GCU Economic Journal, Volume LVII, 2024, pp. 100-124

Exploring the Impact of Population Aging on Economic Growth: Evidence from Selected Developed and Developing Countries

*Shahid Adil, **Muhammad Awais Ur Rehman &

***Iman Asif

Abstract: Population age structure is mainly impacted by economic changes, living standards and quality of life, pro-family policies, and advances in medical treatment. The present study investigates how population aging affects economic growth in selected developed and developing countries, specifically focusing on the impact of the aged dependency ratio, labor force participation rate, domestic savings and gross fixed capital formation (GFCF) on the GDP growth rate. The study utilizes panel data taken from the World Development Indicators (WDI), covering the period from 1971 to 2022. The estimation technique used is PMG (Pooled Mean Group) Panel ARDL (Autoregressive Distributed Lag) because the variables are integrated at different orders: some at level and others at first difference. The findings demonstrate that population ageing significantly slows growth process. However, the labor force participation rate, GFCF, and domestic savings positively contribute to economic progress.

Keywords: Population, Aging, Economic Growth, Panel ARDL

1. Introduction

Since the 1970s, increasing access to medical and reproductive health services has led to a higher life expectancy and an older population, but decreased reproductive capability. As a result, the population structure of most countries began to shift to a stage where the share of elderly people increased, leading to a new trend known as 'population aging' (Trong et al., 2024). Population aging is a major social transition that has become increasingly significant in the twenty-first century (United Nations, 2013). The term "population aging" refers to the phenomenon in which a

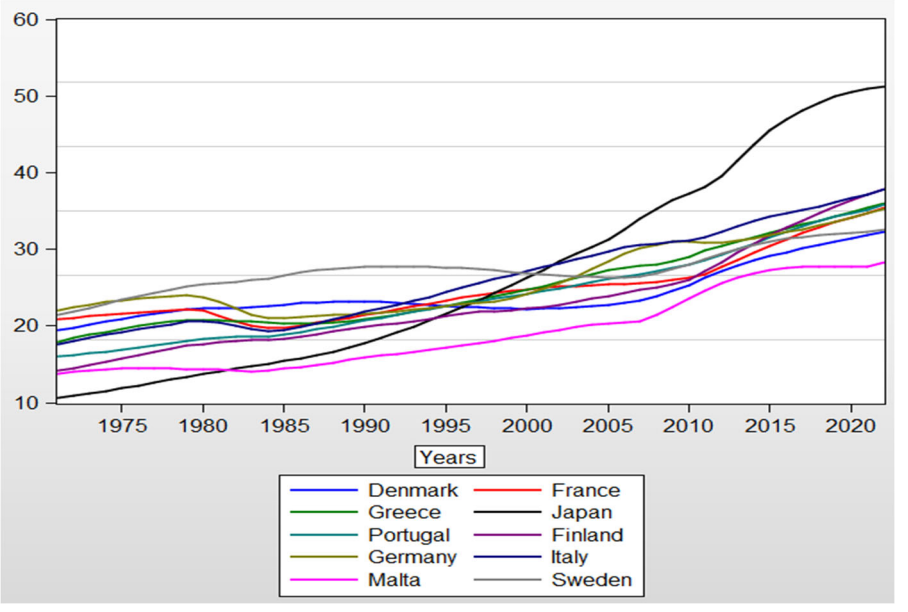
* Public Sector Specialist, Punjab Resource Improvement and Digital Effectiveness (PRIDE) Program-World Bank Funded, Government of the Punjab, Pakistan,
Email: Shahidadil313@hotmail.com
** M.PHIL Scholar, Department of Economics, University of Sargodha,
Email: Khalidawais1995@gmail.com
*** Student BS (Economics), Lahore University of Management Sciences (LUMS) Lahore-Pakistan

significant part of a country's population is comprised of elderly people (Yue, 2023). In other words, it is a shift in population towards older ages (Gavrilov & Heuveline, 2003). The structure of ageing population for most countries around the globe has seen a considerable transformation due to decreasing fertility rates, higher life expectancy at birth, and increased conditional life expectancy in the later stages of life. Therefore, many nations are experiencing a rise in the share of elderly persons in their populations (Lee et al., 2011) but in 2050 more of the aging population will be in developing countries (Shetty, 2012). Two-thirds of the world's aging population lives in developing nations, and their proportion is increasing more rapidly than in developed countries (United Nations, 2015). Many studies have demonstrated that the population aging can hinder economic progress. The rise in the older population results in a reduction in the proportion of young individuals, potentially lowering labor force participation. However, certain studies depict that older individuals do not inherently impede economic progress (Fougère et al., 2009). The media typically exaggerates concerns about population aging, which are frequently based on incomplete facts (Herrmann, 2012).

According to the United Nations (2017), in 1950, just 5.1 percent of the world population was 65 years of age or older; by 2000, this number had risen to 6.9 percent. Experts predicted that the proportion of elderly people in the global population will rise to 1.4 billion by 2030 and further to 2.1 billion by 2050. Further, it might potentially reach 3.1 billion by the year 2100. The net influence of these shifts is that by 2050, there will be a greater number of older individuals compared to adolescents and young adults, and the number of children under five will be more than doubled (United Nations 2019). Population ageing is often viewed as a fiscal and economic challenge for the near future (Yue, 2023). The issue of population aging is included in Sustainable Development Goals 2030 to ensure healthy lives, poverty eradication, provide productive employment, decent work for everyone, and the well-being of people of all ages (Sachs, 2012). As the population aging rapidly, the government needs to design innovative policies for older persons and give them healthcare, employment, housing, infrastructure, and social protection (Obi et al., 2013).

