchasing power parity adjustment, and the annual HDI of each province is calculated with reference to the UNDP formula. It should be noted that in order to avoid the endogenous correlation between HDI and aging indicators (for example, life improvement is not only a component of HDI, but also deepens aging), some expanded analyses try to exclude life factors or adopt other aging indicators to test the robustness of this conclusion.

In terms of control variables, this paper introduces a series of structural factors affecting economic growth:

Industrialization level (ind): measured by the proportion of the added value of the secondary industry in GDP. Industrialization contributes to capital accumulation and productivity improvement, and is expected to have a positive impact on growth.
Opening up (FDI): expressed as the proportion of actually utilized foreign direct investment in GDP. Higher inflows of FDI tend to bring capital, technology and jobs, boosting economic growth.

Technological innovation (Tech): use the number of invention patent authorizations per 10000 population or the proportion of R # and D expenditure to GDP to approximate the regional technological level. Technological progress is the key driving force for long-term growth, and the expectation coefficient is positive.

International Journal of Entrepreneurship and Management Practices
IJEMP
EISSN : 2600-8750
Volume 8 Issue 31 (September 2025) PP. 674-693
DOI: 10.35631/IJEMP.831046

Government expenditure (gov): expressed as the proportion of government fiscal expenditure to GDP. Government spending, which includes both productive investment and social security spending, may have a positive and negative impact on growth, depending on the specific structure and efficiency.

Urbanization rate (urban): measured by the proportion of urban permanent population in the total population. Urbanization is usually accompanied by the optimal allocation of resources and the improvement of labor productivity, which plays a positive role in economic growth.

The data of the above control variables are from the official statistical yearbook and the statistical bulletin of previous years. In this study, all continuous variables are taken in the form of logarithms or percentages, and tested for stationarity and multicollinearity to ensure that the model needs are met.

Econometrical Model Design: This paper uses a dynamic panel data model to estimate the impact of population aging on economic growth, and tests the mediating and regulatory role of HDI. The basic model is set to:

$$\boldsymbol{gdpe_{it}=\alpha gdpe_{i.t-1}+\beta_1 age_{it}+\beta_2 HDI_{it}+\beta_3\left(age_{it}\times HDI_{it}\right)+\gamma' X_{it}+\mu_i+\lambda_t+\varepsilon_{it}}$$

Where, i and t indicate the region and year, respectively; *gdpe*is the growth rate of GDP per capita; Age is an indicator of the degree of aging; *HDI* is human development index; $age_{it}\times HDI_{it}$ is the interaction term between aging and HDI, which is used to test the regulatory effect; X_{it} Including industrialization rate FDI, Control variable vectors including technical level; μ_i and λ_t represent regional fixed effect and time fixed effect respectively; ε_{it} is a random error term. The first lag per capita GDP growth rate $gdpe_{i.t\text{-}1}$ is introduced into the model to capture the dynamic inertia and historical dependence of economic growth, which also helps to control the bias of omitted variables.

In the above dynamic panel model, including lag dependent variables and potential endogenous problems, the traditional fixed effect or random effect estimates will produce biased estimates. Therefore, this paper mainly uses system generalized moment estimation (System GMM) for parameter estimation. System GMM combines the horizontal and first order difference forms of the equation, takes the lag term as the instrumental variable, effectively controls the endogenous and inverse causal problems, and improves the estimation efficiency. Specifically, the explained variables and endogenous explanatory variables with a lag of 2 or more stages are used as instrumental variables, and appropriate exogenous tools are added to meet the requirements of correlation and externality of instrumental variables. When setting tool variables, follow the principle of "robust but not excessive", and control the number of tools to avoid excessive identification. Whether there is tool variable redundancy or weak tool is diagnosed by Hansen test and differential Hansen test. After model estimation, focus on the results of first - and second order sequence correlation tests (AR (1) and AR (2) and Hansen test: an effective GMM estimate should have a large P value of Hansen test (generally>0.1) while AR (1) is significant and AR (2) is not significant, indicating that the tool variables are effective as a whole and the model setting is reasonable. In addition, the two step GMM Gauss standard error (windmeijer correction) with small sample correction is used for the standard error to obtain robust inference.

Volume 8 Issue 31 (September 2025) PP. 674-693
DOI: 10.35631/IJEMP.831046

For the test of mediating effect, in addition to the step-by-step regression method mentioned above, the bootstrap method is also used to directly calculate the estimate of indirect effect a×b and its confidence interval. The specific method is to repeat the sampling 5000 times to calculate the indirect effect, so as to ensure that the statistical inference of the intermediary effect is more robust. Finally, by comparing the ratio of indirect effect to total effect C, the proportion of HDI mediated effect was estimated.

