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ASEAN +3 MACROECONOMIC RESEARCH OFFICE

Working Paper (WP/24-08)

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

Aruhan Rui Shi and Hongyan Zhao

July 2024

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

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July 2024

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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[2] The authors would like to thank Jorge A. Chan-Lau, Diana del Rosario, and Li Lian Ong for useful comments. All remaining mistakes are the responsibility of the authors.

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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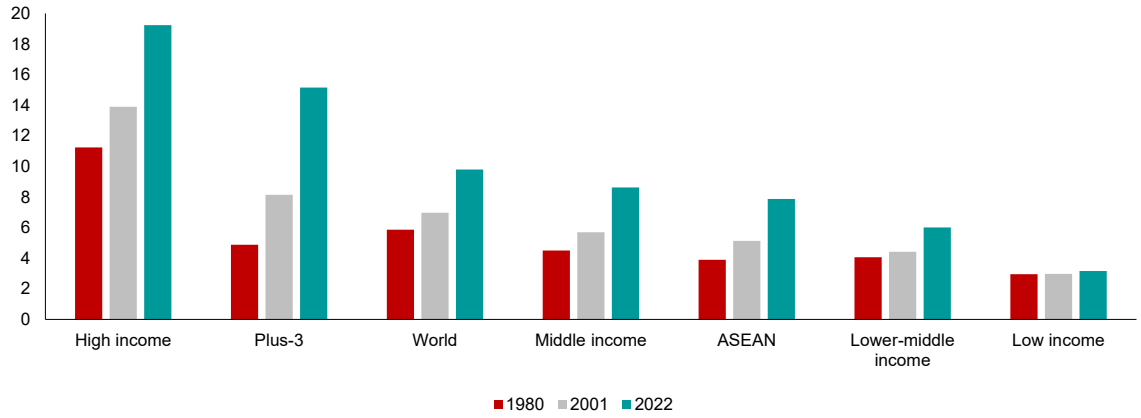
I. Introduction

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):

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

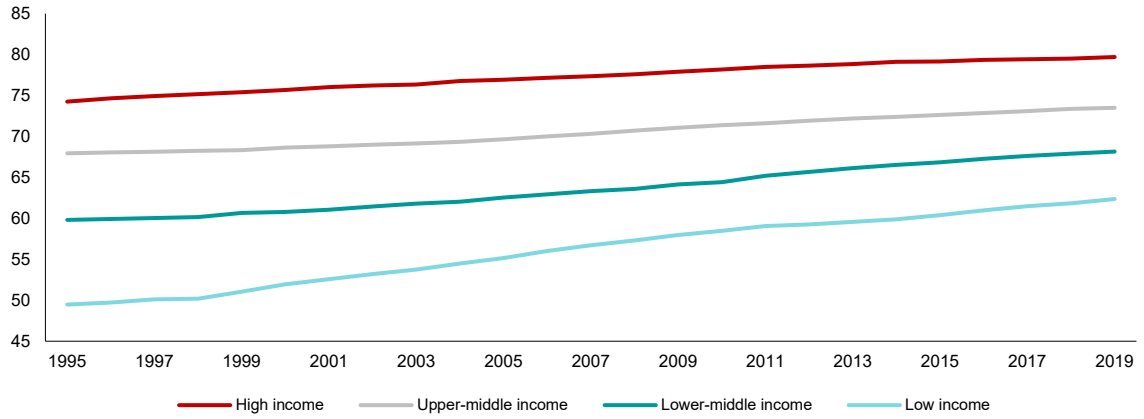
The OADR measure does not account for changes in life expectancy, and thus may not capture the contribution of people who are close to retirement or above retirement age to the economy. Therefore, studies based on the OADR as a measure of aging could lead to misleading interpretations and results.

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)

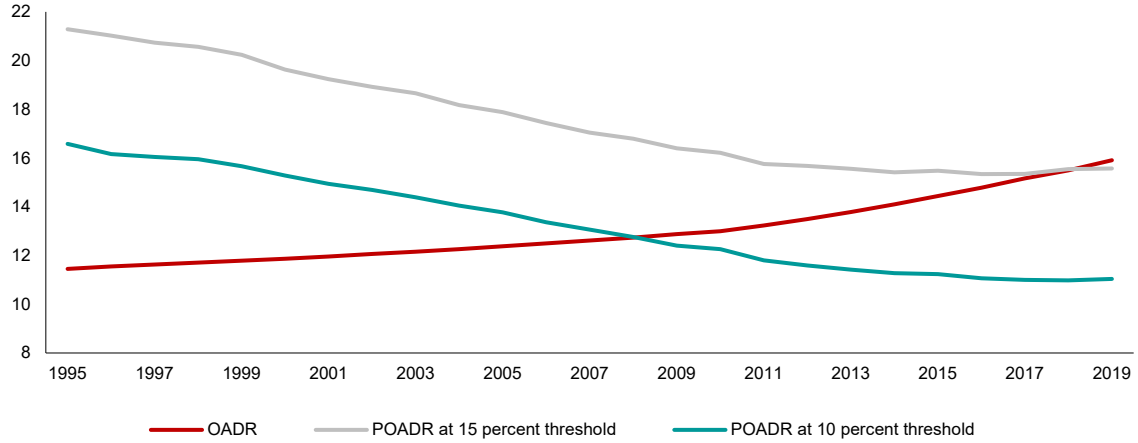


Source: Authors' calculation based on data from the UN DESA (2022).[5]

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).

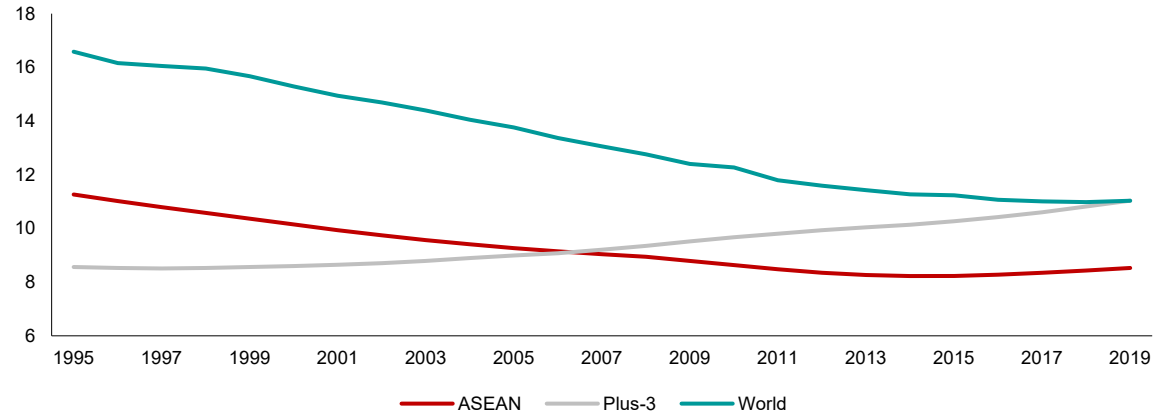
Figure 3. Measures of Old-Age Dependency
(Percent)



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.

