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Population Aging in ASEAN+3: But is 60 the New 40?

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Population Aging in ASEAN+3: But is 60 the New 40?

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Abstract

Population aging is becoming a significant concern, particularly as its pace accelerates, especially in emerging market economies. However, labeling all individuals aged 65 and above as elderly can be misleading and inaccurate when life expectancy is increasing. Therefore, using the prospective old-age dependency ratio to define what is elderly would allow for more precise measurements and facilitate research into the impact of aging on economic growth. Our findings suggest that while a negative relationship between aging and economic growth at the global level was more prominent before 1990, this negative effect has decreased over time. Moreover, the population nearing retirement age exhibits an increasing contribution to growth. Harnessing the potential of those typically deemed old by traditional measures, yet who remain productive, could effectively bolster economic development. Additionally, we find that the impact of aging on growth varies across individual economies in the ASEAN+3 region. The accumulation of human capital and technological advancements appears to mitigate negative effect from aging, underscoring the need for economies to promote both as their populations age.

JEL classification:	J11, J14, J26, O47
Keywords:	economic growth, labor productivity, life expectancy, population aging, prospective old-age dependency ratio

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Abbreviations

ASEAN	Association of Southeast Asian Nations
OADR	old-age dependency ratio
OLG	overlapping generations
POADR	prospective old-age dependency ratio
Plus-3	China (including Hong Kong),[3] Japan, Korea
PWT	Penn World Table
R&D	research and development
TFP	total factor productivity
UN DESA	United Nations Department of Economic and Social Affairs
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific

[3] For brevity, “Hong Kong, China” is referred to as "Hong Kong" in the text.

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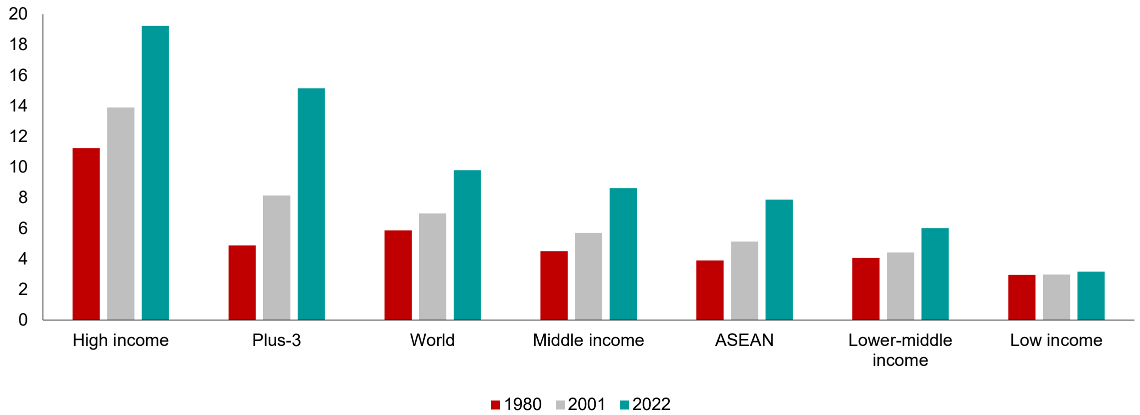
I. Introduction

Population aging is a global trend observed not only in advanced economies but also in emerging market economies, where accelerated aging is happening before populations become rich. The proportion of individuals aged 65 and above, typically considered elderly, has surged over the past two decades (Figure 1). High-income economies have witnessed the most rapid growth in their elderly populations, while middle- and even lower-middle-income economies have also experienced sharp increases in the proportion of elderly individuals among their populations.

The elderly population ratios in ASEAN and the Plus-3 economies have increased. They jumped from 5.1 and 8.1 percent in 2001 to 7.9 and 15.1 percent, respectively, in 2022. Moreover, nations such as China, Thailand, and Vietnam are expected to transition from aging to aged societies in a shorter timeframe compared to advanced economies such as France and the US. Indeed, France and the US took 115 years and 69 years, respectively, to undergo this transition, whereas China is expected to achieve it in 25 years, Singapore and Thailand in 22 years, and Vietnam in only 19 years (UNESCAP 2017).

Population aging has raised concerns about its economic impact, particularly through channels that reduce labor supply and diminish labor productivity. Extensive research from both theoretical and empirical perspectives has been conducted on this topic. Lower birth rates contribute to fewer young workers entering the workforce, insufficient to offset the number of older individuals exiting the labor force, resulting in a shrinking labor supply. Additionally, labor productivity is influenced by demographic structure. Both these factors are found to have a significant impact on economic growth (Daniele, Honiden, and Lembcke 2019; Maestas, Mullen, and Powell 2023).

Figure 1. Share of Population Ages 65 and Above
(Percent)



Source: World Bank.
Note: Plus-3 refers to China (including Hong Kong), Japan, and Korea.

Higher life expectancy contributes to population aging, yet it also complicates the measurement of “aging.” On the one hand, increased life expectancy leads to a larger elderly population alongside declining birth rates. Conversely, as life expectancy rises as a result of advancements in nutrition and healthcare, individuals deemed “old” by conventional standards may not necessarily fit the traditional perception of old age. Typically, the threshold for old age is set at 65, categorizing individuals beyond this age as elderly. However, with longer life spans, this definition may inaccurately classify a portion of the population as “old,” including those who remain productive. Consequently, utilizing conventional measures such as the old-age dependency ratio (OADR) to assess the impact of aging on economic growth may yield misleading results.

The use of a measure of aging that considers life expectancy could provide valuable insights into the population aging issue and its implications for economic growth. Drawing on research by Sanderson and Scherbov (2005), which uses the prospective old-age dependency ratio (POADR), we propose a distinct approach that acknowledges the dynamic nature of life expectancy that varies across economies and over time. This approach categorizes a certain proportion of the population closer to life expectancy as elderly, offering a more nuanced understanding of aging demographics.

We apply this measure to examine the relationship between prospective old-age dependency and real economic growth. Our analysis reveals that there is a negative relationship between aging and economic growth at the global level, in contrast to the traditional measure of aging. The effect operates primarily through reductions in human capital in tandem with the accumulation of physical capital. We also examine the contribution of age groups nearing and surpassing the mandatory retirement age on the growth rate of GDP per capita using a global sample. Previous studies commonly label the 55–64 age group, as well as the 65+ group, as unproductive. However, our analysis shows that their contribution to the growth of real GDP per capita has increased since 2000. Moreover, the service intensity of an economy significantly influences the magnitude of contribution from population groups nearing and surpassing the mandatory retirement age.

The ASEAN+3 sample yields a different result compared to the global sample, indicating an overall insignificant link between aging and economic growth. This could be attributed to diverse demographic stages across the region. When examining the impact of aging on various channels of growth, we find that in ASEAN, aging has a significantly negative impact on physical capital accumulation, but not on human capital accumulation and TFP. In Plus-3, there is no significant relationship between aging and all channels of growth.

The rest of the paper is structured as follows: Section II summarizes the literature on the impact of aging on economic growth. Section III discusses life expectancy and provides an improved measure of aging. Section IV describes the data and methodology followed by our analysis of results for both global and ASEAN+3 samples in Section V. Section VI concludes with policy recommendations for the region.

II. Literature Review

Population aging is primarily driven by higher life expectancy and lower birth rates, without considering migrations in economies. This process, known as demographic transition, involves a shift from high fertility and mortality rates with younger age distributions to lower fertility and mortality rates with older age distributions (Lee 2003). Bloom and Luca (2016) explores these determinants and the nature of aging. Such demographic changes have significant implications for various economic aspects. They can impact macroeconomic indicators including GDP growth per capita, unemployment rates, productivity, consumption and saving patterns, financial markets, migration, and the political economy. These changes raise critical concerns about resource allocation and welfare. In the following subsections, we focus our review of the literature on the impact of population aging on economic growth as well as its channels.