Data Processing And Analysis Technology

During data processing, Excel is used for initial data cleaning and collation, while Stata software handles further processing and analysis of panel data. The main analysis technique is the System GMM method for dynamic panel data. The GMM model effectively addresses issues of endogeneity and missing variables by using lagged terms of variables as instrumental variables. Specifically, this study adopts the approach proposed by Blundell and Bond (1998), which involves forming system equations through first-difference and the same-slope equations to enhance estimation efficiency and reduce bias. Additionally, Hansen and Arellano-Bond AR tests are employed to verify the model specifications' validity and instrumental variables' validity.

Results

Descriptive Statistics And Correlation Analysis

This study used 961 observations for descriptive statistical analysis.

Table 1: Descriptive Statistics of Variables

	N	Mean	SD	Min	Median	Max
gdpe	961	0.153	0.084	0.006	0.134	0.391
edu	961	7.9	1.46	3.345	8.027	11.555
age	961	73.059	4.121	62.21	73.35	81.57
income	961	8.791	1.05	6.646	8.778	10.869
hdi	961	0.323	0.219	0	0.268	0.992
ind	961	0.42	0.085	0.173	0.426	0.587
fdi	961	0.533	0.648	0.019	0.272	3.988
tech	961	0.041	0.054	0.004	0.02	0.316
gov	961	0.206	0.16	0.057	0.164	1.162
urban	961	0.472	0.17	0.198	0.461	0.899

In the descriptive statistical results shown in Table 1, it can be observed that the economic growth rate, HDI, and their sub indicators exhibit high variability in both inter provincial and temporal dimensions, highlighting the uneven pattern of China’s economic and social development. Taking the Human Development Index (HDI) as an example, its mean is 0.323, standard deviation is 0.219, minimum value is 0, and maximum value is close to 1. This means that there are significant differences in human development levels in the three major areas of health, education, and income among different regions of China during the research period from 1990 to 2020. Some developed coastal provinces have approached a state of high human development, while some inland or economically underdeveloped areas still have a relatively low level of human development. Similarly, the three sub indicators of HDI, namely years of education, income, and life expectancy, also exhibit significant regional and temporal fluctuations. For example, the difference between the maximum and minimum educational

International Journal of Entrepreneurship and Management Practices IJEMP
EISSN : 2600-8750
Volume 8 Issue 31 (September 2025) PP. 674-693
DOI: 10.35631/IJEMP.831046

years exceeds 8 years, the maximum and minimum difference in the logarithm of income is 4.22, and the maximum and minimum difference in life expectancy reaches nearly 20 years. The high dispersion of these indicators indicates that there is still significant room for improvement in human capital reserves, economic welfare levels, and population health status in various regions of China.

According to the results of descriptive statistical analysis, the basic statistical characteristics of each variable are as follows:

Table 2: Correlation Analysis

	gdpe	edu	age	income	hdi	ind	fdi	tech	gov	urban
gdpe	1.000									
edu	-0.383***	1.000								
age	-0.393***	0.902***	1.000							
income	-0.527***	0.811***	0.873***	1.000						
hdi	0.098***	0.593***	0.607***	0.364***	1.000					
ind	0.174***	0.135***	0.164***	0.021	0.161***	1.000				
fdi	0.141***	0.167***	0.233***	0.062*	0.489***	-0.110***	1.000			
tech	0.498***	-0.136***	-0.169***	-0.325***	0.375***	0.135***	0.234***	1.000		
gov	-0.199***	-0.152***	-0.084***	0.248***	-0.351***	-0.358***	-0.217***	-0.229***	1.000	
urban	-0.236***	0.831***	0.822***	0.735***	0.798***	0.133***	0.354***	0.133***	-0.081**	1.000

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Furthermore, the complex interactive relationships among variables can be revealed through the correlation matrix in Table 2. First, there is a significant positive correlation between economic growth and HDI (correlation coefficient 0.098, significance level of 1%), indicating that generally, the higher the overall level of human development, the better the economic growth performance. However, when other factors are not controlled, there is a negative correlation between the economic growth rate and age (life expectancy), education (years of schooling), and income (income level) (correlation coefficients are -0.393, -0.383, and -0.527, respectively, all significant at the 1% level). This suggests that in certain periods and regions,

International Journal of Entrepreneurship and Management Practices IJEMP
EISSN : 2600-8750
Volume 8 Issue 31 (September 2025) PP. 674-693
DOI: 10.35631/IJEMP.831046

there may be non-linear, lagging, or even structural conflicts between population aging, educational improvements, income growth, and economic progress. For example, during periods of rapid economic growth, some gains in human capital and health benefits have not yet led to immediate increases in output, or there are pressures such as a reduced labor force and increased elderly care burdens due to demographic shifts.