[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):

$$\Delta \ln Z_{it} = \gamma_1 X_{it} + u_{it} \quad (4)$$

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):

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

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** (0.401)	0.034 (0.076)	0.055 (0.180)	0.230* (0.126)
Population share of age group 66–70	–1.381** (0.590)	0.309** (0.132)	–0.287 (0.176)	0.469*** (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

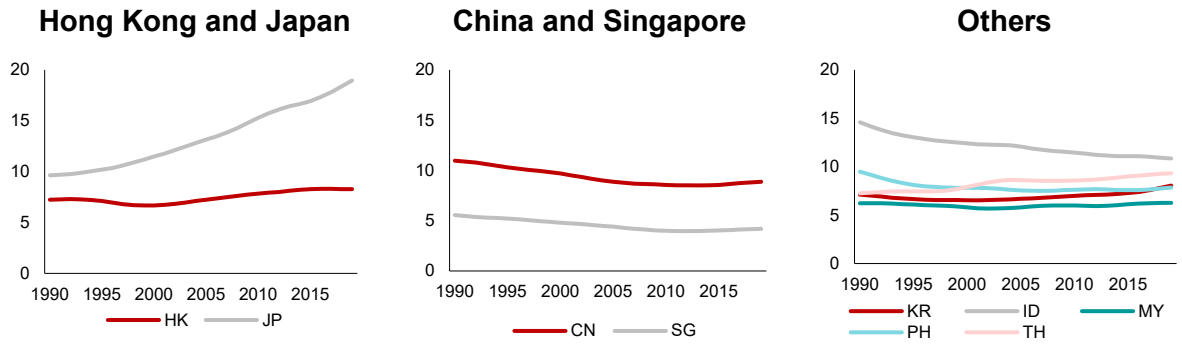
Source: Authors' estimates.
Note: Columns (1) and (2) are the baseline regressions when the POADR measure is used at a 90 percent threshold. Columns (3) and (4) show regression results using the conventional OADR measure. Robust standard errors are in brackets. ***, **, and * represent statistical significance 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.

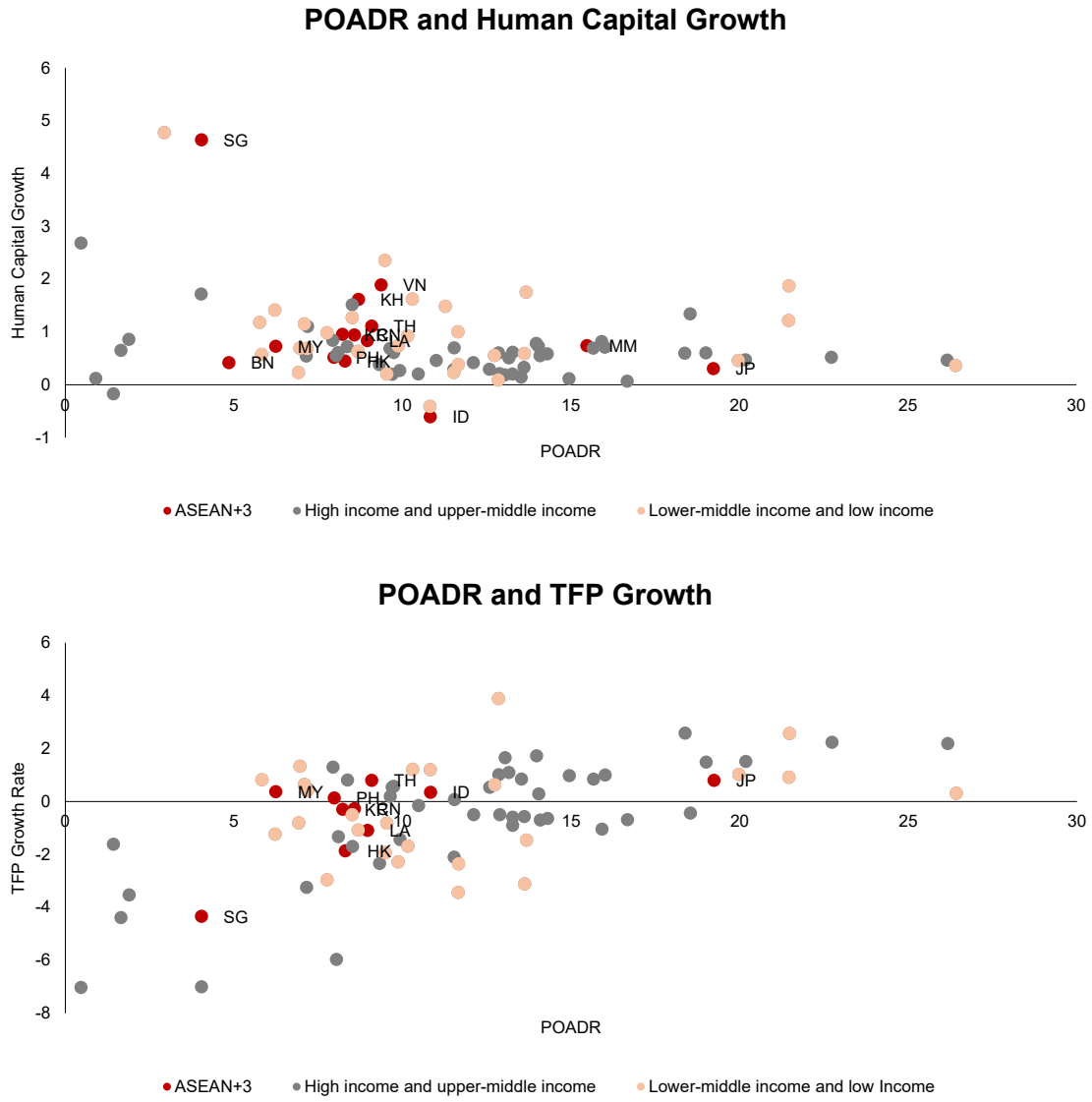
VI. Conclusion and Policy Suggestions

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 Prospectives: 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 Prospectives: 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 Prospectives: 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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Population Age Structure Change and Labour Productivity:

Evidence from Brunei Darussalam

Kartini Rahman

Sufrizul Husseini

Abstract

This paper examines the long-term equilibrium relationship between population age structure and labour productivity in Brunei Darussalam using a vector error correction model. Using annual data from 1991 to 2021, we find a long-run co-integrating relationship between population age structure and labour productivity. We find that our age productivity profile does confirm to the traditional inverted U-shaped pattern over time. Furthermore, we find a negative association between prime adults and labour productivity, and a positive relationship between elderly and labour productivity, contrary to the extent literature. The findings of the study suggest that productivity is observed to manifest at a later stage. This implies the need for policymakers to identify and prescribe labour policies that effectively address the distinct requirements of various age cohorts within the workforce.