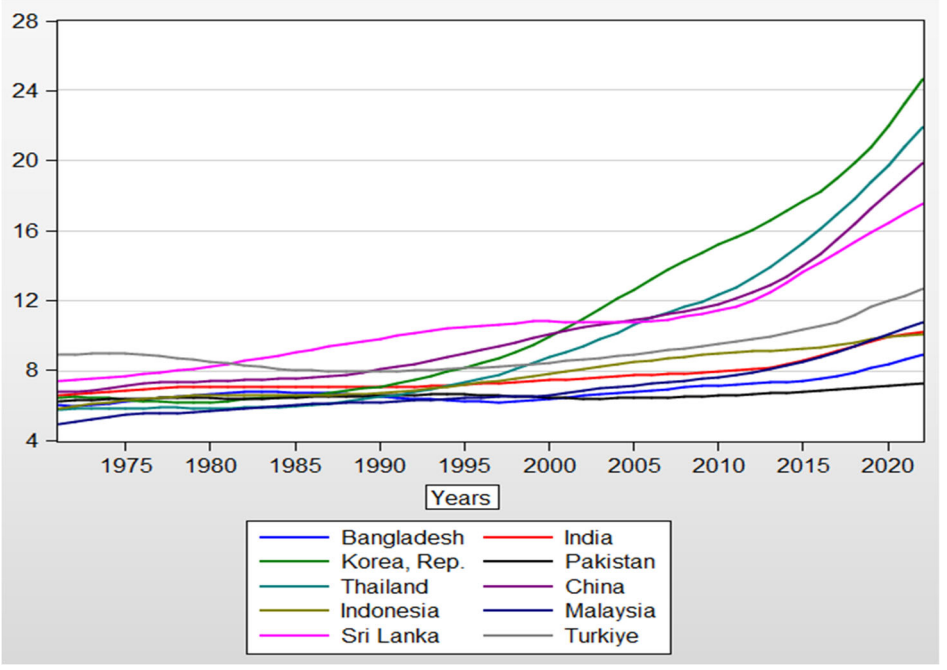
In Figure 1, the age dependency ratio of ten selected developed economies is given from 1971-2022. It is evident from the figure that, over time, there has been an increasing trend in the dependency ratio. In 1980 it ranged from 5 to 25 in all the countries while at the end of 2022, all had an age dependency ratio of more than 30 percent and in one country it was more than 50 percent. Figure 2 depicts a somewhat different story for developing economies over the same period. In 1980 the dependency ratio of all the selected countries was less than 10 percent and over time in some countries it showed a very sharp rise while in some countries it showed a very modest rise. At the end of 2022, four countries have an age dependency ratio of less than 10 while the remaining have higher than 10 and lower than 25 percent. The majority of developing countries have a sharply increasing trend. Therefore, it is significantly important to study the effect of the aging population on economic performance. Considering this fact, the present study is an attempt to investigate this phenomenon.

Figure 1: Age Dependency Ratio in Developed Economies (1971-2022)



Source: Author's rendering using data from World Bank, WDI

Figure 2: Age Dependency Ratio in Developing Economies (1971-2022)



Source: Author's presentation using data from World Bank, WDI

The structure of this paper is as follows: Section 2 presents an overview of the most recent scholarly works on the effect of population ageing on economic growth. Section 3 focuses on data, variable description and model specification. Section 4 describes the methodology and interpretation of results. Section 5 summarizes the study and suggests recommendations.

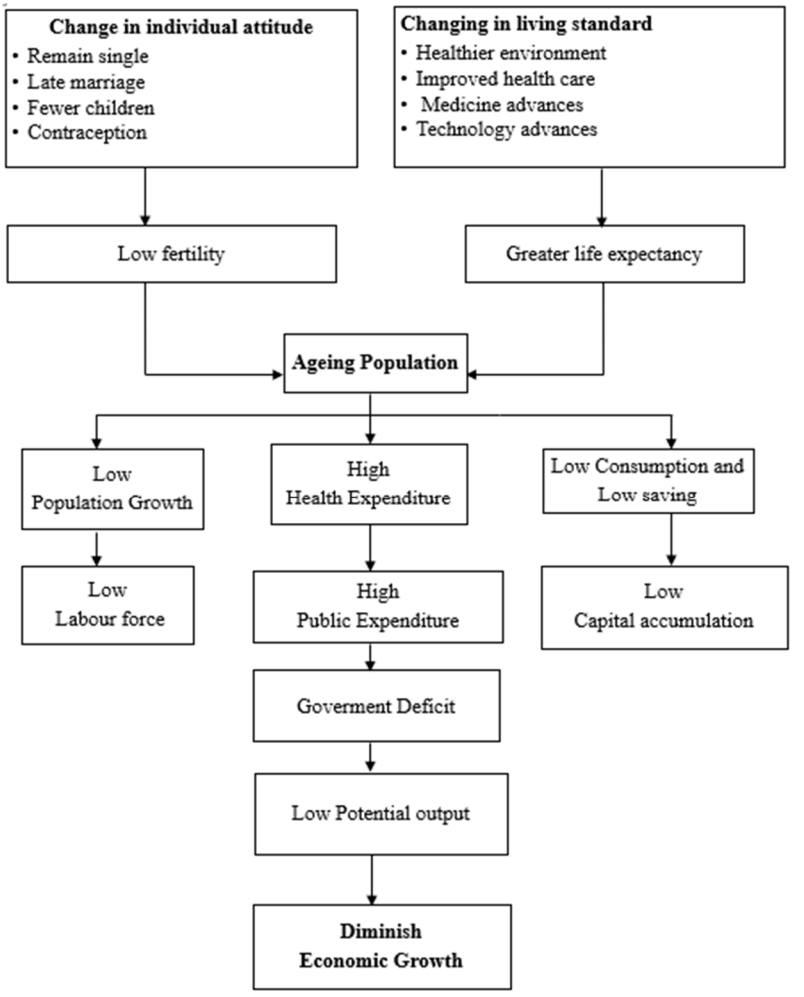
2. Review of Literature

The existing literature provides no consensus on the debate about the association between economic growth and ageing population. Two main theories exist on whether the population ageing promotes economic growth or not. One perspective suggests that the age structure of a country's population, particularly the proportion of elderly individuals,

can have a negative impact on the nation's productivity. This view is often referred to as the pessimistic theory (see