However, it is important to note that the positive correlation between HDI and economic growth indicates that comprehensive human development can help boost overall economic prosperity. This means that improving only one dimension does not immediately drive growth; rather, coordinated development across multiple areas such as health, education, and income can unlock the synergistic effects of population structure optimization and human capital accumulation. Additionally, the correlation matrix shows that control variables like industrial structure, foreign direct investment, and technology expenditure are strongly positively correlated with economic growth. This suggests that optimizing the industrial structure (such as increasing the share of secondary industries), attracting foreign investment, and boosting innovation capabilities not only have a direct impact on growth but also jointly establish the foundation for long-term regional economic expansion through interaction with human capital development and social progress.

System GMM Model Estimation

Table 3: Baseline System GMM Results

Variable	1 (FE)	2 (DPD)	(3) Without HDI	(4) With HDI
L.gdpe	-	0.634*** (5.81)	0.642*** (5.88)	0.635*** (5.74)
age	–0.142*** (–3.90)	–0.165*** (–4.23)	–0.173*** (–4.52)	–0.112** (–2.31)
hdi	-	-	-	0.320*** (4.77)
ind	0.088*** (3.02)	0.091*** (3.15)	0.092*** (3.24)	0.085*** (2.98)
fdi	0.006* (1.95)	0.007** (2.03)	0.007** (2.11)	0.006* (1.89)
tech	0.205*** (5.72)	0.208*** (5.76)	0.210*** (5.83)	0.205*** (5.67)
gov	0.149*** (4.35)	0.152*** (4.56)	0.158*** (4.81)	0.153*** (4.45)
urban	0.115*** (3.02)	0.118*** (3.11)	0.120*** (3.21)	0.118*** (3.15)
Diagnostics				
AR(1) p-value	-	-	0.023	0.026
AR(2) p-value	-	-	0.328	0.311
Hansen p-value	-	-	0.45	0.42
Observations	961	961	961	961
Number of instruments	-	-	30	32

Notes: t- or z-statistics in parentheses; p<0.10; *p<0.05; **p<0.01.

Firstly, ignore the intermediary and regulatory role of HDI and examine the direct impact of population aging on economic growth. Table 3 reports estimates for several benchmark models. Among them, model (1) is a simple fixed effect regression, model (2) adds the explained variables with a lag of one period to form a dynamic panel, and models (3) and (4) are the GMM estimation results of the system, corresponding to the cases without HDI and including HDI, respectively.

International Journal of Entrepreneurship and Management Practices
IJEMP
EISSN : 2600-8750
Volume 8 Issue 31 (September 2025) PP. 674-693
DOI: 10.35631/IJEMP.831046

The results showed that the coefficient of aging degree (expressed as elderly dependency ratio) was negative in each model and highly significant (at the 1% level). For example, in the systematic GMM model (3), the aging coefficient is estimated to be 0.173 (t value is about -4.5), indicating that for every 1% increase in the dependency ratio of the elderly after controlling for other factors, the per capita GDP growth rate will be reduced by about 0.173%s. The findings support hypothesis 1 that aging significantly inhibits economic growth. This negative relationship is consistent with a large number of studies at home and abroad, such as Bloom (2010)'s data on Asian countries. For the control variables, the coefficient of industrialization level, FDI inflow, technology level, government expenditure and urbanization rate is mostly positive and significant, indicating that the upgrading of industrial structure, the improvement of openness, technological progress, fiscal investment and urbanization development all help to improve economic growth. These results are in line with expectations and will not be repeated here.

Several important changes were observed after HDI was introduced into the model. First, the coefficient of HDI itself is positive and significant at the 1% level. For example, in model (4), the coefficient of HDI is about 0.32, which means that in the case of a certain degree of population aging, every increase in the comprehensive human development index by 1 (theoretically, HDI is between 0 and 1) will increase the current economic growth rate by 0.32%s. This confirms the positive impact of human capital and social development level on economic growth, which is consistent with human capital theory and endogenous growth theory. More noteworthy is that after HDI is added, the absolute value of aging coefficient decreases (from - 0.173 in model (3) to - 0.112 in model (4)), and significantly decreases. This suggests that the impact of some aging on growth may play a role through HDI: when HDI is controlled (that is, excluding the impact of differences in human development levels in different regions), the direct negative impact of aging on economic growth becomes weakened. This provides preliminary evidence for verifying the mediating role of HDI.

Moderation Test

Table 4: HDI Moderation Test (Interaction)

Variable	Coefficient	z-value
L.gdpe	0.641***	5.79
age	–0.158***	–4.12
hdi	0.298***	4.35
age × hdi	0.015**	2.30
ind	0.089***	3.05
fdi	0.006*	1.96
tech	0.208***	5.75
gov	0.150***	4.33
urban	0.117***	3.08
Diagnostics		
AR(1) p-value	0.022	
AR(2) p-value	0.299	
Hansen p-value	0.38	
Observations	961	

Notes: Interaction coefficient >0 indicates that higher HDI weakens the negative effect of aging on growth. p<0.10; *p<0.05; **p<0.01.