Keywords: population age structure change, labour force participation rate, error correction model, Brunei Darussalam

1. Introduction

Population ageing has a profound effect on the economy, influencing labour market characteristics by decelerating the development of the labour force and ultimately leading to its contraction (Cadiou et al., 2002; Peng, 2006; Bloom and Sousa-Poza, 2013). The ageing of the population impacts the labour market structure and performance in two ways: (1) directly, through the interplay between labour supply and demand and productivity; and (2) indirectly,

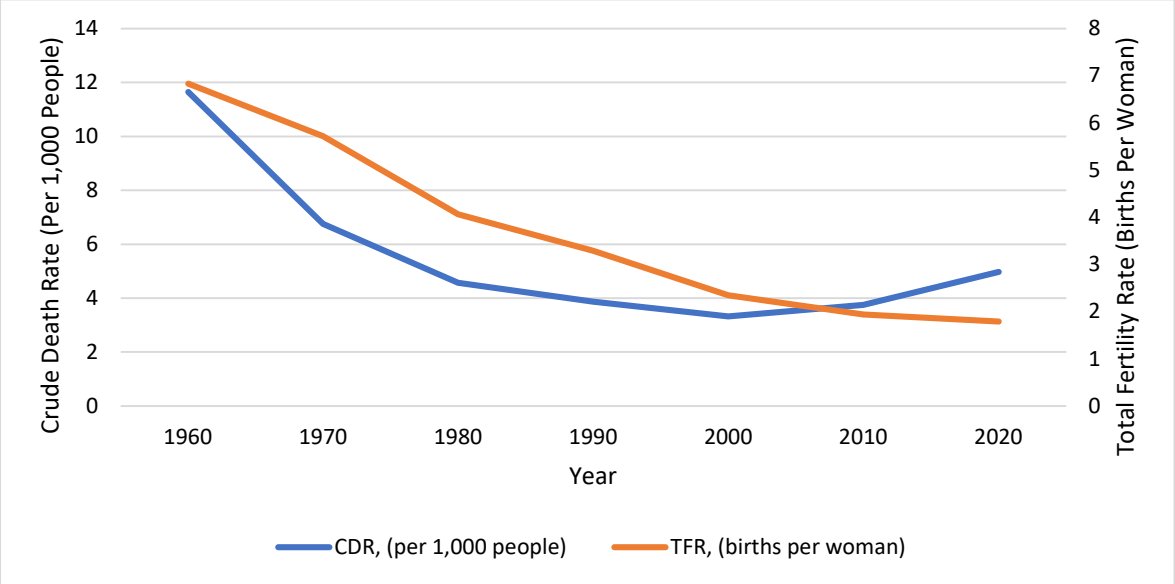
through a reallocation of aggregate demand towards a greater emphasis on services. The ageing of the labour force may have an impact on the mobility, employment, and productivity of workers, and thus on the performance and adaptability of the labour market. Thus, the applicability of the age-productivity profile in an ageing society is established.

Numerous studies have examined the relationship between age and individual productivity, revealing an inverted U-shaped profile in which older individuals are less productive than younger ones (Haltivanger et al., 1999; Crépon et al., 2002). Nevertheless, it would be erroneous to presume that these specific effects are universally applicable (Lindh & Malmberg, 1999; Chawla et al., 2007; Brunow & Hirte, 2006, 2008; Van Ours & Stoeldraijer, 2010). Systematically deriving the conclusion that an ageing population could potentially reduce aggregate productivity and economic development is a challenging endeavor at the macroeconomic level. As a result, examining the age-related changes in total labour productivity continues to be a significant and contentious topic.

The focus of this paper is on the changing population age structure of Brunei Darussalam and its potential effects on labour productivity and consequential policy implications. Brunei is experiencing the inevitable demographic transition, reductions in mortality and reductions in fertility, which results in an ageing population (Caldwell, 1996). An examination of Brunei's demographic transition shows there is a steady decrease in crude death rate (CDR) and total fertility rate (TFR) over a period of 80 years (1960-2020), shown in Figure 1. The decrease in CDR from 11.7 deaths per 1,000 people in 1970, to 5 deaths per 1,000 people in 2020, signifies the improved standard of living, better health care which have contributed to a longer life span in Brunei over time. Whereas, the rapid decrease of TFR, particularly from 5.6 births per woman in 2000 to 1.9 in 2020, indicates a demographic shift towards a TFR below the population replacement rate of 2.1 births per woman. Studies have shown that a trend of

persistent TFR declines to far below the population replacement rate of 2.1 would result in population shrinkage and contribute to rapid population ageing (Harper and Zhang, 2024).

Figure 1: Crude Death Rate (Per 1,000 People) and Total Fertility Rate (Births per Woman), Brunei Darussalam, 1960-2020