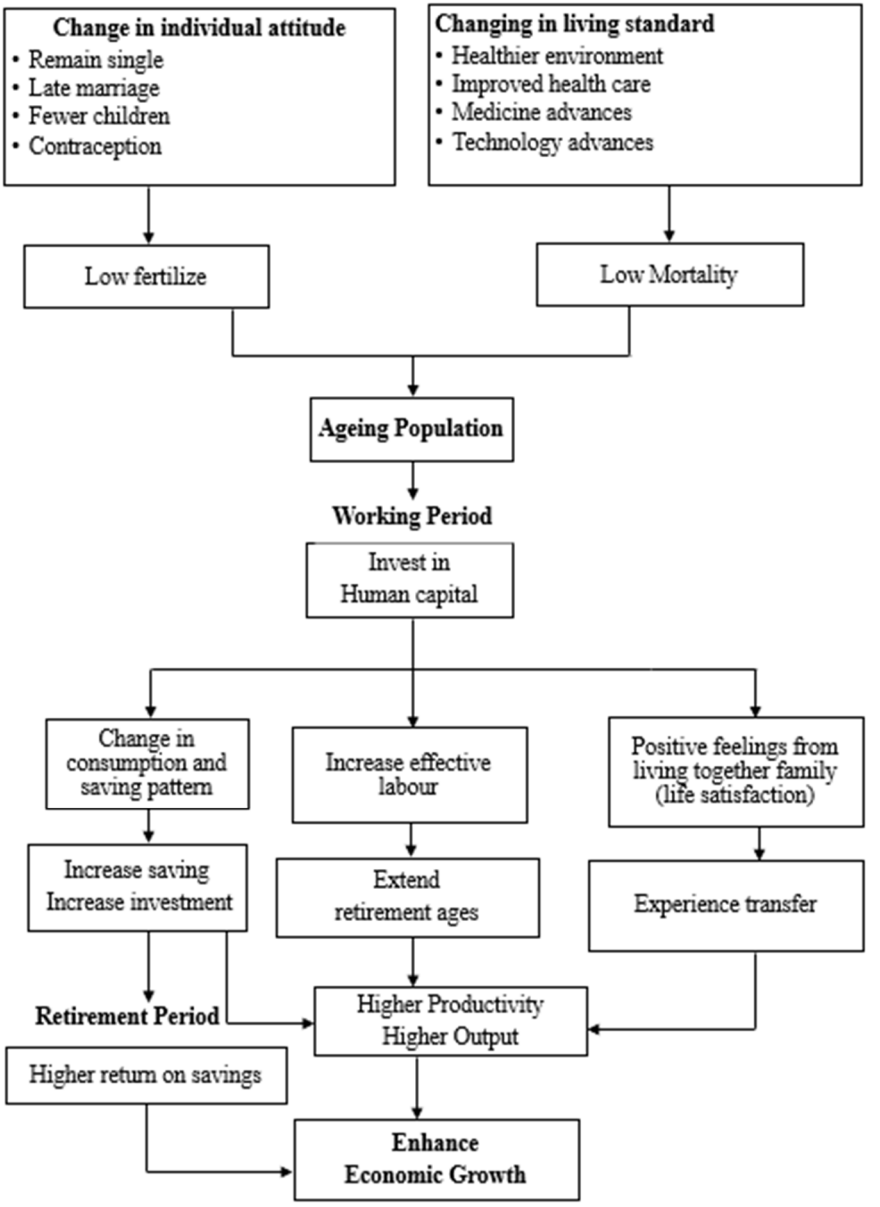
Figure 3). It is important to mention that in an aging society, several factors can have a significant impact on the economy. These include a reduction in savings rates and labor force participation, which can lead to reduced investments and real output. Additionally, fiscal problems are likely to arise, further affecting the overall economic situation (Young, 2018). As the number of elderly individuals increases, there will be a corresponding rise in healthcare demands and pension costs. This, in turn, will limit the amount of public funds available for investing in infrastructure. Unfortunately, this will negatively affect the accumulation of and productivity growth. Figure 4 shows the second perspective, which is the optimistic theory that there is a positive connection between economic growth and an aging population. Based on extensive research in the field, it has been observed that as individuals grow older, they tend to exhibit a greater inclination toward saving. This can be attributed to the fact that a longer lifespan often necessitates higher savings to adequately prepare for retirement. Consequently, the rise in life expectancy will result in a greater accumulation of savings and a surplus of resources available for investment.

Figure 3: The pessimist's perspective on the effect of the elderly population on economic progress



Source: Taken from Sukpaiboonwat, Plyngam, & Jaroensathapornkul (2014)

Figure 4: The optimist's perspective on the effect of an older population on economic progress



Source: Taken from Sukpaiboonwat, Plyngam, & Jaroensathapornkul (2014)

Extensive studies have been conducted on the association between an aging population and economic progress. Recent empirical research has identified a negative association. These impacts may arise from a decline in labor force participation, i.e., a decrease in the number of older people who are working but are not productive, or the gap between savings and investment due to aging, which can lead to a situation of secular stagnation. For instance, Trong et al. (2024) investigated the effects of ageing population on economic development in ASEAN countries. They utilized a dataset from 2001 to 2021 and employed the fixed effect model (FEM). The findings revealed that a high old-age dependency ratio negatively impacts the growth of GDP per capita. Conversely, in the ASEAN region, the productive workforce, or young labour, is a crucial asset for per capita growth and overall economic development. Besides demographic factors, trade openness, investment rates, and institutions are key drivers of the increase in GDP per capita. Furthermore, the study showed that countries with higher levels of development will experience faster population ageing. In contrast, Gao et al. (2023) highlighted that the ageing population has a mixed effect on economic progress. The study employed a spatial econometric model and an intermediary effect model, examining 31 provinces in China using data from 2013 to 2020. The findings indicated that population aging significantly affects technological innovation and ultimately economic development in eastern and central regions while it impedes technical advancements and economic progress in the western region.

Ferede and Dahlby (2023) studied the effects of population aging on per-capita output and labor productivity growth in Canada, using provincial information from 1981 to 2020. They found that a 10 percent increase in the proportion of elderly persons aged 65 and older correlates with a 0.23 percentage point decline in the growth rate of real GDP per capita. Liu et al. (2023) investigated the association between population aging and growth in 30 provinces of China from 2000 to 2019. The study employed panel data models and mediating effect model to estimate the results.