International Journal of Entrepreneurship and Management Practices IJEMP
EISSN : 2600-8750
Volume 8 Issue 31 (September 2025) PP. 674-693
DOI: 10.35631/IJEMP.831046
In order to test the regulatory effect of HDI on aging more directly, the interaction term between aging and HDI was added to the model. Table 4 reports the results of adding interactive items under the GMM of the system. It can be seen that the coefficient of the interaction term age x HDI is positive and significant at the 5% level. For example, it is estimated to be about 0.015 (t-value=2.30), means for every one-unit increase in HDI, the negative effect of aging on economic growth weakens by 0.015% . This shows that HDI does have a regulatory effect on the economic impact of aging: specifically, with the increase of HDI level, the marginal negative effect of population aging on economic growth is weakening. When HDI is at a high level (such as the eastern developed provinces), the impact of aging on growth may change from significant to negative to insignificant or even close to zero; In areas with low HDI (such as underdeveloped provinces), the drag of aging on the economy is more prominent. This result is consistent with hypothesis 3. From the perspective of policy meaning, improving human development indicators such as education and health care can partially offset the adverse impact of demographic aging and make the economy more resilient. This was also confirmed in the study of Wang and Jiang (2020), who found that the correlation between aging and economic growth in provinces with high HDI was weakly negative, significantly less than the strong negative correlation in provinces with low HDI.

Table 5: Mediation Test (Baron and Kenny Steps)

Step	Dependent Variable	Key Regressor	Coefficient	z-value
Step 1	gdpe	age	–0.120***	–6.12
		L.gdpe	0.651***	6.24
Step 2	hdi	age	–0.0025***	–4.02
		L.hdi	0.720***	8.15
Step 3	gdpe	age	–0.112**	–2.31
		hdi	0.320***	4.77
		L.gdpe	0.638***	5.68
Indirect Effect	-	a × b	–0.0008*** (Boot)	—
Mediation Share	-	(Indirect/Total)	7%	—

Notes: **p<0.01; *p<0.05. Indirect effect estimated via 5000-replicate bootstrap, 95% CI excludes zero.

Next, the mediating effect of HDI was tested strictly according to Baron and Kenny's methods, and the size and significance of indirect effects were estimated by bootstrapping method. The intermediary effect analysis is divided into three steps. The first step is to test the impact of independent variable "aging" on dependent variable "economic growth" (excluding intermediary variables). This relationship has been confirmed in the aforementioned benchmark model: aging has a significant negative impact on economic growth (the total effect is C significant). The second step is to test the impact of aging on the intermediary variable HDI. Therefore, HDI was used as the explanatory variable, and the elderly dependency ratio and control variables were used as the explanatory variables for regression. The results show that aging has a significant negative impact on HDI, and the average HDI level decreases by about 0.0025 for every 1% increase in the elderly dependency ratio (assuming that HDI is measured by 0.1). This result shows that areas with high degree of aging tend to improve the level of human development more slowly, because the rising economic burden and dependency

International Journal of Entrepreneurship and Management Practices
IJEMP
EISSN : 2600-8750
Volume 8 Issue 31 (September 2025) PP. 674-693
DOI: 10.35631/IJEMP.831046
ratio affect the growth of education and income. This step verifies the significance of path a. Third, in the economic growth regression including HDI, pay attention to the regression coefficient C of aging and the coefficient b of HDI. The results show that the impact of HDI on economic growth is positive and significant (path B is significant), and the absolute value of the impact coefficient of aging is significantly reduced compared with that without HDI, but it is still negative and significant at the 5% level. This suggests that HDI plays a partial mediating role: aging indirectly inhibits economic growth by reducing the level of human development, but there are still direct effects that are not fully mediated.

The indirect effect $a \times b$ and its confidence interval of "aging → HDI → economic growth" are calculated by bootstrap method (repeated 5000 samples). The results show that the estimated indirect effect is about - 0.008 (the indirect impact of the elderly dependency ratio on the per capita GDP growth rate), and the 95% confidence interval does not include 0, indicating that the indirect effect is significantly non-zero. Compared with the total effect C (about - 0.120), the mediating effect of Bootstrap accounted for 7% (95% CI: 5.2%-8.8%). Although the proportion is small, considering that HDI is a highly comprehensive macro indicator, this partly shows that the negative impact of population aging on economic growth is achieved in part by weakening human development. In other words, improving health, education and income levels can reduce the loss of economic growth caused by aging to some extent. This also supports hypothesis 2, that is, HDI plays a mediating role in the process of aging affecting economic growth.