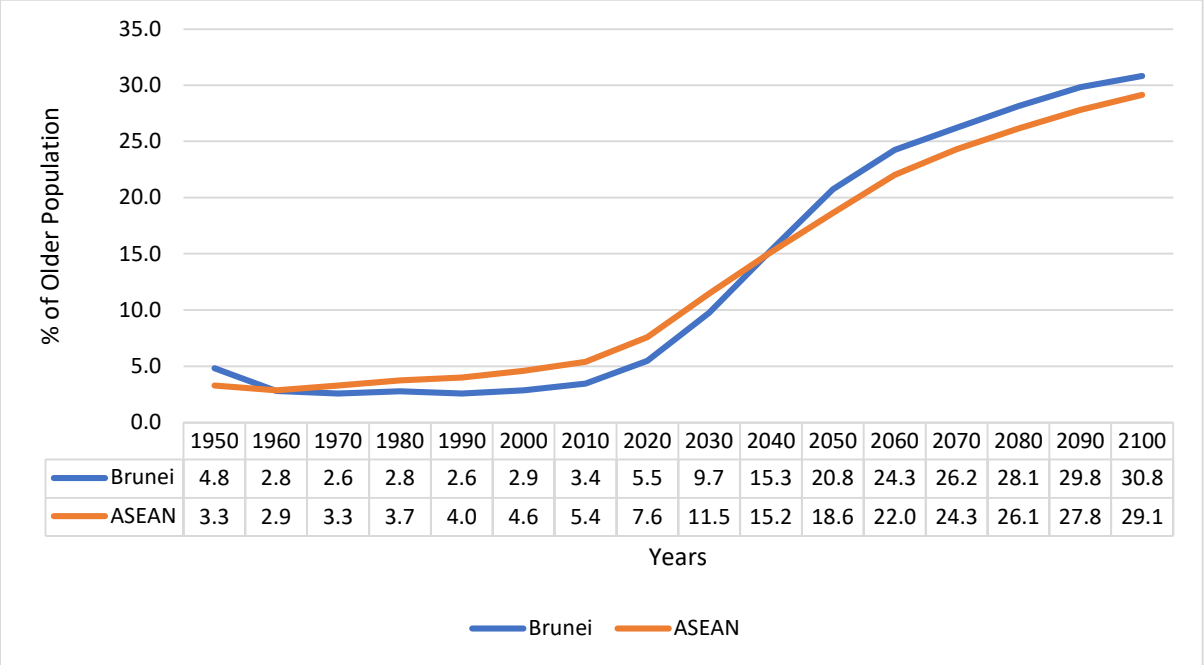


Source: Authors' calculations based on "medium-variant" projections from the World Population, Prospects 2022, using (United Nations, 2022)

Within ASEAN, according to UN projections and OECD calculations, the fastest ageing nation is Brunei Darussalam (United Nations, Department of Economic and Social Affairs, Population Division, 2019; OECD, 2020). According to Figure 2, Brunei will become a super aged society by 2040, with 21% of the population over 65[1]. This is evidence through a rapid increase of 4-5% every 10 years between 2020 to 2060, a distinctively short time frame (Figure 2). Concerningly, Brunei's population aged 80 years and over are expected to increase by six-fold from 2020 to 2050 (OECD, 2020).

[1] A country is considered an 'super aged society' when their share of population over 65 is above 21% (OECD, 2020)

Figure 2: Growth of older population (persons aged 65+ years) in ASEAN and Brunei Darussalam, 1950-2100



	1950	1960	1970	1980	1990	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
Brunei	4.8	2.8	2.6	2.8	2.6	2.9	3.4	5.5	9.7	15.3	20.8	24.3	26.2	28.1	29.8	30.8
ASEAN	3.3	2.9	3.3	3.7	4.0	4.6	5.4	7.6	11.5	15.2	18.6	22.0	24.3	26.1	27.8	29.1

Source: Authors' calculations based on "medium-variant" projections from the World Population, Prospects 2022, using (United Nations, 2022)

Table 1 shows the proportion of population over 65 in different ASEAN countries. The ASEAN countries are comparatively young in 2021, except for Thailand and Singapore, which are already considered an aged society[2]. By 2050, there will be a dramatic increase in the share of the population over 65, with all countries at least doubling in their share of the population over 65, if not more than double, as in the case of Brunei Darussalam (Table 1).

[2] A country is considered an 'aged society' when their share of population over 65 is between 15-20% (OECD, 2020)

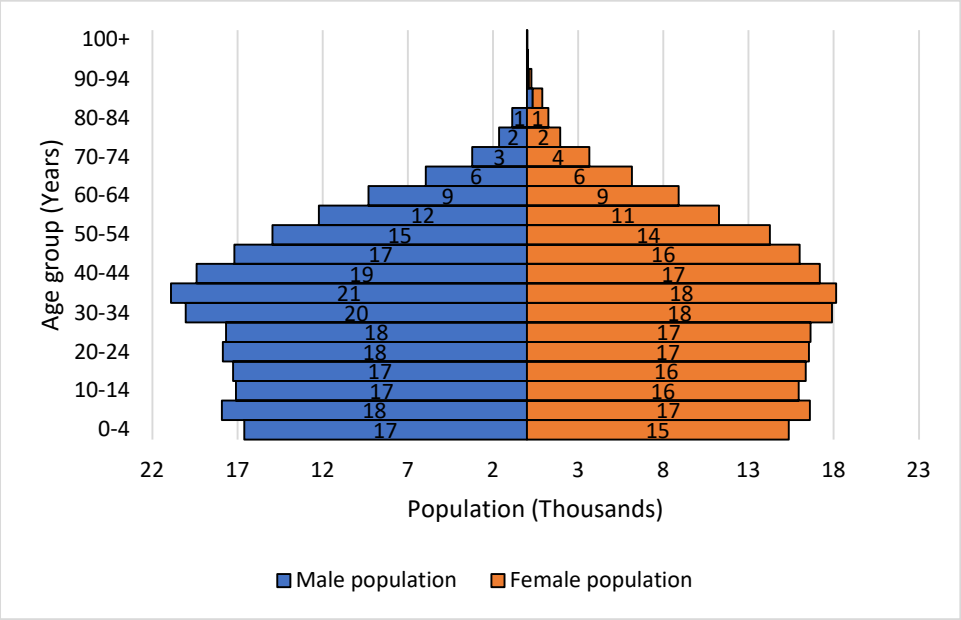
Table 1: Percentage of population aged 65 years and above, ASEAN countries, 2021, 2050, 2080

ASEAN Countries	2021	2050	2080
Brunei Darussalam	6	21	28
Cambodia	6	13	22
Indonesia	7	15	22
Lao People's Democratic Republic	4	10	20
Malaysia	7	17	28
Myanmar	7	14	20
Philippines	5	11	18
Singapore	14	34	38
Thailand	15	32	39
Viet Nam	9	20	27

Source: "Medium-variant" projections from the World Population, Prospects 2022, (United Nations, 2022)