Aging and Economic Growth

The relationship between demographic shifts and macroeconomic outcomes has been a focus of extensive study since the 1950s. Seminal works such as Samuelson (1958) and more comprehensive reviews by Weil (2006), Bloom and Luca (2016), and Lee (2016) underscore this connection. Nonetheless, achieving consensus on the effects of population aging on economic growth remains challenging.

Some empirical evidence points to a negative relationship between population aging and GDP per capita. Using OECD country data from 1950 to 1990, Lindh and Malmberg (1999) finds a negative impact of the age group above 65 on GDP per worker; the impact of the age group before 50 on GDP per worker appears ambiguous. The authors conclude that aging has a detrimental effect on GDP per worker, although the specific mechanism behind this observation remains unresolved. Maestas, Mullen, and Powell (2023) studies the impact of population aging on the US economy and found a negative relationship between the age group above 65 and per-capita GDP, noting that each 10 percent increase in the fraction of the population aged 60 and older decreases per-capita GDP by 5.5 percent. Two-thirds of this reduction is attributable to a decrease in labor productivity.

In contrast, the literature suggests insignificant or positive relationships between the "old" age group and GDP per worker. Acemoglu and Restrepo (2017) discovers an insignificant relationship between the aging structure and per capita GDP growth. The paper uses the ratio of the population aged over 50 to those aged between 20 and 49 as a measure of age structure in the economy. Analyzing data from the Penn World Table (PWT) for the period 1990 to 2015, the authors find that changes in the old-to-young ratio do not significantly affect GDP per capita. Moreover, they apply a model developed by Acemoglu (2010) to demonstrate that the scarcity of younger and middle-aged labor could substantially increase the adoption of robots and other automation technologies, potentially enhancing aggregate output despite the reduced labor input. Rahman and Husseini (2024) identifies an inverted U-shaped relationship between age profile and labor productivity in Brunei Darussalam, using a vector error correction model. Contrary to conventional belief, the authors find a positive correlation between elderly workers and labor productivity.

Given the lack of consensus on the relationship between age structure and economic growth, many researchers have investigated the impact of aging through various growth channels. These channels include physical capital accumulation, human capital accumulation, and total factor productivity (TFP). For instance, Aiyar, Ebeke, and Shao (2016) initially reports an insignificant relationship between population aging and economic growth in European economies. The paper subsequently derives an empirical estimating equation using the Cobb-Douglas production function approach to estimate the impact of aging on different growth channels. The resultant findings indicate that workforce aging reduces labor productivity growth, primarily because of the former's negative effect on TFP growth, and suggest that an aging workforce could decrease TFP growth by an average of 0.2 percentage point annually until 2035.

Aging and Physical Capital Accumulation

Population aging might raise capital intensity and capital per capita. The consensus is that the elderly typically possess more assets than the young. Consequently, as the proportion of the elderly in the population rises, both assets per worker and per capita in the population are anticipated to increase. In other words, in the absence of age-related behavioral differences, the slower population growth associated with aging can raise the capital intensity and per capita income of the economy, assuming constant saving rates (Lee 2016).

Conversely, a larger proportion of the aged population could lead to a higher proportion of dis-savers, potentially resulting in reduced investment in physical capital. Older populations might exhibit higher proportions of dis-savers, leading to a decrease in the aggregate saving rate. However, Hansen (1939) and Summers (2015) argue that an aged population could lead to more savings than investment. It is equally plausible to assume that factors such as lower fertility and longer life expectancy—contributing to population aging—could encourage individuals to save more. This increased saving may be motivated by the need to provide for a longer retirement and the expectation of consuming more in retirement due to lower fertility, as discussed by Sanchez-Romero (2013). The effects of aging on the saving rate involve several channels, but the net effects remain unclear.

Aging and Human Capital Accumulation

Theoretically, population aging is expected to be accompanied by increased investment in the human capital of children, thereby improving the quality of the workforce. Although a reduction in the relative quantity of labor may occur, it could partially be offset by improvements in its quality. This shift toward enhancing the skills and abilities of the younger workforce could yield several outcomes. For example, it would elevate the earnings and income of younger generations relative to older ones, and raise the level of per capita income:

- Lee and Mason (2010) uses an overlapping generations (OLG) model to highlight the quantity-quality trade-off and the links between human capital investment and economic growth. Simulations show that lower fertility rates lead to higher consumption per capita through human capital accumulation, illustrating that lower fertility is associated with higher investment per child.

- Ludwig, Schelkle, and Vogel (2012), also employing an OLG model, shows that increased investments in human capital may substantially mitigate the macroeconomic impact of demographic change, with profound implications for individual welfare. As labor will be relatively scarce and capital relatively abundant in an aging society, interest rates are expected to fall. However, the model operates under the assumption that human capital is formed without any market friction; if market failures are taken into account, the benefits of human capital accumulation may not materialize following a change in the demographic structure.

Aging and TFP

Some argue that an aged population produces fewer ideas and is less innovative, whilst others contend that an aging population can lead to more innovations and higher TFP through the higher accumulation of human capital. Another second-round effect often studied in the literature, such as by Acemoglu and Restrepo (2017), is that to support the transition of an aged population and a reduced labor force, governments may increase their investment in automation and advanced technologies. These investments can compensate for labor shortages and, in turn, lead to increases in TFP. This channel is arguably more prominent when interest rates are low, thus supporting investment. Prettner and Strulik (2020) proposes R&D-based growth models where robots can easily perform low-skilled tasks. They demonstrate that this scenario could explain why establishing a negative relationship between population aging and economic growth might be challenging to justify.

Empirical evidence also suggests that changes in workforce demographics have significant impact on TFP growth rate. Using a large panel of countries, Feyrer (2007) shows that a 5 percent increase in the size of the age cohort 40 to 49 over ten years is associated with a 1–2 percent higher productivity growth each year of the decade. Park and Shin (2023) finds that lower TFP growth is the main mechanism through which population aging harms economic growth. Labor shortages caused by population aging are mostly offset by higher labor force participation rates among males, females, and older workers, with that of older people increasing the most.

III. Life Expectancy and Measures of Aging

Life expectancy has steadily increased worldwide since the 1980s. High-income economies had an average life expectancy of 75 years in 1995, which rose to 80 years by 2019. In contrast, low-income economies experienced a sharp increase from an average life expectancy of only 49 years in 1995 to 60 years by 2019 (Figure 2).[4] Considering the dynamic nature of life expectancy, an individual aged 55 in 1995 would have a different economic growth relationship compared to an individual of the same age today. Thus, relying solely on chronological age to assess the relationship between aging and economic growth can be misleading. It is essential, therefore, to utilize an aging measure that takes account of changes in life expectancy. Furthermore, this measure should be adaptable to the varied life expectancies across economies.

The literature often references the OADR as one of the standard measures of aging. It defines the ratio of those aged 65 and above to those between 15 and 64 years as shown in equation (1):

$$OADR = \frac{population\ aged\ 65\ and\ above}{population\ aged\ 15-64} \tag{1}$$

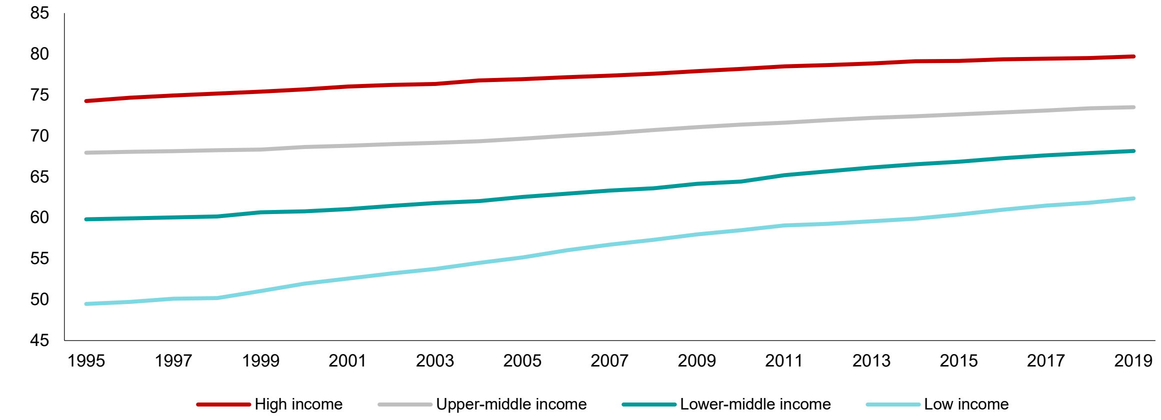
The OADR measure does not account for changes in life expectancy, and thus may not capture the contribution of people who are close to retirement or above retirement age to the economy. Therefore, studies based on the OADR as a measure of aging could lead to misleading interpretations and results.