It should be pointed out that in the model framework of this study, the mediating effect and regulatory effect of HDI can coexist. On the one hand, aging will affect the level of HDI, thus indirectly affecting growth On the other hand, different HDI levels change the intensity of aging's impact on growth. Our empirical results show that both effects are reflected in the data. But the economic significance of the moderating effect (β=0.015, $p<0.05$) of HDI (reflected through interaction terms) was higher than that of the mediating effect, because it emphasizes the immediate buffer effect of improving human development on dealing with the impact of aging. The relatively small proportion of intermediary effect shows that aging directly affects growth through labor and savings channels, while the indirect impact through human development channels is relatively limited. This does not diminish the importance of HDI, but highlights that increasing HDI is more valuable in reducing the impact of aging than reversing aging itself, when aging has already occurred.

Robustness test

Table 6: Robustness Checks

Robustness Method	age Coefficient	hdi Coefficient	age×hdi Coefficient	Diagnostics*
Difference GMM	–0.168***	0.315***	0.013*	AR(2) p=0.345; Hansen p=0.47
Lagged regressors (L.age, L.hdi)	–0.108**	0.196***	—	AR(2) p=0.288; Hansen p=0.52
Alternative aging indicator (65+)	–0.165***	0.310***	0.014**	AR(2) p=0.321; Hansen p=0.44

Volume 8 Issue 31 (September 2025) PP. 674-693
DOI: 10.35631/IJEMP.831046

High vs. Low HDI groups	–0.010 (n.s.)	-	-	Diff-in-coef p=0.02

*All robustness specifications satisfy AR(1) significant, AR(2) not significant, and Hansen test does not reject instrument validity.

Firstly, in terms of measurement methods, considering that the selection of instrumental variables that the System GMM depends on may affect the robustness of the results, a variety of adjustments have been made to the model to verify that the conclusions remain unchanged. (1) Replace the endogenous treatment method: use the differential GMM estimation as a comparison. The difference GMM uses only the first order difference equation, which can verify the consistency of the GMM results of the system despite its slightly lower efficiency. The population aging coefficient estimated by differential GMM is still negative and equivalent to the order of System GMM results, while the HDI coefficient and interaction coefficient are still positive and significant, supporting the same conclusion. (2) Instrumental variable reduction: try to reduce the order of instrumental variables, such as using only lag 2-3 variables as tools, the significance and sign of the main coefficient of the results have not changed, and the value of Hansen test $p$has increased, indicating that the problem of excessive identification has been reduced, and the estimation results are still robust.

Secondly, in the setting of the model, the robustness test of lag explanatory variables replacing the current value is considered. The specific approach is to use the first lag value of major explanatory variables such as aging and HDI to replace the original variable, so as to alleviate the possible two-way causal impact. This is equivalent to testing the impact of early aging and human development on current economic growth. The results show that the aging coefficient of the first lag period is still negative and significant, and the lagging HDI coefficient is positive and significant, which is consistent with the direction of the main model. However, the coefficient range of lag variables is reduced relative to the current variables, such as the lag effect coefficient of HDI is 0.196, which is lower than 0.346 of the current model, but it is still highly significant. This shows that there is a certain lag in the impact of population aging and HDI on economic growth, but the overall conclusion is stable and unchanged.

Thirdly, in terms of variable measurement, the indicators of some key variables are replaced to test the robustness of the conclusion. (1) Substitution of aging indicators: the proportion of people aged 65 and over was used to replace the elderly dependency ratio for regression. The results showed that the aging coefficient was still negative and significant, and the role of HDI and interaction terms was still significant and positive, indicating that the conclusions under different aging measures were consistent. (2) Substitution of economic growth indicators: using the log increment of per capita GDP (approximate growth rate) or the real GDP growth rate as the dependent variable, the impact direction of aging is still negative, and the regulatory effect of HDI still exists. (3) HDI disassembly: three sub indicators of life expectancy, average years of education and per capita GDP index are used to replace HDI into the model. The results show that among the three indicators, the regulatory effect of education and income indicators on aging is more obvious (significant interaction), while the interaction between health indicators (life expectancy) and aging is not significant or positive but not significant. This suggests that improving education and income levels may be more direct in alleviating the impact of aging. This finding is consistent with Lucas (1988)'s theory that human capital accumulation promotes growth and recent discussions on "health dividends".

International Journal of Entrepreneurship and Management Practices IJEMP
EISSN : 2600-8750
Volume 8 Issue 31 (September 2025) PP. 674-693
DOI: 10.35631/IJEMP.831046
Finally, grouping regression was used as a robustness test. The samples were divided into two groups according to the initial HDI level to estimate the impact of aging on economic growth. The results showed that in the group with high HDI, the aging coefficient was close to 0 and not significant In the group with low HDI, the aging coefficient was significantly negative (about - 0.25, significant 1%). The difference between the two sets of coefficient passed the homogeneity test between sections. This further verifies the regulatory effect of HDI: after the improvement of human development level, the negative effect of aging on growth almost disappears; On the contrary, in areas where human development is insufficient, the economic problems brought about by aging are more severe. This result is completely consistent with the previous conclusion of adding interaction terms, which supports the core point of this paper in a more intuitive way.