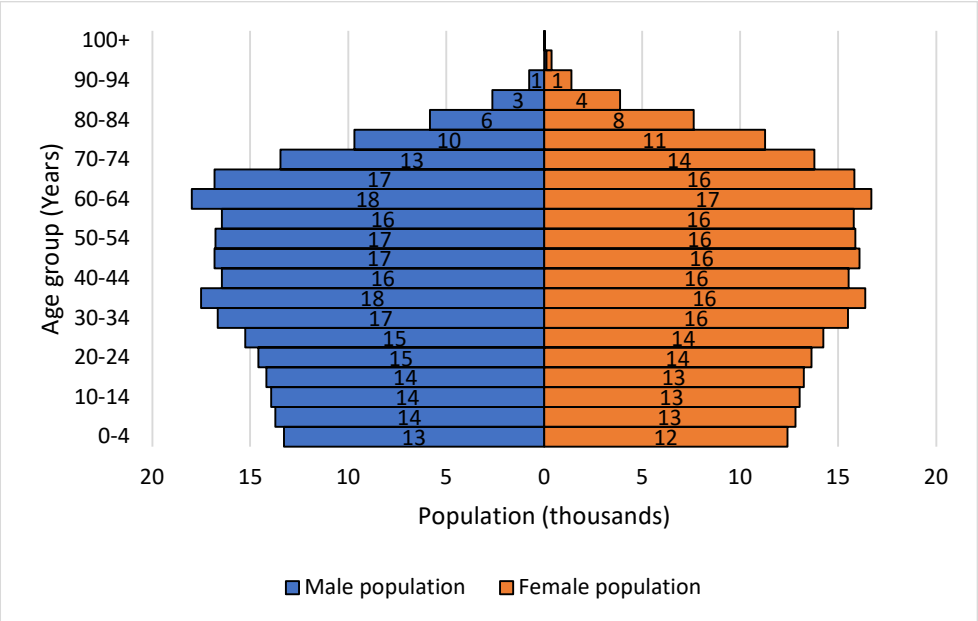
Implications on these distinct increases of share of older population in Brunei Darussalam are examined via the evaluation of the Brunei's population pyramids (Figures 3-5).

Figure 3: Population pyramid, Brunei Darussalam, 2021



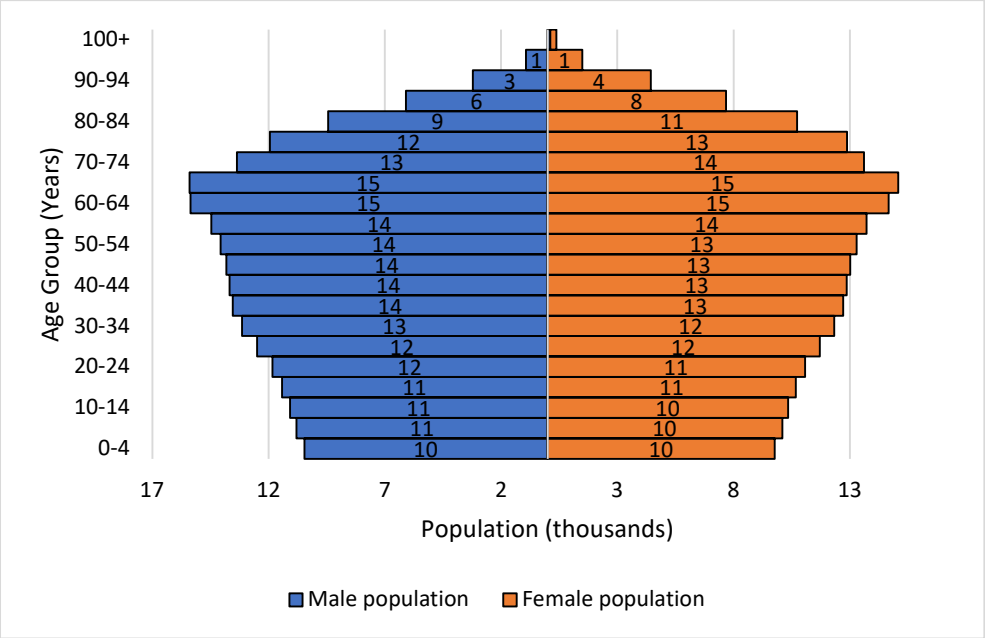
Source: Authors' calculations based on "medium-variant" projections from the World Population, Prospects 2022 (United Nations, 2022).

Figure 4: Population pyramid, Brunei Darussalam, 2050



Source: Authors' calculations based on "medium-variant" projections from the World Population, Prospects 2022 (United Nations, 2022).

Figure 5: Population pyramid, Brunei Darussalam, 2080



Source: Authors' calculations based on "medium-variant" projections from the World Population, Prospects 2022 (United Nations, 2022).

Three main demographic trends to affect Brunei are discussed:

i. **A female dominant older population**. A drastically higher proportion of the female population of Brunei are expected to age than the male population. This is repeated since 2021 (Figure 3), and corroborated by a consistently higher life expectancy of female population (76.8 in 2021) compared to male life expectancy (72.6 in 2021) in Brunei (United Nations, 2022). The population pyramids (Figures 3-5 in Appendix) illustrate a disconcerting rise in the proportion of women in the oldest-old[3] age group of 85 and above, compared to men. On average in Brunei, for a female born in 2021 they are expected to live about 16.8 years more than Brunei's retirement age of 60, and about 4.2 years longer than men. Older women would

[3] The old-age category definitions, 'young-old' for 65-74, 'middle-old' for 75-84, and 'oldest-old' for 85 and above, used for this paper, are based on gerontology and demography literature.

spend a longer time after retirement, without financial support needed for potential increasing requirements and expenditures, particularly for health support in later ages.

ii. **Health of the older population.** With the rapidly increasing oldest-old group in Brunei, health is an important issue to address. Maintaining health and functional ability is important to achieve healthy ageing, for older adults re-enter the labour market for financial security, and to continue to be productive contributors to the economy and society (WHO, 2020). Additionally, a study in Malaysia by Mafauzy (2000) found that continued employment would provide longevity, better wellbeing, and important widening of social networks for both sexes.

iii. **Ageing labour force**. The population pyramids (Figures 3-5) depict a decreasing working age population for Brunei, whilst experiencing an increasing proportion of the older population. The decreasing number of working-age group (15-64 years) would affect support to older adults, which is evidenced by a projected increasing old-age dependency ratio in Brunei (Table 2).

Table 2: Old-Age Dependency Ratio [65+/15-64] (%), Brunei Darussalam, China, DPR-Korea and Japan, 2021/2050/2080.