Their analysis concluded that population aging impedes economic growth by affecting the overall advancement of the industrial structure. Maestas et al. (2023) estimated the influence of an aging population on economic expansion for U.S. from 1980 to 2010. They discovered that a 10 percent increase in the population of people aged sixty years or older resulted in a 5.5 percent reduction in per capita GDP. One-third of this reduction was due to lower employment, while the other two-thirds were because of lower labour productivity.

Park and Shin (2023) examined the channels to link population aging with economic progress and found that reduced total factor productivity growth is the primary way population aging negatively impacts economic growth. Temsumrit (2023) investigated the influence of aging populations on government spending across eighty-seven nations from 1996 to 2017. They also explored how this demographic shift affects the allocation of government funds and changes in economic growth. Employing the generalized method, their results indicated that an aging population leads to increased government spending but only in developed countries, particularly in social protection and environmental categories. However, it also results in reduced expenditure on education. Additionally, reallocating government spending towards cultural expenditures contributes to economic growth slowdown, while directing funds towards education positively impacts economic growth.

Bodnár and Nerlich (2022) investigated the macroeconomic and fiscal implications of population aging in the euro area. Their research revealed that demographic shifts are constraining potential growth, primarily due to impacts on labor supply and productivity growth. Population aging is also creating fiscal challenges by raising pension expenditures and negatively affecting tax bases and public revenue structures. Consequently, it presents significant hurdles to fiscal sustainability, constraining fiscal policy space and effectiveness. Chen et al. (2022) investigated how ageing population influence economic performance in China. They used the entropy approach to assess provincial ageing population indexes from 2008 to 2019 and built an intermediary effect model with this index as the main explanatory factor. Their findings showed that population aging

positively influences economic growth, particularly in more developed regions. Additionally, it positively impacts spending on endowment insurance and medical and health expenditures. Williams et al. (2022) investigated how population aging affects economic growth and health expenditure in Mongolia by utilizing Fixed-effects models. They analyzed the relationship between older working-age population (aged 55–69) and economic progress from 2020 to 2100. Their findings indicated that the anticipated rise in individuals aged between 55 and 69 is linked to a 4.1 percent decrease in per-capita GDP growth from 2020 to 2050 and a 5.2 percent decrease from 2020 to 2100.

Lee and Shin (2021) investigated the impact of population aging on output growth per capita in 35 OECD countries with already high old dependency ratios. They examined six channels through which population aging impacts economic progress: changes in physical capital, human capital, labor participation rate, average working hours, age composition of the population aged between 15 and 64 years, and total factor productivity (TFP). Their study confirmed previous findings that aging in OECD countries negatively affects GDP growth per capita. They identified lowered TFP growth as the most significant channel through which aging impacts economic progress.

Mohd et al. (2021) assessed the association between aging population and economic growth in Malaysia for the period from 1981 to 2019. They employed the ARDL method to estimate the results. Their findings revealed that the age dependency ratio, serving as a proxy for the aging population, had a notably adverse effect on economic growth. However, factors such as physical capital, labor participation, and human capital were positively correlated with economic growth. Park and Son (2021) explored the threshold impacts of population aging on economic growth using panel data from 98 countries spanning from 1970 to 2015. Their analysis revealed significant nonlinear effects on economic progress concerning the percentage of aged individuals, with a threshold ranging between 10.1 percent and 10.9 percent. Beyond this threshold, population aging was found to have adverse effects on economic growth. Yang et al. (2021) analyzed the correlation between aging, health investment, and

economic prosperity using an extended Mankiw–Romer–Weil model (MRW). Their empirical analysis utilized cross-country panel data spanning from 2000 to 2016. The findings indicated that there is an inverted U-shaped association between ageing and economic growth, and health investment significantly contributes to economic progress. Furthermore, Investments in health and population aging can mutually mitigate their effects on economic growth.

Aksoy et al. (2019) utilized a panel-based vector autoregressive (VAR) model to assess how changes in population composition affected the long-term trends of major macroeconomic indicators across 21 OECD nations from 1970 to 2014. Their findings indicated that the ongoing trends of the elderly population and declining fertility rates are projected to diminish output growth, investment levels, and real interest rates across OECD member states. This suggests that demographic shifts, particularly population aging, act as a hindrance to sustained economic growth over the long term. Lee and Shin (2019) assessed the effect of the elderly population on economic growth, utilizing a panel dataset for 142 economies from 1960 to 2014. They discovered that population aging negatively contributes to economic growth only at high levels, with its adverse effects intensifying as aging deepens. This effect has been especially pronounced in recent years, especially in countries with higher levels of aging, primarily developed nations. Emerson et al. (2019) examined the influence of ageing on economic progress using a panel dataset encompassing OECD nations from 1975 to 2014. They found that households tend to save more in response to extended retirement periods, which is linked to an increased growth rate per worker. However, population aging leads to reduced investment in children or other productive ventures, thereby impeding overall economic growth.

Yoshino et al. (2019) investigated the phenomenon of population aging across G20 countries. They noted that the effects of population aging are significant and varied, encompassing challenges such as worsening fiscal balances, shifts in saving and investment patterns, labor supply shortages, substandard welfare systems, particularly prevalent in developing economies, potential declines in productivity and economic prosperity,

and limitations in the effectiveness of macroeconomic policies. Uddin et al. (2016) assessed the connection between Australia's savings rate, dependency ratio, and real GDP from 1971 to 2014. Their findings suggested that a rise in dependency ratio correlates with a decline in GDP per capita, while the savings rate exhibits a positive association with GDP per capita. Specifically, there is a negative association between age dependency ratio and GDP per capita. Muto et al. (2016) conducted a study on the macroeconomic impact of population aging in Japan from the period of 1980 to 2000 by using an overlapping generation model. It was found that due to a decrease in fertility and a faster increase in longevity, Japan's aging population rose rapidly. The decline in the working-age population impacts negatively on per capita GNP and fiscal variables.