To capture the variations in life expectancy across economies and over time, we propose an alternative aging measure, the POADR, first introduced by Sanderson and Scherbov (2005). Their definition of "elderly" considers individuals aged less than 15 years younger than their life expectancy. Instead of using a fixed threshold of 15 years, our methodology adopts a percentage-based threshold to better accommodate changing life expectancy patterns. We define "old age" as ages above 90 percent of the life expectancy, with supplementary analysis conducted at 85 percent. This POADR is defined in equation (2):

$$POADR = \frac{population\ aged\ above\ a\ threshold}{population\ aged\ between\ 15\ and\ the\ threshold} \tag{2}$$

[4] The list of economies is included in Appendix I.

Figure 2. Life Expectancy at Birth Across Income Groups
(Years)

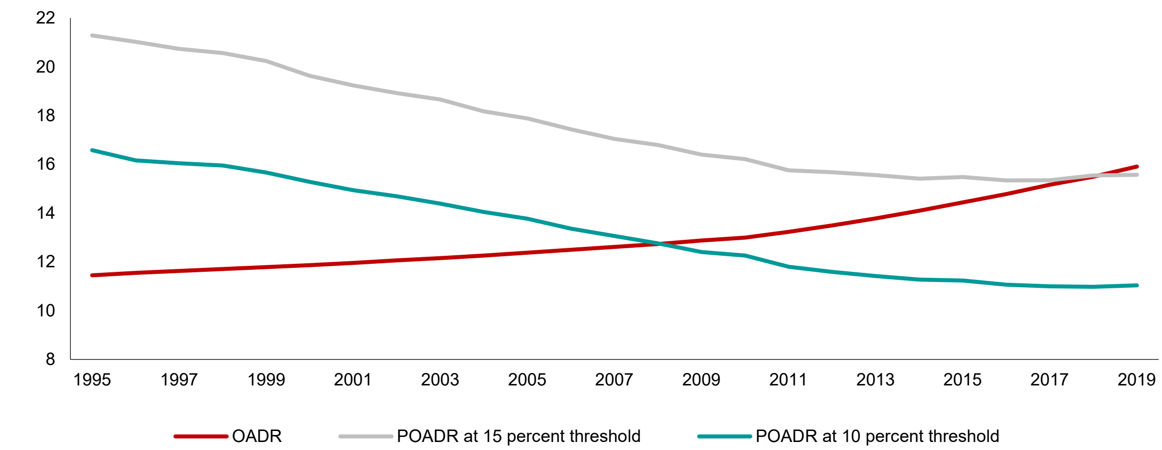


Source: Authors' calculation based on data from the UN DESA (2022).[5]

The average OADR and POADR across economies exhibit a different pattern. The OADR trend illustrates a rapid aging process from 1995 to 2019, particularly accelerating after 2000, prompting concerns about aging societies. However, the POADR indicates a decline over the same period, suggesting a sharply different view of aging when adjusting for evolving life expectancy (Figure 3). The POADR is much larger than the OADR in the early years, primarily because the OADR fails to capture the impact of shorter life expectancies. For instance, in an economy with a life expectancy of 67, a threshold of 65 implies a small "old" population relative to a large working-age population, leading to a lower OADR value.

ASEAN and Plus-3 economies exhibit different POADR trajectories. Since 1995, the ASEAN region has shown a downward-sloping POADR up until around 2014, after which a slight increase corresponds to a rise in the older age group. Plus-3 economies, however, have displayed an upward trend starting from 1995, indicating that these economies are experiencing aging earlier than the ASEAN economies. Moreover, the average POADR in ASEAN economies is around eight percent, which is lower than that of the Plus-3 economies and the world average (Figure 4).

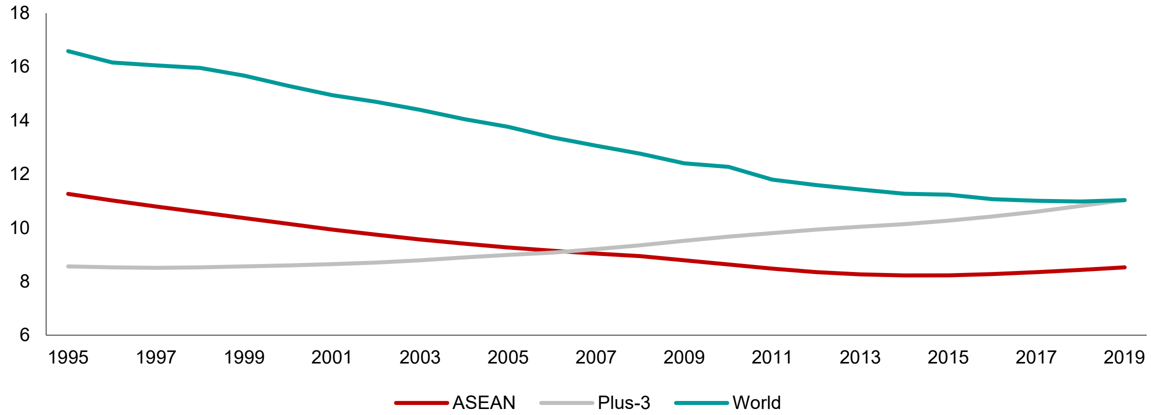
Figure 3. Measures of Old-Age Dependency
(Percent)



Source: Authors' calculation based on data from the UN DESA (2022).
Note: The POADR threshold is set at 15 percent or 10 percent remaining life expectancy.

[5] See Section IV for data description.

Figure 4. POADR Across Regional Groupings
(Percent)



Source: Authors' calculations based on data from PWT and UN DESA.
Note: ASEAN refers to Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam. Plus-3 economies refer to China (including Hong Kong), Japan, and Korea.

IV. Data and Methodology

A. Databases

The OADR and POADR measures for each economy are calculated based on the 2022 revision to the United Nations Department of Economic and Social Affairs (UN DESA) World Population Prospects. Data on GDP, TFP, human capital, physical capital, and engaged population are collected from the Penn World Table 10.01.[6] Data on shares of service and industry in GDP are collected from the World Bank. Data on mandatory retirement ages are collected and compiled from the OECD and the World Bank.[7]

We present the summary statistics of the main variables used in our empirical analysis in Table 1. We do not limit the time frame; instead, we exclude samples with life expectancies of less than 65 years to avoid having economies with very short life expectancies skewing the analysis. In the resultant sample, the average life expectancy is 73, with a maximum of 85, and a minimum of 65; the average threshold age is 65, with some economies having a threshold age of 58, while others reach a threshold of 76. Therefore, using a fixed threshold age of 65 for all economies across different years may be a gross generalization of the aging concept. The calculated OADR possesses a higher mean of 16.8 percent compared to POADR, which is 12.3 percent. As discussed above, it is not surprising that the OADR measure would indicate a faster rate of aging than the POADR measure.

B. Models

We conduct three sets of regressions in this section to investigate the relationship between population aging and economic growth. These comprise (1) the baseline regression of economic growth on demographics, human and physical capital and TFP; (2) the impact of aging on growth channels, and (3) the contributions of various age groups to growth.