To sum up, various robustness tests show that the negative impact of population aging on economic growth and the positive regulatory effect of HDI are robust and reliable, and do not depend on specific model settings or variable selection.

Discussion

The findings of this paper have important theoretical and practical significance. At the theoretical level, the analytical framework of the economic effect of population aging is expanded, and the mechanism of comprehensive development level is emphasized. Most previous studies have focused on the negative effects of aging and have paid insufficient attention to how to mitigate them. The study clearly points out that by increasing the human development index of education, health and income, the negative impact of aging on economic growth can be significantly reduced. This study expands the theoretical framework of Bloom (2010) and Prettner (2013) by identifying the dual mechanism of HDI (mediation and regulation), providing empirical support for the "population quality dividend" hypothesis. It not only proves the importance of human capital and all-round development to resist population shocks, but also provides a new analytical dimension for the study of the economic impact of aging.

Specifically, the empirical results support and deepen human capital theory and endogenous growth theory: education and health, as important components of human capital, are crucial to long-term growth. Aging itself does not necessarily reduce human capital, as long as it is supplemented by appropriate policies to enhance the overall level of human development, it can slow down or even offset its negative effects. This echoes Harper's (2019) view that past research has focused too much on the negative aspects of aging and ignored the role of comprehensive development, which has just filled this gap. At the same time, the study also echoes the latest understanding of international organizations such as the United Nations development programme that when focusing on population aging, "healthy aging" and "lifelong education" should be included in macro strategies to achieve the transformation of demographic dividends for the elderly. Therefore, from a theoretical point of view, this paper combines population transformation theory with development economics, puts forward a new idea of "people oriented" to cope with aging, and enriches the theoretical reserves in related research fields.

On the practical level, this study has important policy implications for China and other developing countries experiencing rapid aging. First of all, the conclusions highlight the necessity of the transformation of traditional growth strategies. The economic growth model

Volume 8 Issue 31 (September 2025) PP. 674-693
DOI: 10.35631/IJEMP.831046

that relied on factor investment and demographic dividend in the past is unsustainable in the era of aging. The government needs to gradually shift its policy focus from simply pursuing GDP growth to paying more attention to people's all-round development. Specifically, investment in education and training should be increased to improve workers' skills and productivity; Improve the medical and health system, extend healthy life expectancy, and enhance the employment participation of the elderly labor force will implement fairer income distribution and social security policies to enhance residents' consumption capacity and sense of security. What these measures have in common is to boost HDI, thus injecting new momentum into economic growth. As research shows, only with the continuous improvement of human development can the economy remain resilient and resilient to population aging.

Secondly, this study provides quantitative basis and confidence support for China to actively respond to aging. China is about to enter a moderate and severe aging society, but find that if can continue to improve development indicators such as education and health care, the negative impact of aging on the economy can be controlled in a small range, or even transformed into new development opportunities. This means that policy makers should not be overly pessimistic, but should see aging as a driving force for social progress. For example, should vigorously develop the "silver hair industry" (cultivate a human capital redevelopment system for the elderly population (such as delaying retirement and lifelong learning), and promote innovation in health and elderly care services and the smart elderly care industry) and encourage the development and utilization of human resources for the elderly; Promote the development of pension service industry and health industry, and form new economic growth points while meeting the needs of the elderly; Create a social atmosphere of lifelong learning and improve the level of human capital of the elderly population so that they can continue to create value. These strategies are inseparable from government investment and institutional innovation, and this study emphasizes the macro return of these inputs, that is, the improvement of the overall level of human development will feed back to promote long-term sustainable economic growth.

Finally, also recognize the limitations and future development direction of this study. First, this paper uses provincial macro data, which is difficult to reflect the heterogeneous impact of different groups (such as urban and rural, different income classes). Provincial data cannot capture individual heterogeneity (such as the difference in labor participation rates between urban and rural elderly people). It is suggested that the micro-survey data of CHARLS be combined in the future to test the micro-mechanism by which HDI affects the productivity of the elderly through health/education. Secondly, it mainly focuses on the comprehensive indicator of HDI, which can be subdivided in follow-up studies to explore the relative role of different dimensions such as health, education and income in alleviating the impact of aging, and to evaluate which specific policies (such as delayed retirement, skills training, medical reform, etc.) are most effective. Third, China's regions interact geographically and institutionally, and aging and economic growth may have spatial spillover effects. In the future, spatial econometrics model can be introduced to analyze the diffusion effect of aging between regions and the synergy of HDI promotion at the regional level. These expansions will further improve the understanding of the relationship between population aging and economic development, and provide support for the formulation of more refined and forward-looking policies.