The aging population affects economic growth by different channels (Bloom et al., 2010). Due to growth in the population aged 60 or over, growth in per capita GDP decreases. Reduction in GDP growth occurs due to a decrease in labor productivity and slow labor force growth (Powell, 2016). Neo-classical modeling primarily presumes that the growth rates of labor force participation and population growth are equal. In the long term, this assumption is true when both the size of the population and the population distribution in distinct age groups remain the same. However, it is less important in the period of demographic transition, where mortality and birth rates change from high to low levels. So, economic growth will rise when working-age adults grow more than the dependent population while growth will slow down when the population aging rapidly (Choudhry & Elhorst, 2010). According to Tamiya et al. (2011), older people are net providers at least till the age of seventy-five years. They provide financial, emotional, childcare, and practical assistance to family members and help the people outside the family. Such unpaid and volunteer work adds up to around 7 percent of GDP (Warburton, 2010). Li et al. (2012) suggest that China is currently undergoing a demographic transition, where economic progress is being driven by rising savings and investment rates among its aged individuals.

On the other hand, Irmen (2017) argued that neither increased life expectancy nor decreased fertility rates affect long-term economic growth,

and that an economy's population age structure does not influence its steady-state growth rate in the long-run. Similarly, Hsu et al. (2018) conclude that aging population does not eventually hinder economic growth in China. Huang et al. (2019) analyzed the association between aging of the workforce and economic progress for the period from 1981 to 2017 in Taiwan. They found that workforce aging positively contributes to economic progress, while old-age dependency has a negative impact.

Most of the empirical literature concludes that there exists a negative association between economic growth and population aging (Trong et al., 2024; Ferede & Dahlby, 2023; Lee et al., 2013; Aigner-Walder & Döring, 2012; Lisenkova et al., 2012; Bloom et al., 2010; Narciso, 2010). Due to the elderly population, labor force participation and saving rate will decrease; as a result, economic growth will slow down. The relative size of the aging population to the total population has a more negative effect on the growth of the economy than the increase in number of children. In an emerging economy, the elderly dependency ratio and the ageing index can hinder growth. However, there are still some studies that show positive, mixed or no impact of population aging on economic growth (Gao et al., 2023; Huang et al., 2019; Hsu et al., 2018; Irmen, 2017; Li et al., 2012; Tamiya et al., 2011). The empirical literature on the aging population-economic growth nexus shows no clear consensus. Therefore, further research is necessary to predict the effect of an aging population on economic progress.

2. Model Specification and Data

The study employs the neoclassical production function, which originated from the research conducted by Ramsey (1928), to examine how population ageing affects economic progress. Solow (1956) developed the neoclassical model. This model presumes that returns to scale are constant and that technological change is regarded as exogenous. The model proposes that capital and labor can be interchanged and their marginal products are assumed to be decreasing. The fundamental neoclassical production function can be written as:

$$Y = f(K, L)$$

Here, Y represents the level of output, K depicts capital formation and L denotes labor force. Introducing the population aging (PA) and domestic savings (DS) as independent variables in the above given aggregate production function, it can be written as:

$$Y = f(K, L, PA, DS)$$

For our analysis, the GDP growth rate has been used as a proxy for economic progress. Bloom et al. (1998) and Akintunde et al. (2013) used the same dependent variable as a proxy of economic growth. Explanatory variables, which we include in the model, are explained as follows:

Table 1: Variables Description

Variable name	**Description**
Age Dependency Ratio	Age dependency means the population is 65 years of age or older. The aged dependency ratio is calculated by dividing the working-age population (15-64 years of age) by population of age 65 and above.
Labor force participation rate	It is the percentage of people in the working age group who are engaged in the economy. It is calculated by taking the number employed, divided by the total working-age population, and multiplying by 100 to get the percentage.
Gross fixed capital formation	Gross fixed capital formation is basically a net investment. In simple words, GFCF measures the net rise in fixed capital.
Domestic Saving	The amount of money that people save over a period of time is called saving. The saving rate used in the model is calculated by dividing savings to GDP.

Source: Own elaboration (2024)

To analyze the effect of population aging and other explanatory variables on economic growth, the econometric form of the model is as follows:

$$GDP_{it} = \beta_0 + \beta_1 ADR_{it} + \beta_2 LFPR_{it} + \beta_3 GFCF_{it} + \beta_4 DS_{it} + \mu_{it}$$

Where:

GDP_{it} = Growth rate of gross domestic product

ADR_{it} = Aged dependency ratio

$LFPR_{it}$ = Labor force participation rate

$GFCF_{it}$ =Gross fixed capital formation

DS_{it} = Domestic saving

μ_{it} = Error term

i = Number of cross sections i.e. $i = 1,2,3, \ldots\ldots, N$

t = Number of time periods i.e., $t = 1,2,3, \ldots\ldots, N$

Macro panel data has been used for this study. The dataset is extracted from the World Development Indicators (WDI) from 1971 to 2022. Ten selected developed countries i.e. Japan, Italy, Germany, Finland, Portugal, Greece, Malta, Sweden, France, and Denmark are taken for analysis. These countries are taken on the base of the highest ratio of aging population. Ten selected developing countries i.e. Korea Republic, Thailand, China, Sri Lanka, Turkey, Malaysia, India, Indonesia, Bangladesh, and Pakistan are taken. These countries are moving towards an aging population rapidly. However, the collection of panel data involved various issues, particularly missing values, which may impact the reliability and validity of the dataset. Addressing this issue requires significant consideration and the use of appropriate handling techniques

for missing data. To handle missing values, this study used the interpolation technique. And, for China, where the data on gross fixed capital formation (GFCF) is not available, we substitute it with a proxy variable, i.e., gross capital formation.