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[6] The variable engaged population serves as a proxy for the number of workers in an economy. In this study, we use "engaged population" and "workers" interchangeably.

[7] See Appendix II for data sources.

Table 1. Summary Sample Statistics

Variables	(1) Number of Observations	(2) Mean	(3) Standard Deviation	(4) Minimum Value	(5) Maximum Value
Life expectancy	3,837	73.730	4.534	65.020	85.180
OADR	3,837	0.168	0.089	0.010	0.581
Threshold age (10 percent prospective life remaining)	3,837	65.860	4.096	58.000	76.000
POADR	3,837	0.123	0.054	0.004	0.313
Growth rate of real GDP per engaged population	3,837	0.024	0.066	–0.920	0.686
Growth rate of human capital	3,837	0.009	0.006	–0.017	0.046
Growth rate of TFP	3,837	0.003	0.043	–0.550	0.605
Growth rate of physical capital stock per engaged population	3,837	0.032	0.062	–1.021	0.577

Source: Authors' estimates.
Note: The summary statistics are calculated for the sample consisting of observations with a life expectancy above 65 years.

Baseline Regression Specification

Following previous studies,[8] our baseline regression model is defined as:

$$\Delta \ln y_{it} = \gamma_i + \beta_1 X_{it} + \beta_2 \Delta \ln h_{it} + \beta_3 \Delta \ln k_{it} + \beta_4 \Delta \ln A_{it} + u_{it} \quad (3)$$

where,
i is the economy index, and t is the time index;
$\Delta \ln y_{it}$ is the real GDP per engaged population growth rate;
γ_i is the economy's fixed effect;
X_{it} is a measure of demographics (OADR or POADR);
$\Delta \ln h_{it}$ is human capital growth rate;
$\Delta \ln k_{it}$ is physical capital stock per worker growth rate; and
$\Delta \ln A_{it}$ is TFP growth rate.

The set up of the aged population's share influencing the real growth rate comes from the derivation of the production function. We assume a Cobb-Douglas variant of a neoclassical production function and augment it with a variable h representing human capital per worker, such that:

$$Y_{it} = A_{it} K_{it}^{\alpha} (h_{it} L_{it})^{1-\alpha}$$

We divide both sides by the population, rewriting it in terms of output per capita, and rearranging yields, such that:

$$y_{it} = A_{it} k_{it}^{\alpha} (h_{it})^{1-\alpha} \left(\frac{L}{P}\right)$$

where, $y = \frac{Y}{P}. k = \frac{K}{L}$. Taking natural logarithms leads to a linear equation, such that:

[8] See Hall and Jones (1991), Feyrer (2007), Werding (2008), and Park and Shin (2023).

$$\ln y_{it} = \ln A_{it} + \alpha \ln k_{it} + (1-\alpha) \ln h_{it} + \ln \left(\frac{LFPR_i}{POADR_{it}+1}\right)$$

Here, we assume the entire population comprises aged individuals and working-age population,[9] where LFPR refers to the labor force participation rate, assumed to be time-invariant for simplification purposes.

Calculating first differences, based on $\ln\left(\frac{x_t}{x_{t-1}}\right) = \ln x_t - \ln x_{t-1} \equiv \Delta \ln x_t$, we obtain:

$$\Delta \ln y_{it} \approx \Delta \ln A_{it} + \alpha \Delta \ln k_{it} + (1-\alpha)\Delta \ln h_{it} + \Delta \ln (POADR_{it})$$

We estimate the baseline equation (3) using a panel fixed effects estimation so that each economy can have a different intercept term, which captures the leftover variation in the dependent variables that cannot be explained by the regressors. We run the baseline specification equation (3) for the OADR and POADR measures. Additionally, we split the sample into periods before and after the 1990s to examine the possibility of structural changes arising from technological advancements affecting the results of the baseline regressions. Moreover, we include economic income group dummies to observe variations across different income groups. A limitation of using the baseline model is its inability to detect any causal relationship, and there may be issues of endogeneity within this specification.

Regressions of Growth Channels on Aging

After comparing different measures of aging through the baseline regression, we also adhere to the specification commonly used in the empirical literature that examines the impact of aging on growth channels. We apply equation (4):

$$\Delta \ln Z_{it} = \gamma_1 X_{it} + u_{it} \tag{4}$$

where, $\Delta \ln Z_{it}$ includes change in human capital accumulation, physical capital accumulation as well as TFP; X_{it} denotes the measure of aging, and in our case, it is the POADR. Additionally, we split the sample by the economy's income levels and examine heterogeneity across economies when looking at the impact of aging on channels of real growth.

Regressions to Compare Labor Productivity

The final specification we consider is the contribution to real GDP per capita from age groups that are around retirement age. As highlighted by plotting the increase in life expectancy over the years, one chronological age group in the past may show different contributions to the economy from the same chronological age group now. We examine the specifications defined by equation (5):

$$\Delta \ln y_{it} = \gamma_i + \beta_1 age_{it}^{25-45} + \beta_2 age_{it}^{55-59} + \beta_3 age_{it}^{66-70} + u_{it} \tag{5}$$

where,

[9] To simplify, we exclude the aged group of 0–14.

$\Delta \ln y_{it}$ is the growth of real GDP per capita;
age_{it}^{25-45} represents the population share of the age group 25 to 45;
age_{it}^{55-59} denotes the population share of the age group 55 to 59; and
age_{it}^{66-70} denotes the population share of the age group 66 to 70.

As our primary focus is on the population contribution of age groups approaching retirement, we constrain our sample to include only economies with mandatory retirement ages ranging from 60 and 65. Moreover, the population share of the age group 55–59 is used as proxy for the pre-retirement age group's contribution to the real economic growth rate. Similarly, the population share of the age group 66–70 serves as proxy for this age group's contribution to real economic growth. Additionally, we use the services and industry shares of economies as additional criteria to further examine the contributions of these "old" age groups to economic growth.

We assess whether the age groups immediately before and after retirement exhibit the same levels of productivity before and after 2000. It is important to note that to fully assess the labor productivity of each age group, data on the labor force by age and labor force participation rate by age are essential. However, as these data are not readily available for the panel of economies under study, we use population share and GDP per capita as proxies to offer insights into the respective contributions of different age groups to real GDP growth per capita.

V. Results

A. Global Sample

We conduct regressions based on the specifications and empirical strategy detailed above, using the global sample to examine the relationship between aging and economic growth. In particular, we run the baseline regression to assess the impact of aging on the growth of GDP per engaged population. We then analyze the impact of aging on various channels of economic growth. Lastly, we investigate changes in the contribution to growth by various age groups over time.

Baseline Regressions: Aging and Economic Growth

The POADR measure shows a statistically significant negative relationship with the growth rate of real GDP per engaged population in our baseline regressions. A one percentage point increase in POADR correlates to a 0.045 percentage point decrease in real GDP growth per worker (Table 2). This significance is not observed when using the OADR measure. In both models, human capital, physical capital, and TFP have significantly positive relationships with real GDP growth, consistent with established economic theories.[10] Specifically:

- It may seem intuitive that biologically older individuals would be less productive, thus not contributing to economic growth. The POADR effectively captures this effect through its measure of old age dependency.

[10] The significance and direction of estimates for our baseline regressions and growth channels regressions are robust to both 90 percent and 85 percent POADR thresholds.

- The absence of any significant relationship between aging—as measured by the OADR—and economic growth aligns with findings in the empirical literature (Aiyar, Ebeke, and Shao 2016). The OADR's insignificance might stem from its inclusion of a demographic considered "aged" yet remains productive, obscuring a clear relationship in regression analyses.