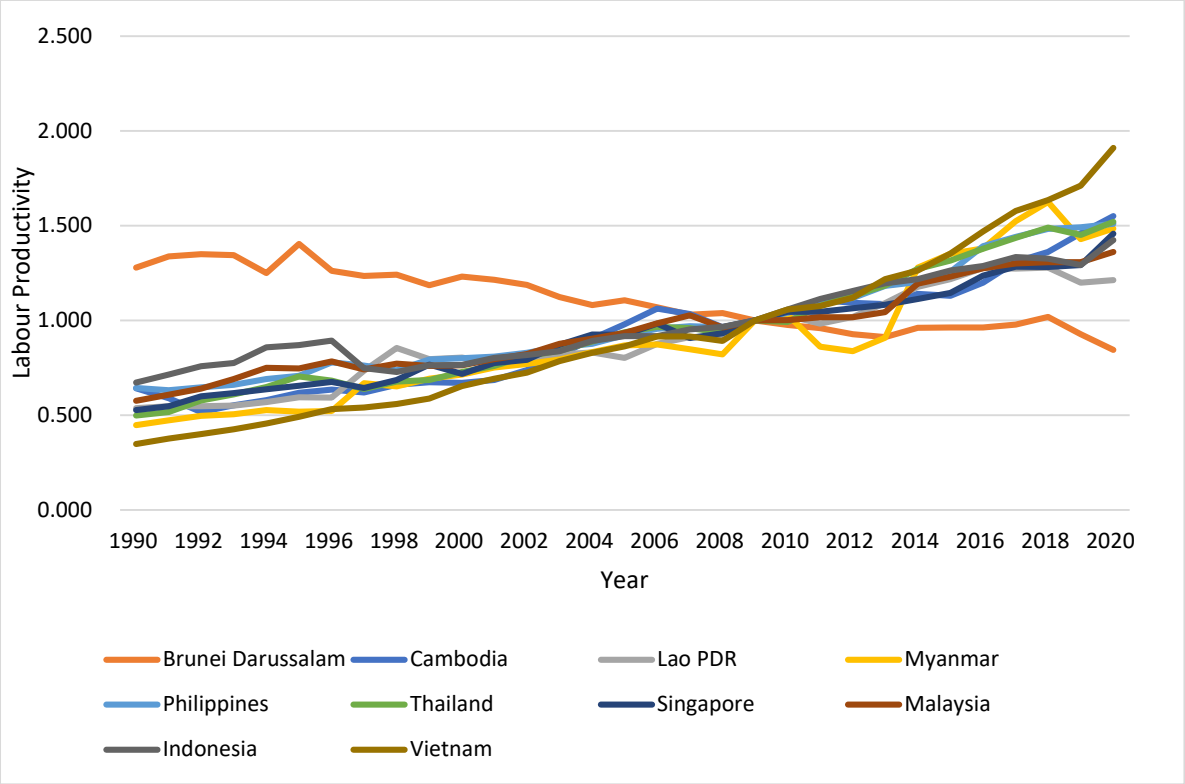
Countries/Organisation	2021	2050	2080
Brunei Darussalam	8.1	32.8	48.7
China	19	51.5	82.2
DPR-Korea	16.3	34.8	45.8
Japan	51	73	78.5

Source: Authors' calculations based on the World Population, Prospects 2022 (United Nations, 2022)

The old-age dependency ratio is used to gauge the potential support to older adults (World Bank, n.d). It is defined as the number of people aged 65 and over per 100 people of working age. Table 2 shows that Brunei's old-age dependency ratio will

more than quadruple between 2021 and 2050. By comparison, East Asian countries would more or less double their old-age dependency ratio, which highlights the intensity of Brunei's ageing population during 2021 to 2050. Such a high dependency ratio increase in short period of time indicates potential burden towards the economically active population, and also, if there are no supportive initiatives available, challenges for the older population in attaining adequate financial and social support.

Figure 6: Labour Productivity in ASEAN countries from 1990 to 2021



Source: Asian Productivity Organization (2023)

In terms of productivity in Brunei, Cheong (2013) has provided a comprehensive framework for enhancing productivity in Brunei. The author stated that there exists a pressing necessity for the government to expeditiously enact laws that foster productivity, as well as establish a National Productivity Council. Figure 6 presents the labour productivity in all ASEAN

countries. The primary distinguishing characteristic is that, in contrast to the other ASEAN nations, Brunei has exhibited a negative and declining trend in production. This is worrisome since Brunei has articulated its Long-Term Development Plan (2007), Vision 2035, which aims to establish the nation's reputation for producing educated and highly trained individuals, maintaining a high quality of life among the top 10, and fostering a dynamic and sustainable economy with a high per capita income. Considering the occurrence of ageing and a decrease in labour productivity in Brunei, it is intriguing to investigate the relationship between these two occurrences.

This paper investigates the population ageing effects on productivity from a macroeconomic perspective. Contrary to previous studies which concentrated either on the total population (Barro & Sala-i-Martin, 1992 and Lindh and Malmberg, 1999), or on the working-age population (Mankiw, Romer and Weil, 1992) or also on the employees (Brunow and Hirte, 2006), we focused our empirical study on the labour force population. However, similar to Frini and Ben Jedidia (2018; 2019), we assessed the labour force according to the age structure effect, taking into account three age ranges: young adulthood (15-29) years, prime age (30-49) and old age (50-59).

The remainder of the paper is organized as follows. Section 2 presents the literature review. Section 3 provides the econometric methodology and the description of the data. Section 4 presents the estimated results. Section 5 presents the conclusion and policy implications.

2. Literature Review

Demographic change can alter the distribution of population age, the magnitude of various age groups within the working-age population, and subsequently impact the age structure of the labour force. This, in turn, can have long-term implications for both overall labour productivity and the productivity of specific age groups (Dixon, 2003; Börsch-Supan, 2003; and Vodopivec

& Arunatilake, 2008). The phenomenon of ageing has both microeconomic and macroeconomic implications on labour productivity. However, to address key macroeconomic concerns about the productivity of an ageing labour population, our primary focus in this study necessitates a comprehensive comprehension at the microeconomic level.

Multiple studies conducted at the microeconomic level have demonstrated a pattern of age productivity that follows an inverted U-shaped curve. This pattern involves an increase in productivity as workers reach their prime age, followed by a subsequent decline as they approach retirement (Aubert and Crepon, 2004; Bruno and Hirte, 2006; Haltiwanger et al., 1999; Prskawet et al., 2007). The detrimental effects of ageing can be attributed to the use of novel technology (Bos and Weizsacker, 1989). Elderly employees encounter challenges in adapting to novel work methodologies, hence impeding their efficiency. In addition, they experience a diminishing reservoir of information, expertise becoming outdated (De Grip and Vanloo, 2002), deteriorating cognitive capacities (particularly by the age of 50, as highlighted by Verhaegen and Salthouse (1997)), and a decrease in the value of their qualifications. The deterioration in cognitive capacities that occurs with age is a significant factor contributing to decreased productivity associated with ageing (Skirbekk, 2003).