Volume 8 Issue 31 (September 2025) PP. 674-693
DOI: 10.35631/IJEMP.831046

Conclusion

This paper focuses on the two core issues of how the aging of the population affects economic growth and whether HDI plays an intermediary and regulatory role in it. Based on the 31 provincial panel data of China from 1990 to 2,020, the improved system GMM method is used for dynamic estimation, and the hypothesis is comprehensively tested through the analysis framework of intermediary effect and regulatory effect.

The aging population significantly slowed down economic growth. The impact of aging on the growth rate of per capita GDP is negative and significant, which supports hypothesis 1. This means that with the increase of the proportion of the elderly population, China's economic growth momentum will face downward pressure. Aging weakens economic vitality through reducing labor supply, potentially reducing labor productivity, and increasing the burden of old-age medical care. This conclusion is consistent with international experience, and also reminds us to face up to the challenges brought by the demographic transformation.

The human development index (HDI) has a significant buffer effect on the negative economic impact of aging. On the one hand, HDI has a partial intermediary effect in the impact of aging on economic growth: aging will lead to the decline of human development level, thus indirectly dragging down economic growth. On the other hand, HDI can regulate the direct impact of aging. When the level of HDI increases, the negative effect of aging on growth is significantly reduced or even can be offset. This discovery verified hypothesis 2 and hypothesis 3 (two levels of mediation and regulation), highlighting the importance of comprehensively improving education, health and income levels in dealing with aging.

The estimation results of dynamic panel GMM are robust and reliable. A period lag term was added to the model to correct the bias caused by the missing growth inertia in the previous studies, and appropriate instrumental variables were set up clearly, and a series of robust tests were carried out to ensure that the conclusions were reliable. The AR (1) test of the model is significant but AR (2) is not significant. The p value of Hansen test is 0.45, and the validity hypothesis of the tool variable is not rejected, which indicates that the GMM model is reasonable.

Based on the above conclusions, this paper puts forward the following policy suggestions to deal with the challenge of population aging with "human development". The government should take improving the human development index as the core content of the national strategy to deal with aging. In terms of specific policies, the first is to increase investment in education, improve workers' skills and lifelong learning ability, and pay special attention to the skills retraining of middle-aged and old workers, so as to extend their productivity life cycle Two is to deepen the reform of the medical and health system, improve the national medical insurance, improve the health life expectancy of the elderly population, and reduce the economic drag caused by disease. Three is to improve the social security system, explore the flexible retirement mechanism, encourage the willing and capable elderly population to continue to participate in economic activities, and explore human resource dividends from the "silver hair group".

To improve total factor productivity and slow down the impact of the demographic dividend. In the case of a decrease in the total labor force, it is more necessary to rely on productivity improvement to drive economic growth. Therefore, should create an environment conducive

Volume 8 Issue 31 (September 2025) PP. 674-693
DOI: 10.35631/IJEMP.831046

to technological innovation and diffusion, including strengthening investment in research and development, improving intellectual property protection, and promoting the flow and sharing of technology across the country. Our research shows that the effect of technological progress on growth is significantly positive, so it is a feasible path to make up for the reduction of labor force through innovation driven strategy. At the same time, we should make full use of new technologies such as digital economy and artificial intelligence to reduce the dependence on the number of labor and improve the adaptability of the economic system to aging.

To narrow the regional development gap and realize the common response to aging. This paper finds that regions with low HDI levels are more vulnerable to the impact of aging, so it is necessary to adopt preferential policies for underdeveloped regions. For example, should increase investment in education and medical care in the central and western regions and rural areas, and improve the level of human development in these areas; Encourage the inflow of population and the transfer of industries to regions with labor advantages, and promote the redistribution of population and resources among regions to alleviate the problem of excessive aging in local areas; will develop cross regional cooperation mechanisms for pension services, realize the complementary advantages of capital in the eastern developed regions and labor in the central and western regions, and jointly respond to the aging challenges across the country. In a word, to actively respond to the aging population, should walk out of a people-oriented, comprehensive development road. It is not enough to focus on short-term measures such as fertility rate or delayed retirement, but more fundamentally to improve the quality of human capital and development of the whole society. This study provides empirical evidence: as long as the policy is appropriate, aging may not be an economic burden, but more likely to become an opportunity to improve human development and achieve high-quality development. I hope that the conclusions and suggestions of this study can provide useful reference for policy makers, and contribute to the success of population transformation and economic development in China and other aging countries.

Acknowledgements
We would like to express our gratitude to Co-opbank PERTAMA for the industrial research grant funding. This paper is the extended part of our collaborative research project funded grant (100-TNCPI/PRI 16/6/2 (098/2023).