3. Estimation Technique and Results

The economic literature outlines various methods for estimating panel data models. Recent studies include models with both large cross-sections (N) and large time periods (T), as data for extended periods is now more readily available. Small T panel estimation typically employs the generalized method of moments, or fixed and random effect estimators. For large T panel estimation, nonstationarity must be considered since large panels often include nonstationary series. Pesaran et al. (1999) introduced an innovative technique called the Pooled Mean Group (PMG) to estimate nonstationary dynamic panels. This method combines and averages panel coefficients, allowing short-run parameters, intercept terms, and error variance to differ across groups while constraining long-run coefficients to be equal. From the initial estimation of long-run parameters, short-run coefficients and error correction terms can then be derived.

This study utilizes the IPS (Im, Pesaran, and Shin) panel unit root tests to assess the stationarity of the time series variables being examined. Table 2 illustrates the results. The null hypothesis is that the panel has a unit root or the panel is non-stationary. If we reject the null hypothesis at level, it means that the variable is stationary at level or it is I(0), if we reject it at first difference, the variable is called stationary at first difference or I(1). To reject the null hypothesis the value of probability (P-value) must be less than 0.05. The outcomes indicate that the variables are integrated at order I(1) and I(0). As the variables included in the study are a mixture of I(1) and I(0) so, the relevant regression technique is the Pooled Mean Group (PMG) which is also known as Panel ARDL model. This method is advantageous because it handles variables with different levels of stationarity and provides both long-run and short-run estimates. The return to any divergence from long-term equilibrium is one of the basic properties of a co-integrated variable. This characteristic predicts the

dynamics of error correction that occur as a result of the variables in the model deviating from equilibrium. Hence, it is crucial to redefine the aforementioned model in the error-correcting format.

$$\Delta Y_{it} = \emptyset Y_{t-j} + \theta_i X_{i,t-j} \sum_{j=1}^{p-1} y_{ij} \Delta Y_{i,t-j} + \sum_{j=0}^{q-1} \delta_{ij} \Delta X_{i,t-j} + \mu_t + \varepsilon_{it}$$

Here θ = error correction term shows how fast the adjustment is made. When $\emptyset$ = 0 long run association does not exist. Therefore, for a long-run connection among dependent variables and regressors it is essential for $\emptyset i$ to be significant with the negative sign and its value must be within that range of 0 and 1. Because in that case, it will show the convergence tendency.

Table 2: Results of (IPS) Panel Unit Root Test

Variables	Developed Economies			Developing Economies		
	Level	**First difference**		**Level**	**First difference**	
GDP	-10.830*** (0.000)	-	I(0)	-10.223*** (0.000)	-	I(0)
ADR	5.206 (1.000)	-3.703*** (0.000)	I(1)	16.036 (1.000)	-1.720** (0.042)	I(1)
LFPR	-0.292 (0.385)	-12.042*** (0.000)	I(1)	0.392 (0.652)	-11.767*** (0.000)	I(1)
GFCF	-10.349*** (0.000)	-	I(0)	-7.947*** (0.000)	-	I(0)

DS	-1.988** (0.023)	-	I(0)	-1.156 (0.124)	-15.245*** (0.000)	I(1)

Source: Author's estimations

Note: Figures in parenthesis are P-values, i.e., ***p<0.01, **p<0.05, *p<0.10

The long-run results are reported in Table 3 for both developed and developing countries. The age dependency ratio is the variable of main interest. It is clear from the results that the variable has a negative sign and it is statistically significant for developed as well as in developing countries. If there is an increase in the age dependency ratio it will lead to a decrease in GDP growth. Such finding is in line with recent literature (Trong et al., 2024; Park & Shin, 2023; Maestas et al., 2023; Bodnár & Nerlich, 2022; Mohd et al., 2021; Yoshino et al., 2019; Aksoy et al., 2019). The primary reason for this decline in GDP growth is lowered labor force participation rate (Lee & Shin, 2021). Additionally, aging reduces the capacity of the government to fund public services and raises healthcare spending (Ferede & Dahlby, 2023).

The coefficient of labour force participation of the working-age population is positive for both developed and developing countries. When more individuals enter the labor market, the overall output of goods and services rises. Additionally, higher participation can stimulate economic growth by improving the utilization of human resources. However, it is statistically significant in the case of developing countries only, it may be due to the reason that in developed economies the labor force participation rate is already quite high and there is very little space for any addition in it to contribute significantly. On the other hand, the labor force participation rate is quite low in developing economies, and there is great potential to increase the aggregate output level by increasing the labor force participation rate, so it contributes significantly.

Goss fixed capital formation has a positive coefficient and is statistically significant for both developed and developing economies. It indicates that if there is an increase in the growth rate of gross fixed capital formation it

will lead to an increase in economic growth. It is very much in line with the economic growth theory. The parameter of domestic savings is also positive and statistically significant for both types of economies. It indicates that savings are positively associated with economic growth. An increase in domestic saving enhances economic growth. Uddin et al. (2016) and Bloom et al. (2010) explained the same results in their studies.

Table 3: Panel ARDL Regression Results

	Developed economies			**Developing economies**		
	Coefficient	**t-value**	**Prob**	**Coefficient**	**t-value**	**Prob**
Long run results						
ADR	-0.067	-4.220	0.000***	-0.469	-9.108	0.000***
LFPR	0.011	1.024	0.306	0.070	3.795	0.000***
GFCF	0.251	13.648	0.000***	0.123	6.512	0.000***
DS	0.114	3.806	0.000***	0.114	7.128	0.000*
Short run results						
ECT	-0.886	-9.096	0.000***	-0.866	-2.905	0.003***
D(Age dependenc	-1.431	-	0.099*	1.678	1.04	0.294

y)		1.652			9	
D(Labor)	0.088	1.454	0.146	0.005	0.074	0.940
D(Capital)	0.029	1.047	0.295	0.094	2.076	0.038**
D(Saving)	0.571	6.523	0.000***	0.198	1.380	0.168
C	-0.091	-0.299	0.764	2.318	2.694	0.007***

Source: Author's

Significance levels: ***p<0.01, **p<0.05, *p<0.10

After the long run results, the short run estimates are given. Error Correction Term (ECT) offers valuable insights in understanding how variables adjust in response to deviations from equilibrium. Its coefficient represents the speed at which the system returns to equilibrium following a shock in the previous year. The ECM coefficient in our study is negative and statistically significant, underscoring both convergence and a long-term association among the variables. Specifically, the coefficient is -0.886 and -0.866 for developed and developing economies, respectively. This indicates that, in the event of a shock, the model will converge at a rate of 88.6 percent per year in developed countries and 86.6 percent per year in developing countries. The majority of the variables are not significant in the short run. As there exists a long-run association between the variables and same is not true for the short run which may be due to the reason that the growth of an economy is a long-run process.