However, it is important to note that the inverted U-shaped age-productivity profile is not absolute or unquestionable. Several research has established positive links between older workers and productivity. According to Disney (1996) and Dixon (2003), it has been argued that older workers possess a greater mean degree of job experience, which might potentially provide a favorable impact on productivity. They continuously received higher ratings for their good attitudes, reliability, and competence compared to ordinary workers. Learning enhances productivity in relation to seniority, as demonstrated by Aubert and Crépon (2003). In addition, older employees typically maintain consistent ties with their employers, whereas younger employees often experience numerous job and employer changes (Gregg &

Wadsworth, 1999). According to Dixon (2003), a decrease in voluntary job mobility has the potential to decrease turnover costs for employers, such as those related to recruiting and early training. This reduction in turnover costs might have a positive effect on overhead labour costs and overall profitability. Furthermore, Cardoso et al., (2011) have demonstrated that the older workers' impact on firm-level productivity surpasses their impact on the salary bill. There is a lack of consensus about the connection between ageing and productivity, particularly in terms of the variety of skills needed and the abilities of individuals. The type of the employment, education level, and physical demands are determining factors in this connection. According to Skirbekk (2008), the age productivity profile is not inherently fixed, but rather contingent upon the demands of the labour market. The decline in labour productivity among older individuals appears to be more pronounced in occupational activities that require physical ability, learning, and task execution speed. However, in occupations that prioritize experience and linguistic skills, older employees tend to exhibit a comparatively elevated degree of productivity.

Conversely, the existing body of empirical research indicates the potential existence of variations in age productivity profiles across different industries. Aubert and Crépon (2006) have reached the conclusion that there is a notable rise in relative productivity within the French manufacturing, commerce, and services sectors until the age of 35. Within the commerce sector, those aged 40 to 59 exhibit notably higher levels of productivity, whereas those aged 45 to 54 demonstrate greater productivity compared to younger workers in the services industry. However, the researchers demonstrated that there are no disparities in manufacturing practices between older employees and individuals in the 35-39 age bracket. In their study, Van Ours and Stoeldraijer (2010) demonstrate notable variations in age productivity trends across different industries within the Netherlands. The study conducted by Mahlberg and Prskawetz (2013b) examines the mining, manufacturing, and market-oriented services sectors in Austria. The

findings of their research demonstrate a favorable link between older employees and productivity. However, the study does not find a significant relationship between older employees and productivity.

Hence, considering the variation in the impact of an ageing labour force on productivity across various sectors, the overall effect of ageing will be contingent upon the industrial composition of an economy (Göbel & Zwick, 2012). Therefore, drawing a definitive conclusion at a macroeconomic level on the potential impact of an ageing working population on aggregate productivity and subsequent economic development of a country is challenging.

At the macroeconomic level, the impact of an ageing population is characterized by a decrease in the proportion of the labour force in relation to the overall population. From this perspective, the availability of labour becomes comparatively limited, but capital becomes comparatively more plentiful. This phenomenon results in fluctuations in the comparative cost of labour and contributes to an increased level of capital intensity. The alteration in the labour force has a significant impact on the growth of the economy. In details, as per capita output $\left(\frac{Y}{N}\right)$ (where Y denotes the output and N is the total population) is a function of capital (K), labour (L) and total factor productivity (A) as follows $\left(\frac{Y}{N)}\right) = A\, f\left(\frac{L}{N}, \frac{K}{L}, \frac{L}{N}\right)$; a change in total population (N) changes the labour (L) structure and subsequently affects growth output (Bloom and Williamson, 1998). A decrease in N induces an increase in both of the labour force ratio $(\frac{L}{N})$ and the capital intensity $(\frac{K}{L})$. Additionally, considering the working-age population (WAP), the labour ratio can be expressed as a multiplication of two components$\left(\frac{L}{N}\right) = (\frac{L}{WAP})(\frac{WAP}{N})$ (Mankiw et al., 1992; Barro and Sala-i-Martin, 1995). Thus, per capita output expression becomes a function of the labour force participation rate $\left(\frac{L}{WAP}\right)$; $(\frac{Y}{N} = \frac{Y}{L}\left(\frac{L}{WAP}\right)\left(\frac{WAP}{N}\right))$. This

expression highlights the effects of the labour force participation rate and therefore its age structure on economic growth.

Extensive empirical data has demonstrated a favorable impact of an ageing workforce on overall productivity. Lindh and Malmberg (1999) conducted a study utilizing five-year data from OECD nations spanning from 1950 to 1990. Their findings revealed that the age range of 50-64 positively impacts productivity, as measured by GDP per worker. Conversely, the age group over 65 has a negative contribution, while the impacts on lower age groups are uncertain. Furthermore, when assessed within the Tunisian context from 1965 to 2014, Frini and Ben Jedidia (2018) observed a decrease in production during the early stages of life (15-29), followed by an increase throughout the later stages of life (50-64). Nevertheless, the underlying mechanism responsible for these ageing effects remains unresolved. The study conducted by Tang and Macleod (2006) on Canadian provinces from 1981 to 2001 found that older workers have little adverse effect on productivity.

3. Methodology

3.1 Data

This paper utilizes yearly data on Brunei from 1991 to 2021. The data was obtained from various sources such as the Asian Productivity Organization (APO), World Development Indicators (WDI) and the Department of Economic Planning and Statistics, Ministry of Finance and Economy. Most variables remain in percentages to facilitate the interpretation of standardized coefficients. Variables that are not in percentage form were transformed into log form. Table 3 presents the summary statistics of the variables. Like many time series analysis, we aim to investigate the questions by inquiring about the information that the data may provide. From a technical perspective in the field of time-series analysis, it is imperative to

take into account the concept of stationarity and employ appropriate methodologies to mitigate the issue of false correlations.