Table 2. Baseline Regression

Variables	(1) Growth of Real GDP Per Engaged Population[11]	(2) Growth of Real GDP Per Engaged Population
POADR	–0.045***	
	(0.011)	
OADR		0.002
		(0.002)
Human capital	0.470***	0.456***
	(0.058)	(0.060)
Physical capital	0.512***	0.510***
	(0.025)	(0.026)
TFP	0.970***	0.969***
	(0.015)	(0.016)
Observations	3,837	3,837
Adjusted R-squared	0.955	0.955
Number of economies	99	99

Source: Authors' estimates.
Note: Column (1) is the baseline regression when the POADR measure is used at a 90 percent threshold. Column (2) shows regression results using the conventional OADR measure. Robust standard errors are in brackets. ***, **, and * represent statistical significance at 1 percent, 5 percent, and 10 percent levels, respectively. Constants are included in the regressions, but the estimates are not reported in the table.

Our analysis also reveals a more pronounced negative relationship between the POADR measure and real GDP growth per engaged population before 1990. A one percentage point increase in the POADR corresponds to a 0.063 percentage point decrease in real GDP growth per worker prior to 1990 (Table 3). After 1990, this negative relationship vanishes, indicating that changes in old-age dependency no longer affect the growth rate of real GDP per worker. Such a shift could potentially be a result of technological advancements. The negative relationship between aging and growth is more pronounced in high-income economies and least in lower-middle-income and low-income economies. The reason for this observed heterogeneous correlation between income groups is likely attributable to the younger age structure of the population. Further analysis is conducted to explore the specific channels through which aging might influence real GDP growth.

Impact of Aging on Economic Growth Channels

While theoretical discourse suggests that aging could affect economic growth channels in both positive and negative ways, our findings primarily indicate a negative relationship between aging and the accumulation of human and physical capital. We demonstrate this relationship through the commonly-used empirical specifications in the literature and regress various growth channels on the aging measure, POADR, as presented in Table 4. Columns (1) to (3) in Table 4 detail the effects of aging on human capital accumulation, TFP, and

[11] Engaged population is defined, in the PWT, as all persons aged 15 years and over, who performed work during the reference week, even just for one hour a week, or were not at work but had a job or business from which they were temporarily absent.

physical capital accumulation, respectively. Conversely, the relationship between aging and TFP does not show statistical significance.

Table 3. Baseline Regression with Split Samples

Variables	(1) Pre-1990	(2) Post-1990	(3) Income Dummies
POADR	–0.063***	0.002	–0.011
	(0.016)	(0.019)	(0.008)
Human capital	0.569***	0.464***	0.434***
	(0.079)	(0.070)	(0.050)
Physical capital	0.520***	0.519***	0.508***
	(0.031)	(0.028)	(0.024)
TFP	0.969***	0.970***	0.965***
	(0.013)	(0.022)	(0.016)
Dummy for high income			–0.017**
			(0.007)
Dummy for upper-middle Income			–0.005
			(0.008)
Observations	1,264	2,573	3,790
Adjusted R-squared	0.961	0.952	
Number of economies	64	99	98

Source: Authors' estimates.
Note: The dependent variable is real GDP per engaged population. Column (1) presents the baseline regression for the sub-sample covering observations pre–1990. Column (2) conducts the same regression for the sub-sample covering observations post-1990. Column (3) features the baseline regression with two additional interaction terms between a dummy variable categorizing the economy's income level and the POADR measure. Robust standard errors are presented in brackets. The symbols ***, **, and * denote statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. Constants are omitted from the table.

We also find that in lower-middle-income and low-income economies, the negative impact of aging on real growth is more prevalent.[12] A one percentage point increase in the POADR results in a 0.016 percentage point decrease in human capital growth, a 0.058 percentage point decrease in physical capital growth and, notably—despite previous indications of statistical insignificance—a 0.065 percentage point reduction in TFP growth (Table 4). Possible reasons include insufficient investment in education and infrastructure, which hampers the potential positive effects of an aging population. Additionally, an older population may contribute less to innovation, and without significant public investment in automation and technology, the negative impact on TFP and physical capital becomes more pronounced.

Table 4. Impact of Aging on Economic Growth Channels

Variables	(1) Human Capital	(2) TFP	(3) Physical Capital	(4) Human Capital (LML)	(5) TFP (LML)	(6) Physical Capital (LML)
POADR	–0.031*	–0.007	–0.097*	–0.016**	–0.065***	–0.058**
	(0.017)	(0.053)	(0.055)	(0.007)	(0.015)	(0.028)
Observations	4,396	3,837	5,045	1,561	833	1,678
Adjusted R-squared	0.079	0.081	0.110	0.201	0.067	0.111
Number of economies	117	99	142	45	28	52

Source: Authors' estimates.
Note: The dependent variable is displayed in the first row of each column. LML represents the subsample that includes economies classified within the lower-middle-income and low-income groups. Robust standard errors are presented in brackets. The symbols ***, **, and * denote statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

[12] The analysis of high-income and upper-middle-income economies is presented in Appendix III.

GDP Contributions by Age Groups: Pre- and Post-2000

We investigate how different age groups contribute to the growth rate of real GDP per capita over time, organizing our data based on the service intensity of each economy. We calculate the service-to-industry ratio for each economy and year, categorizing the economies using the 50th percentiles. Economies with service-to-industry ratios below the 50th percentile are labeled as industry-focused, while those above are deemed service-focused. In addition, to ensure that we focus on age groups before and after retirement; while taking into account the variations in retirement age across economies, we limit our sample to include only economies with retirement ages ranging from 60 to 65. Within this sample, the pre-retirement age group comprises individuals aged 55 to 59, while the post-retirement age group includes those aged 66 to 70.

We analyze each age group's contribution to real growth over time by comparing estimates from two distinct periods—before and after 2000. The regression estimates are presented in Table 5 across four columns: columns (1) and (2) relate to industry-focused economies, while columns (3) and (4) correspond to service-focused ones. It is important to note that the lack of consistent long-term series data across the sample economies results in some economies dropping in and out of the sample throughout the regression time span. Therefore, estimates for industry-focused economies should be interpreted with caution. Conversely, service-focused economies include samples with relatively long time spans, the majority consisting of more than 20 years of time series observations.

Table 5. Contributions to Economic Growth by Age Groups: Pre-2000 and Post-2000

Variables	(1) Industry Focused 1985–2000	(2) Industry Focused 2001–2019	(3) Service Focused 1985–2000	(4) Service Focused 2001–2019
Population share of age group 55–59	–1.020**	0.034	0.055	0.230*
	(0.401)	(0.076)	(0.180)	(0.126)
Population share of age group 66–70	–1.381**	0.309**	–0.287	0.469***
	(0.590)	(0.132)	(0.176)	(0.155)
Observations	232	289	415	673
Adjusted R-squared	0.865	0.831	0.832	0.767
Number of economies	31	23	40	47

Source: Authors' estimates.
Note: Columns (1) and (2) display regression outcomes for industry-focused economies, whereas columns (3) and (4) correspond to service-focused economies. Economies with a service-to-industry ratio below the 50th percentile are defined as industry-focused, while those with ratios above the 50th percentile are considered service-focused. Robust standard errors are presented in brackets. The symbols ***, **, and * denote statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. Other control variables in the regressions include population share of age group between 25 and 45, human capital, physical capital as well as TFP.

Contrary to prevailing beliefs, our analysis indicates that individuals nearing or surpassing retirement age are showing a marked shift toward productivity, especially post-2000. This finding applies to both service- and industry-focused economies:

- For service-focused economies, a one percentage point increase in the population share of the age group 66 to 70 is associated with a significant 0.469 percentage point increase in the growth rate of real GDP per capita after 2000, up from insignificant estimates pre-2000. Additionally, the population share of the age group of 55 to 59 also exhibits similar trends—raising the growth rate of real GDP per capita by 0.23 percentage point from previously insignificant estimates before 2000.

Such evidence suggests possible increases in productivity for this age cohort post-2000,[13] and may be attributable to the high-skilled nature of many jobs in the service sector (such as academic positions), where productivity extends well beyond retirement. Additionally, the low-skilled service sector also contributes to economic growth, thanks to the minimal skill requirements for employment in this area.