4. Conclusion and Policy Implications

This study uses panel data from 1971 to 2022 to explore the effect of population aging on economic growth in selected developed and developing countries. We used the PMG (Pooled Mean Group) Panel ARDL (Autoregressive Distributed Lag) technique to check the short-run

and long-run relations among the variables. The main findings of the study indicate that the aging population negatively affects economic progress. In the coming decades, as the number of elderly people, i.e., those aged 65 and over, increases, there will be more negative effects on economic growth in the future. There is a dire need to make appropriate policies to handle this issue. To increase the participation rate of older people, make it easier for them to do work, and lower their working hours. Older people should also pay taxes until a later age. In this way, the burden of pensions will also be reduced on the economy. In developing countries, the labor force participation rate is lower. Therefore, it is necessary to ensure a rise in labor force participation in developing countries. Pension should be given to those persons who had low income in their working life and those who do not have any private pension. In this way, social and income inequality will be reduced. The cost of pensions for the government will also decrease. Private sectors should provide pensions and health care facilities so that the dependency ratio can be reduced. Gradual retirement may be opted for as it will be beneficial for employers, workers, and societies as it maintains tax revenues and reduces pension costs. It also contributes to fiscal and macroeconomic stability because older workers are valuable to younger colleagues and the organization because of their experience and knowledge. Finally, working into later life has a positive influence on older workers' health and well-being because early retirement typically causes stress and tension.

References

Aigner-Walder, B., & Döring, T. (2012). The effects of population ageing on private consumption — a simulation for Austria based on household data up to 2050. *Eurasian Economic Review*, *2*(1), 63–80. https://doi.org/10.14208/bf03353833.

Akintunde, T. S., & Oladeji, P. A. O. S. I. (2013). Population dynamics and economic growth in Sub-Saharan Africa. *Population*, *4*(13).

Aksoy, Y., Basso, H. S., Smith, R. P., & Grasl, T. (2019). Demographic structure and macroeconomic trends. *American Economic Journal. Macroeconomics/American Economic Journal, Macroeconomics*, *11*(1), 193–222. https://doi.org/10.1257/mac.20170114.

Bloom, D. E., & Williamson, J. G. (1998). Demographic transitions and economic miracles in emerging Asia. *The World Bank Economic Review*, *12*(3), 419–455. https://doi.org/10.1093/wber/12.3.419.

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.

Bodnár, K., & Nerlich, C. (2022). The macroeconomic and fiscal impact of population ageing (No. 296). ECB Occasional Paper.

Chen, Q., Chi, Q., Chen, Y., Lyulyov, O., & Pimonenko, T. (2022). Does population aging impact China's economic growth? *International Journal of Environmental Research and Public Health*, *19*(19), 12171. https://doi.org/10.3390/ijerph191912171.

Choudhry, M. T., & Elhorst, J. P. (2010). Demographic transition and economic growth in China, India and Pakistan. *Economic Systems*, *34*(3), 218–236. https://doi.org/10.1016/j.ecosys.2010.02.001.

Emerson, P. M., Knabb, S. D., & Sirbu, A. (2019). Institutional Responses to aging Populations and Economic Growth: A Panel Data approach. *Social Science Research Network*. https://doi.org/10.2139/ssrn.3445827.

Ferede, E., & Dahlby, B. (2023). *The effect of population aging on economic growth in Canada*. https://roam.macewan.ca/items/bbded9fe-42d3-45c1-95f9-af44d64bcf89.

Fougère, M., Harvey, S., Mercenier, J., & Mérette, M. (2009). Population ageing, time allocation and human capital: A general equilibrium analysis for Canada. *Economic Modelling*, *26*(1), 30–39. https://doi.org/10.1016/j.econmod.2008.05.007.

Gao, W., Chen, Y., Xu, S., Lyulyov, O., & Pimonenko, T. (2023). The Role of Population Aging in High-Quality Economic Development: Mediating Role of Technological Innovation. *SAGE Open*, *13*(4). https://doi.org/10.1177/21582440231202385.

Gavrilov, L. A., & Heuveline, P. (2003). Aging of population. The encyclopedia of population, 1, 32-37.

Herrmann, M. (2011). Population aging and economic Development: anxieties and policy responses. *Journal of Population Ageing*, *5*(1), 23–46. https://doi.org/10.1007/s12062-011-9053-5.

Hsu, M., Liao, P., & Zhao, M. (2018). Demographic change and long-term growth in China: Past developments and the future challenge of aging. *Review of Development Economics*, *22*(3), 928–952. https://doi.org/10.1111/rode.12405.

Huang, W., Lin, Y., & Lee, H. (2019). Impact of population and workforce aging on economic growth: case study of Taiwan. *Sustainability*, *11*(22), 6301. https://doi.org/10.3390/su11226301.

Im, K. S., & Pesaran, M. H. (2003). On the Panel Unit Root Tests Using Nonlinear Instrumental Variables. *Social Science Research Network*. https://doi.org/10.2139/ssrn.482463.

Irmen, A. (2017). Capital- and labor-saving technical change in an aging economy. *International Economic Review*, *58*(1), 261–285. https://doi.org/10.1111/iere.12216.

Lee, H., & Shin, K. (2019). Nonlinear effects of population aging on economic growth. *Japan and the World Economy*, *51*, 100963. https://doi.org/10.1016/j.japwor.2019.100963.

Lee, H., & Shin, K. (2021). Decomposing effects of population aging on economic growth in OECD countries. *Asian Economic Papers*, *20*(3), 138–159. https://doi.org/10.1162/asep_a_00839.