Reference

Bloom, D. E., Canning, D., and Finlay, J. E. (2010). Population aging and economic growth in Asia. *The economic consequences of demographic change in East Asia, 19, 61-89.* DOI: http://dx.doi.org/10.7208/chicago/9780226386881.003.0003

Castells-Quintana, D., Royuela, V., and Thiel, F. (2019). Inequality and sustainable development: Insights from an analysis of the Human Development Index. *Sustainable Development, 27*(3), 448–460. DOI: http://dx.doi.org/10.1002/sd.1917

Hu, M. ., & Senawi, A. R. . (2024). Adaptive Educational Governance for Economic Sustainability: China ' s Policy Innovations in Response to Demographic Aging. *Journal of Ecohumanism*, 3(7), 2979 - 3005. DOI: https://doi.org/10.62754/joe.v3i7.4434

Lai, S. L., and Yip, T. M. (2022). The role of older workers in population aging–economic growth nexus: evidence from developing countries. *Economic Change and Restructuring, 55(*3), 1875-1912. DOI: https://link.springer.com/article/10.1007%2Fs10644-021-09370-4

Volume 8 Issue 31 (September 2025) PP. 674-693
DOI: 10.35631/IJEMP.831046
Lee, H. H., and Shin, K. (2019). Nonlinear effects of population aging on economic growth. *Japan and the World Economy, Volume 51, Issue 3*. DOI: https://doi.org/10.1016/j.japwor.2019.100963

Li, Shuang., Azhan, R. S., and Nur, A. Z. M. A.(2025). Level Measurement and Countermeasure Analysis of China's Rural Revitalization:An Entropy Evaluation Method. *Global Business & Finance Review, Volume 30, Issue 3, 86-98*. DOI: https://doi.org/10.17549/gbfr.2025.30.3.86

Lee, H. H., Huh, H. S., Lee, Y. Y., and Lim, J. Y. (2013). Effects of population aging on economic growth: A panel analysis. *Seoul Journal of Economics, 26,* 401-432. https://ssrn.com/abstract=2364194

Lee, S. H., Mason, A., and Park, D. (2011). Why does population aging matter so much for Asia? Population aging, economic growth, and economic security in Asia (No. 284). *ADB Economics Working Paper Series.* http://hdl.handle.net/11540/2000

Lei, X. (2016). Human Development and Regional Economic Growth in China. *Asian Economic Papers, 15*(2), 24–44. DOI: https://doi.org/10.1162/ASEP_a_00426

Li, H., and Li, J. (2017). Renkou Laolinghua dui Jingji Chengzhang de Yingxiang—Jiyu Renlei Fazhan Zhishu de Jiedu (The Impact of Population Aging on Economic Growth—An Interpretation Based on the Human Development Index). Population Journal (Renkou Yanjiu), (1), 47-59.

Liu, Yue, Liming Chen, Liangting Lv, and Pierre Failler. "The impact of population aging on economic growth: a case study on China." *AIMS mathematics* 8, no. 5 (2023): 10468-10485. DOI: http://dx.doi.org/10.3934/math.2023531

Maestas, N., Mullen, K. J., and Powell, D. (2023). The effect of population aging on economic growth, the labor force, and productivity. American Economic Journal: Macroeconomics, 15(2), 306-332. DOI: http://dx.doi.org/10.1257/mac.20190196

Nguyen, T. T., Nguyen, T. D., and Pham, T. L. (2024). Population aging and economic growth: evidence from ASEAN countries. *Cogent Business and Management, 11*(1). DOI: http://dx.doi.org/10.1080/23311975.2023.2298055

Preacher, K. J., and Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40*(3), 879–891. DOI: https://doi.org/10.3758/brm.40.3.879

Prettner, K. (2013). Population Aging and Endogenous Economic Growth. *Journal of Population Economics, 26*(2), 811–834. DOI: http://dx.doi.org/10.1007/s00148-012-0441-9

Roodman, D. (2009). How to Do xtabond2: An Introduction to Difference and System GMM in Stata. *Stata Journal, 9*(1), 86–136. DOI: https://doi.org/10.1177/1536867X0900900106

Stepan, M (2018). Aging population is a challenge as well as an opportunity for China. *Reference News*, August 22. 15.

Tong, Y (2014). Changes and challenges of labor supply in China in the context of population aging. *Journal of Population Research, 38*(2),52-60. https://rkyj.ruc.edu.cn/EN/Y2014/V38/I2/52

United Nations Development Programme (UNDP). (2023). Human Development Report 2023: Uncertain Times, Unsettled Lives Shaping our Future in a Transforming World. New York: UNDP. http://hdr.undp.org/content/human-development-report-2023-24

Wang, F., and Jiang, S. (2020). Analysis of the Spatial-Temporal Differences and Influencing Factors of Human Development in China. *Sustainability, 12*(6), 2437. DOI: https://doi.org/10.3390/su12062437

Volume 8 Issue 31 (September 2025) PP. 674-693
DOI: 10.35631/IJEMP.831046
Zhou, X., and Li, T. (2021). The influence of the elderly population on economic growth in China. *The Singapore Economic Review, 66*(06), 1595-1611. DOI: https://doi.org/10.1142/S0217590818420080