- For industry-focused economies, a significantly negative contribution to the growth rate of real GDP was observed for the population share of age cohorts 55 to 59 and 66 to 70 prior to the year 2000. However, contributions to growth after 2000 are either insignificant or exhibit a positive relationship for the cohorts aged 55 to 59 and 66 to 70, respectively. A one percentage point increase in the population share of people aged 66 to 70 is associated with a 0.309 percentage point increase in real GDP growth per capita after 2000. In these economies, the development of automation and technology could be behind the observed disappearance of the negative relationship between the population of age close to retirement, consistent with the evidence provided by Acemoglu and Restrepo (2017).

B. ASEAN+3 Region

Next, we investigate the impact of aging on economic growth in ASEAN+3 economies and compare the results to those of the global sample. We first run the baseline regression with dummy variables for ASEAN and Plus-3 economies to test for any negative effect. We then explore how aging affects different channels of economic growth separately in ASEAN and Plus-3.

Baseline Regressions

The POADR shows little association with real GDP growth in the ASEAN+3 region, in contrast to the global context. We include separate dummy variables for ASEAN and Plus-3 groupings in our baseline specification and find that the coefficients of these two dummy variables are not statistically significant, suggesting that the elderly in these economies do not necessarily contribute negatively to economic growth (Table 6). The lack of any significant relationship between the POADR and real GDP growth per engaged population across ASEAN+3 economies may be a result of the aggregation across their varying demographic stages. Different patterns are observed between the two variables at the individual economy level (Table 7 and Figure 5):

- Hong Kong and Japan show significantly negative relationships, similar to the global sample; the POADR has risen in both economies between 1990 to 2019, albeit slightly in Hong Kong, from seven to eight percent, while Japan's POADR has increased from 10 to 19 percent.

- Insignificant relationships are observed for Indonesia, Korea, Malaysia, the Philippines, and Thailand; these economies show relatively flat POADRs over time (except Indonesia), suggesting that the proportion of elderly to working-age remains relatively stable.

[13] As clarified in the methodology section, precise estimates of productivity cannot be achieved because of insufficient data. Therefore, we use population share and per capita GDP to indicate the possible productivity trends of relevant age cohorts.

- China and Singapore show significantly positive relationships; their respective POADRs have fallen between 1990 and 2019, with China's declining from 11 to nine percent, while Singapore decreased from six percent to four percent.

Table 6. Baseline Regression with ASEAN+3 Dummy Variables

Variables	(1) Growth of Real GDP per Engaged Population	(2) Growth of Real GDP per Engaged Population	(3) Growth of Real GDP per Engaged Population	(4) Growth of Real GDP per Engaged Population
POADR	–0.025***	–0.027***		
	(0.008)	(0.008)		
OADR			0.006	0.006
			(0.004)	(0.004)
Dummy for ASEAN	0.043		–0.002	
	(0.027)		(0.014)	
Dummy for Plus-3		–0.012		-0.003
		(0.011)		(0.005)
Human capital	0.456***	0.457***	0.465***	0.465***
	(0.051)	(0.052)	(0.053)	(0.053)
Physical capital	0.509***	0.510***	0.508***	0.508***
	(0.024)	(0.024)	(0.024)	(0.024)
TFP	0.969***	0.969***	0.968***	0.968***
	(0.015)	(0.015)	(0.015)	(0.015)
Observations	3,837	3,837	3,837	3,837
Number of economies	99	99	99	99

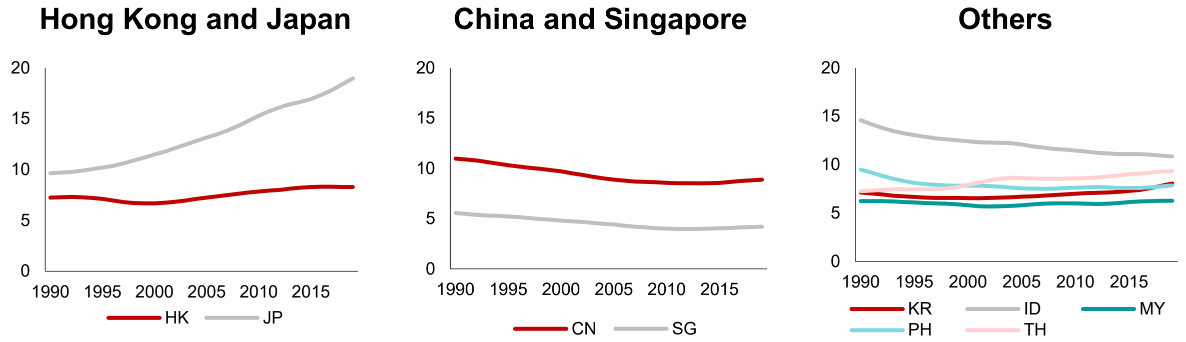
Source: Authors' estimates.
Note: Columns (1) and (2) are the baseline regressions when the POADR measure is used at a 90 percent threshold. Columns (3) and (4) show regression results using the conventional OADR measure. Robust standard errors are in brackets. ***, **, and * represent statistical significance at 1 percent, 5 percent, and 10 percent levels, respectively. Constants are included in the regressions, but the estimates are not reported in the table.

Table 7. Baseline Regression for Individual ASEAN+3 Economies

Variables	(1) CN	(2) HK	(3) ID	(4) JP	(5) KR	(6) MY	(7) PH	(8) SG	(9) TH
POADR	0.285***	–0.322*	–0.165	–0.102***	0.081	–0.048	–0.044	0.290***	–0.231
	(0.069)	(0.174)	(0.191)	(0.032)	(0.155)	(0.060)	(0.108)	(0.088)	(0.605)
Human capital	0.580***	0.322***	0.712***	1.221	0.922*	0.874***	0.668	0.453***	0.612
	(0.172)	(0.117)	(0.165)	(1.279)	(0.464)	(0.118)	(0.586)	(0.057)	(0.656)
Physical capital	0.587***	0.469***	0.570***	0.267***	0.376***	0.744***	0.624***	0.526***	0.372***
	(0.036)	(0.040)	(0.031)	(0.059)	(0.037)	(0.022)	(0.053)	(0.039)	(0.067)
TFP	0.968***	1.001***	0.980***	1.233***	1.059***	1.008***	1.014***	1.019***	0.603***
	(0.029)	(0.022)	(0.015)	(0.055)	(0.036)	(0.019)	(0.055)	(0.030)	(0.143)
Observations	38	55	25	59	42	46	31	55	38
Adjusted R-squared	0.984	0.968	0.991	0.981	0.950	0.984	0.956	0.966	0.744

Source: Authors' estimates.
Note: The dependent variable is growth rate of real GDP per engaged population. Robust standard errors are in brackets. ***, **, and * represent statistical significance at 1 percent, 5 percent, and 10 percent levels, respectively. Constants are included in the regressions, but the estimates are not reported in the table. CN = China; HK = Hong Kong, China; ID = Indonesia; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; and TH = Thailand.

Figure 5. ASEAN+3: POADR, 1990–2019
(Percent)



Source: Authors' calculations based on data from PWT and UN DESA.
Note: CN = China; HK = Hong Kong; ID = Indonesia; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; and TH = Thailand.

The relationship between aging and growth in ASEAN+3 is evolving as well. Similar to the analysis based on the global sample, we divide the regional sample into two periods: pre- and post-2000. Although the POADR coefficients change from positive to negative between the two periods, they remain insignificant. This outcome contrasts with that of the global sample, in which the POADR coefficients shift from being significantly negative to insignificant. Moreover, the ASEAN+3 coefficients for both human capital and TFP have increased between the two periods, suggesting rising contributions from these two factors to growth (Table 8).