Lee, H., Huh, H., Lee, Y., & Lim, J. (2013). *Effects of Population aging on Economic Growth: A panel analysis*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2364194.

Lee, S., Mason, A. W., & Park, D. (2011). Why does population aging matter so much for Asia? Population aging, Economic growth, and Economic Security in Asia. *Social Science Research Network*. https://doi.org/10.2139/ssrn.1960877.

Li, X., Li, Z., & Chan, M. L. (2012). Demographic change, savings, investment, and economic growth. *The Chinese Economy*, *45*(2), 5–20. https://doi.org/10.2753/ces1097-1475450201.

Lisenkova, K., Mérette, M., & Wright, R. (2012). *The Impact of Population Ageing on the Labour Market: Evidence from an Overlapping Generations Computable General Equilibrium (OLG-CGE) Model of Scotland* https://ideas.repec.org/p/ekd/002672/4382.html.

Liu, Y., Chen, L., Lv, L., & Failler, P. (2023). The impact of population aging on economic growth: a case study on China. *AIMS Mathematics*, *8*(5), 10468–10485. https://doi.org/10.3934/math.2023531.

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

Mohd, S. N. A., Ishak, A. A., & Selvaratnam, D. P. (2021). Ageing population's impact on economic growth in Malaysia from 1981 to 2019: Evidence from an autoregressive distributed lag approach. *Frontiers in Public Health*, *9*. https://doi.org/10.3389/fpubh.2021.731554.

Muto, I., Oda, T., & Sudo, N. (2016). Macroeconomic Impact of Population Aging in Japan: A Perspective from an Overlapping Generations Model. *IMF Economic Review*, *64*(3), 408–442. https://doi.org/10.1057/imfer.2016.6.

Narciso, A. (2010). The impact of population ageing on international capital flows. *Social Science Research Network*. https://doi.org/10.2139/ssrn.1702995.

Nations, U. (2013). World population ageing 2013. Department of Economic and Social Affairs PD.

Obi, T., Ishmatova, D., & Iwasaki, N. (2013). Promoting ICT innovations for the ageing population in Japan. *International Journal of Medical Informatics*, *82*(4), e47–e62. https://doi.org/10.1016/j.ijmedinf.2012.05.004.

Park, D., & Shin, K. (2023). Population aging, silver dividend, and economic growth. *Social Science Research Network*. https://doi.org/10.2139/ssrn.4381806.

Park, H., & Son, J. C. (2021). Threshold effects of population aging on economic growth: a cross-country analysis. *The Singapore Economic Review*, 1–23. https://doi.org/10.1142/s021759082150034x.

Peng, X. (2005). Population ageing, human capital accumulation and economic growth in China. *Asian Population Studies*, *1*(2), 169–188. https://doi.org/10.1080/17441730500317246.

Pesaran, M. H., Shin, Y., & Smith, R. P. (1999). Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American Statistical Association*, *94*(446), 621–634. https://doi.org/10.1080/01621459.1999.10474156.

Powell, J. L., & Taylor, P. (2016). Rethinking risk and ageing: Extending working lives. *Social Policy and Society*, *15*(4), 637–645. https://doi.org/10.1017/s1474746416000270.

Ramsey, F. P. (1928). A mathematical theory of saving. *The Economic Journal*, *38*(152), 543. https://doi.org/10.2307/2224098.

Sachs, J. D. (2012). From millennium development goals to sustainable development goals. *Lancet*, *379*(9832), 2206–2211. https://doi.org/10.1016/s0140-6736(12)60685-0.

Shetty, P. (2012). Grey matter: ageing in developing countries. *Lancet*, *379*(9823), 1285–1287. https://doi.org/10.1016/s0140-6736(12)60541-8.

Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, *70*(1), 65. https://doi.org/10.2307/1884513.

Sukpaiboonwat, S., Plyngam, S., & Jaroensathapornkul, J. (2014). Does an ageing population diminish or enhance economic growth?: A survey of literature. *Meiji Journal of Political Science and Economics*, *3*(1), 1-10.

Temsumrit, N. (2023). Can aging population affect economic growth through the channel of government spending? *Heliyon*, *9*(9), e19521. https://doi.org/10.1016/j.heliyon.2023.e19521.

Trong, N. T., Dong, N. T., & Ly, P. T. (2024). Population aging and economic growth: evidence from ASEAN countries. *Cogent Business & Management*, *11*(1). https://doi.org/10.1080/23311975.2023.2298055.

Uddin, G. A., Alam, K., & Gow, J. (2016). Population age structure and savings rate impacts on economic growth: Evidence from Australia. *Economic Analysis and Policy*, *52*, 23–33. https://doi.org/10.1016/j.eap.2016.08.002.

UNFPA, H. (2012). Ageing in the twenty-first century: a celebration and a challenge. London: *United Nations Population Fund*.

Williams, G. A., Cylus, J., Tayara, L. A., Roubal, T., Tsilaajav, T., & Barber, S. L. (2022). Can healthy ageing moderate the effects of population ageing on economic growth and health spending trends in Mongolia? A modelling study. *Health Research Policy and Systems*, *20*(S1). https://doi.org/10.1186/s12961-022-00916-0.

Yang, Y., Zheng, R., & Zhao, L. (2021). Population aging, health investment and Economic Growth: Based on a Cross-Country Panel data analysis. *International*

Journal of Environmental Research and Public Health, *18*(4), 1801. https://doi.org/10.3390/ijerph18041801.

Yoshino, N., Kim, C. J., & Sirivunnabood, P. (2019). Aging population and its impacts on fiscal sustainability. *Aging Societies*.

Young, A. O. (2018). Economic Growth and Population Ageing in Nigeria: Innovation Accounting techniques. *Journal of Sustainable Development*, *11*(4), 190. https://doi.org/10.5539/jsd.v11n4p190.

Yue, Xin. (2023). Exploring the Economic Implications and Challenges of an Ageing Population in the UK and China. Lecture Notes in Education Psychology and Public Media. 9. 358-367. https://doi.org/10.54254/2753-7048/9/20230260.