Table 8. ASEAN and Plus-3: Baseline Regression with Split Samples

Variables	(1) Pre-2000 ASEAN	(2) Post-2000 ASEAN	(3) Pre-2000 Plus-3	(4) Post-2000 Plus-3
POADR	0.142	–0.122	0.005	–0.091
	(0.094)	(0.174)	(0.115)	(0.057)
Human capital	0.436**	0.462***	0.388*	0.533***
	(0.133)	(0.057)	(0.137)	(0.063)
Physical capital	0.526***	0.522***	0.418***	0.423**
	(0.075)	(0.069)	(0.040)	(0.123)
TFP	0.833***	0.939***	1.018***	1.061***
	(0.134)	(0.087)	(0.029)	(0.044)
Observations	95	100	114	80
Number of economies	5	5	4	4
Adjusted R-squared	0.867	0.908	0.968	0.924

Source: Authors' estimates.
Note: The symbols ***, **, and * denote statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. Columns (1) and (2) are regressions for ASEAN economies, which include Indonesia, Malaysia, Philippines, Singapore, and Thailand. The rest of the ASEAN economies have been dropped due to data availability issues. Columns (3) and (4) are regressions for Plus-3 economies, which include China, Hong Kong China, Japan, and Korea.

Impact of Aging on Economic Growth Channels

Aging in ASEAN+3, measured by POADR, shows varying effects on physical and human capital accumulation and TFP. Specifically, it has statistically significant negative impact on physical capital accumulation in ASEAN economies. A one percentage point increase in the POADR is associated with 1.26 percentage points decrease in ASEAN growth in physical capital accumulation, which is greater than the world average. However, the POADR has no significant effect on human capital accumulation and TFP growth (Table 9).[14] The coefficients for human capital, TFP, and physical capital growth are insignificant for the Plus-3 grouping.

Table 9. ASEAN+3: Impact of Aging on Economic Growth Channels

Variables	(1) ASEAN Human Capital	(2) ASEAN TFP	(3) ASEAN Physical Capital	(4) Plus-3 Human Capital	(5) Plus-3 TFP	(6) Plus-3 Physical Capital
POADR	-0.074	–0.271	–1.255***	0.030	–0.024	–0.531
	(0.157)	(0.509)	(0.308)	(0.023)	(0.037)	(0.435)
Observations	318	203	309	198	194	198
Adjusted R-squared	0.009	0.451	0.312	0.092	0.315	0.330
Number of economies	10	6	10	4	4	4

Source: Authors' estimates.
Note: The dependent variable is displayed in the first row of each column. Robust standard errors are presented in brackets. The symbols ***, **, and * denote statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. Columns (1) and (3) use all ASEAN economies, while for column (2), the economies included are Indonesia, Lao PDR, Malaysia, Philippines, Singapore, and Thailand based on the availability of TFP data.

The absence of any relationship between aging and growth in human capital accumulation and TFP in ASEAN could be attributable to the higher-than-average levels of expansion in the latter factors. For example, the ASEAN region not only has a relatively low aging population ratio but also boasts a high human capital growth rate of 1.19 percent in 2019, surpassing the world average of 0.89 percent. Additionally, ASEAN exhibits a better TFP growth rate of –0.63 percent compared to the global average of –0.89 percent (Figure 6). It highlights the importance of developing human capital and promoting TFP growth as the ASEAN economies continue to age.

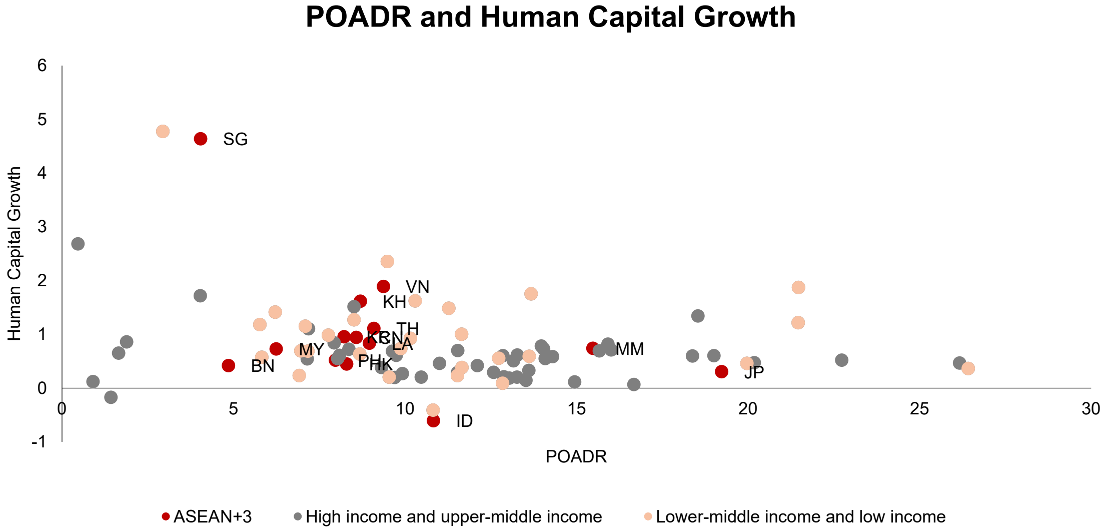
VI. Conclusion and Policy Suggestions

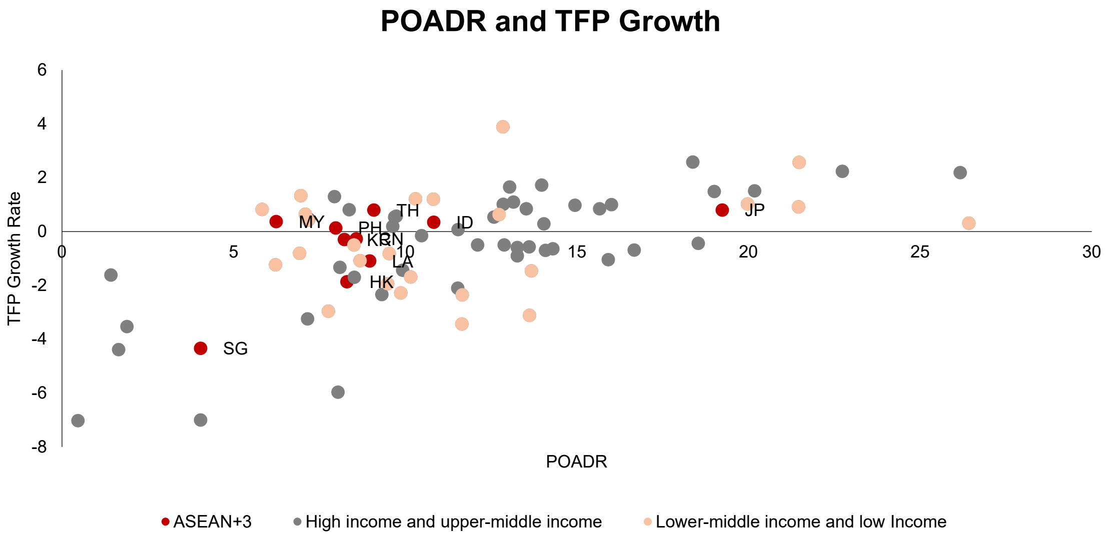
Population aging is accelerating, particularly in less-developed economies, raising concerns among policymakers about its potential negative impact on long-term growth. Rising aged populations can lead to reductions in labor supply and labor productivity, as well as increased burden on the fiscal purse. Advances in medical technology and healthcare have noticeably increased life expectancy. Consequently, the traditional definition of individuals aged 65 (or 60) and above as elderly may be misleading. To address this issue, we propose a dynamic measure based on changes in life expectancy, which adjusts the threshold for classifying the elderly, ensuring a more realistic identification of the elderly population.

Aging adversely affects economic activity. The aging population ratio, as measured by our proposed indicator, shows significant negative correlation with economic growth. It was particularly pronounced before 1990 in our global sample. This negative effect is brought about by the reduction in human and physical capital accumulation. Moreover, the negative relationship is pronounced for lower-middle-income and low-income groups, likely because of their lack of investment in education and public infrastructure to channel any positive effect of aging on growth factors.

[14] Due to data availability, regressions on TFP include ASEAN-5 economies and Lao PDR.

Figure 6. POADR and Growth in Human Capital and TFP, 2019
(Percent)





Source: Authors' calculations based on data from PWT and UN DESA.
Note: BN = Brunei Darussalam; CN = China; HK = Hong Kong, China; ID = Indonesia; JP = Japan; KH = Cambodia; KR = Korea; LA = Lao PDR; MM = Myanmar; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; and VN = Vietnam.

Moreover, the contributions to economic growth by individuals within the same age groups appear to vary over time. In particular, the age group nearing retirement and beyond has increasingly contributed to growth since 2000. In industry-focused economies, the negative contributions by this group turned positive after 2000. Similarly, this age group shows significant positive contributions to GDP growth after 2000 in service-focused economies. Consequently, there is a compelling need to reassess our perceptions of the elderly and attendant retirement ages to fully leverage the potential of older individuals who—despite their advanced age—remain sufficiently productive to contribute to economic growth.

Unlike the global sample results, the ASEAN+3 region shows an overall insignificant relationship between aging and economic growth, possibly due to the varying demographic stages across economies. In ASEAN, aging has a significantly negative impact on physical capital accumulation, but not on human capital accumulation and TFP. In Plus-3, there is no significant relationship between aging and all channels of growth.

The "old-age" demographic has not yet expanded significantly in most economies in ASEAN and China, which presents a window for governments to address the challenges of aging. These economies, particularly the emerging ones, are still positioned on the declining side of the U-shaped curve depicting the POADR. In this phase, the negative impact of aging on economic growth is gradually decreasing. As the POADR starts to rise, the adverse effects on economic growth are likely to become more pronounced unless proactive measures are taken during the former phase to mitigate the potential effects of an aging economy.

Governments play an important role in promoting human capital and technological advancements. Evidence suggests that the negative effects of aging on economic growth were more pronounced before the 1990s and in low-income economies, underscoring the importance of improving economic development. Human capital and technology are key channels through which the aging population affects growth. Therefore, it is imperative for policymakers to prioritize initiatives aimed at fostering education, training, innovation, and other measures that elevate levels of human capital and technological advancement.

Reducing controls on retirement age and making job opportunities available to individuals over the age of 65 can significantly contribute to economic growth. In the contemporary landscape, the traditional categorization of individuals aged 65 and above as elderly is becoming outdated. With advancements in healthcare and skill accumulation, productivity levels among individuals in this age group are on the rise. Extending the retirement age may pose political challenges; however, allowing older people to voluntarily remain in the workforce can enhance the utilization of human resources and foster higher economic growth. Hence, governments could consider relaxing regulations on compulsory retirement ages and incentivize industries to create more job opportunities for older individuals who are experienced and remain efficient and capable of making substantial contributions.

Future research could focus more on sector-level analysis in the ASEAN+3 region, if data are available. It could examine the effects of age composition on productivity in individual sectors to identify opportunities and challenges from an aging population. This study has highlighted how industry- or services-focused economies may differ in terms of their populations' respective contributions to economic growth across age groups. With more granular sectoral data, further research could explore how some sectors may benefit from the experience and expertise of older workers, while others might face challenges due to a lack of younger employees. Understanding these dynamics is important for developing targeted policies that can mitigate potential risks and leverage the strengths of an aging workforce.

Appendix I. Economies Included in the Baseline Regressions

Appendix Table 1. Economies in Baseline Regressions

Argentina	Estonia	Latvia	Senegal
Armenia	Fiji	Lithuania	Serbia
Australia	Finland	Luxembourg Malaysia	Singapore
Austria	France	Malta	Slovakia
Bahrain	Gabon	Mauritania	Slovenia
Barbados	Germany	Mauritius	South Africa Spain
Belgium	Greece	Mexico	Sri Lanka
Bolivia (Plurinational	Guatemala	Mongolia	Sudan
State of)	Honduras	Morocco Netherlands	Sweden
Botswana	Hungary	New Zealand	Switzerland
Brazil	Iceland	Nicaragua	Tajikistan
Bulgaria	India	Norway	Thailand
Canada	Indonesia	Panama	Trinidad and Tobago
Chile	Iran (Islamic Republic of)	Paraguay	Tunisia
China	Iraq	Peru	Türkiye
China Hong Kong SAR	Ireland	Philippines	Ukraine
China Macao SAR	Israel	Poland	United Kingdom
Colombia	Italy	Portugal	United Republic of
Costa Rica	Jamaica	Qatar	Tanzania
Croatia	Japan	Republic of Korea	United States of America
Cyprus	Jordan	Republic of Moldova	Uruguay
Czechia	Kazakhstan	Romania	Venezuela (Bolivarian
Denmark	Kuwait	Russian Federation	Republic of)
Dominican Republic	Kyrgyzstan	Rwanda	
Ecuador	Lao People's Democratic	Saudi Arabia	
Egypt	Republic		

Source: Authors' compilation.
Note: The economies are listed in alphabetical order.

Appendix II. Data Source

Appendix Table 2. Data Source and Descriptions

Variables	Description	Data Source
Aggregate GDP	Expenditure side real GDP	Penn World Table 10.01
Economy classifications	Classification of economies by income levels	World Bank
Total factor productivity (national price)	Total factor productivity at constant national prices (2017 = 1)	Penn World Table 10.01
Population	Population in millions	Penn World Table 10.01
Engaged population	Person engaged is defined in the Penn World Table to include all persons aged 15 years and over, who performed work during the reference week, even just for one hour a week, or were not at work but had a job or business from which they were temporarily absent.	Penn World Table 10.01
Physical capital	Capital stock	Penn World Table 10.01
Human capital/education	Human capital index, based on years of schooling and returns to education	Penn World Table 10.01
Old age dependency ratio (OADR)	Annual old-age dependency ratio	UN DESA (2022) World Population Prospects: the 2022 revision. The working population starts at 15 following the World Bank measure.
Prospective old-age dependency ratio (POADR)	Annual ratio	UN DESA (2022) World Population Prospects: the 2022 revision. The working population starts at 15 following the World Bank measure.
Life expectancy	Life expectancy at birth, total (years)	UN DESA (2022) World Population Prospects: the 2022 revision. The working population starts at 15 following the World Bank measure.
Retirement Age	Mandatory retirement age at 2022 for OECD or 2023 for the World Bank	World Bank (2023) https://genderdata.worldbank.org/indicators/sg-age-rtre/ OECD (2022) Pensions at a Glance
Services (percent of GDP)	Services value added as a percentage of GDP	World Bank National Accounts Data
Industry (percent of GDP)	Industry value added as a percentage of GDP	World Bank National Accounts Data

Source: Authors' compilation.

Appendix III. Additional Regressions Results

Appendix Table 3. Additional Regressions Results

Variables	(1) Human Capital/ High income	(2) Human Capital/ Upper-middle income	(3) Human Capital/ Lower-middle income and low income	(4) Physical Capital/ High income	(5) Physical Capital/ Upper-middle income	(6) Physical Capital/ Lower-middle income and low income	(7) TFP/ High income	(8) TFP/ Upper-middle income	(9) TFP/ Lower-middle income and low income
POADR	–0.005	–0.070	–0.016**	–0.046	–0.115	–0.058**	–0.028	0.179	–0.065***
	(0.012)	(0.061)	(0.007)	(0.071)	(0.105)	(0.028)	(0.039)	(0.169)	(0.015)
Observations	2,645	1,060	1,561	2,850	1,391	1,678	2,463	889	833
R-squared	0.113	0.119	0.232	0.195	0.070	0.142	0.120	0.114	0.129
Number of Economies	52	32	45	60	44	52	49	28	28

Source: Authors' estimates.
Note: The dependent variable is real GDP per engaged population. Robust standard errors are presented in brackets. The symbols ***, **, and * denote statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

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