Table 3. Summary Statistics

Variable	Mean	Std. Dev.	Min	Max
productivity	1.11868	0.16117	0.872	1.425
age1529	57.9097	2.23493	53.2	60.4
age3049	81.8871	3.34502	78.2	86.8
age5059	57.3645	6.44699	51.1	69.2
gfcf	26.4533	10.2069	10.4374	41.3143

Source: Authors' calculations

3.2 Econometric Model Specification

The following is a discussion of the econometric model used in this paper. The literature review has allowed us to build our aggregate labour productivity model that refers to the augmented Solow model based on the work of Mankiw et al., (1992). Labour productivity can be quantified using several methods, including the measurement of added value per worker or per hour worked, or as a measure of marginal productivity. In this paper, we employed labour productivity as based on hours of worked as it is the only available data.

To assess the impact of ageing on labour productivity, we calculate the labour force age structure. This is done to capture the age effect over time. Contrary to the literature, we defined it for an age range as a share of the labour force per working-age population within the same age range. Explicitly, we distinguished three broad age ranges: young adulthood (15-29), prime-age adults (30-49) and old age (50-59). Therefore, we treated three labour force participation rates which are the young (YL), prime-adults (PL) and elderly (AL) as shown below:

$$YL = \frac{Labor\ force\ aged\ 15-}{Population\ aged\ 15-29}; PL = \frac{Labor\ force\ aged\ 30-4}{Population\ aged\ 30-49}; AL = \frac{Labor\ force\ aged\ 50-59}{Population\ aged\ 50-59}$$

In accordance with the study conducted by Mankiw et al. (1992), we evaluated the improvement in productivity over time resulting from the accumulation of capital (K) by taking into account the gross fixed capital formation (GFCF) at constant domestic prices.

The baseline estimation model is as follows:

$$Productivity = \alpha + \theta_1 YL_t + \theta_2 PL_t + \theta_3 AL_t + \theta_4 Capital_t + \mu_t$$

Where $Productivity$ is the labour productivity (based on hours worked), YL_t is the young adults, PL_t is the adults, AL_t is the elderly, $Capital_t$ is the gross fixed capital formation and μ_t is the error term. All of these variables are in percentage forms except for productivity.

Given that these variables are likely to have a unit root or a process integrated order one, I(1), based on the Augmented Dickey Fuller test (ADF), we may employ a regression in a first differenced (FD) form. However, if the dependent and independent variables are co-integrated, then the results from the FD specification will be mis specified in which case, a vector error correction model proposed by Engle and Granger (1987) is reasonable choice of specification. The Johansen's maximum likelihood (ML) is used to determine the cointegration ranks. The number of lags is determined by a series of lag-order selection statistics including the final prediction error (FPE), Akaike Information Criterion (AIC), Schwarz's Bayesian information criterion (SBIC).

4. Estimated Results

Prior to doing our time series estimation, we undertook a reliability assessment of our time series data by examining the presence of unit roots. The outcomes obtained from the Augmented Dickey-Fuller is shown in Appendix. All variables are integrated I (1). Thus, a cointegration VAR model is appropriate to estimate the model. Cointegration rank is estimated using Johansen methodology. The results are presented in the Appendix. The presence of

cointegration between variables suggests a long-term relationship among the variables under consideration. Then the VECM can be applied.

Table 4. VECM estimation results

	D (Productivity)	D (YL)	D (PL)	D (AL)	D (GFCF)
D_logproductivity					
L._ce1	-0.0379***	0.0232*	-0.000882	-0.0634***	4.37
	(0.00829)	(0.00934)	(0.00614)	(0.0143)	(2.29)
LD.logproductivity	-0.669***	-0.129	-0.0928	0.0484	-33.45
	(0.125)	-0.111)	(0.0729)	(0.17)	(27.18)
LD.log (YL)	-1.865***	-0.729**	-0.312	-1.018*	-169.5**
	(0.327)	(0.268)	(0.176)	(0.41)	(65.73)
LD.log (PL)	1.634**	0.934*	0.315	0.345	274.2**
	(0.487)	(0.401)	(0.264)	(0.615)	(98.41)
LD.log (AL)	-0.584**	-0.468***	-0.171*	-0.342	-63.24*
	(0.158)	(0.128)	(0.0844)	(0.197)	(31.47)
LD.gfcf	0.00598***	0.000717	0.000518	-0.000293	0.489
	(0.0013)	(0.00115)	(0.000754)	(0.00176)	(0.281)
_cons	-0.0178***	-0.00439	0.00117	0.00778	-0.897
	(0.0052)	(0.0046)	(0.00302)	(0.00705)	(1.128)

Standard errors in parentheses * p<0.05, ** p<0.01, *** p<0.001

Table 4 presents the estimation results for VECM, which indicate that the error correction component obtained from the long-term cointegration relationship exhibits a strong and negative link to the productivity equation. The short-term changes in productivity tend to align with the long-term state of equilibrium. The process of reaching equilibrium is considered rapid, as evidenced by the coefficients -0.0379. In the short-run, the labour productivity is dependent of its lagged value. While the variables of interest have shown that there is a negative and significant relationship between the lagged value of the young adults, a positive and

significant relationship for the prime-age adults and a negative relationship for the elderly to labour productivity. Whereas capital has shown to have a positive and significant relationship.

$$Productivity = -16.9 + \underset{(13.0)}{12.4}YL - \underset{(8.76)}{32.6}PL + \underset{(6.67)}{19.5}AL + \underset{(0.0173)}{0.0915}gfcf + \mu_t$$

Where μ_t is the error term and standard errors in parentheses.

The long-run relationship between labour productivity, population age structure and capital for one cointegrating vector for Brunei in the period of 1991 to 2021 is displayed above. It can be observed that the prime adults have a negative and significant relationship while the elderly working age population has a positive and significant at 1% level relationship on the labour productivity. For 1% increase in prime adults, labour productivity is reduced by 32.6%. In the elderly, an increase in 1%, labour productivity reduced by 10%. While capital has a positive and significant relationship with labour productivity. For 1% increase in capital, labour productivity increases by 0.0915%. These results present a contrasting depiction of the short-run outcomes. In line with Dixon (2003), Cardoso et al. (2011) and Gobel and Zwick (2013), the older workers are productive.

An examination into the context of Brunei may provide possible reasons as to why the older working age population (50-59) has a positive and significant at 1% level relationship on the labour productivity, while the prime adults (30-49) have a negative and significant relationship in the long run analyses. One reasoning could be how most adults in Brunei are employed in relatively low productivity industries. This is suggested by how mining and quarrying only make up for 5.6% of the employed population in 2020, 3.8% in 2021, and 4.7% in 2022 (Table 5), yet the oil and gas sector accounts for an average of 45%[4] of Brunei's GDP during 2010-2023. By comparison, public administration consistently had the highest proportion of

[4] Authors own calculation using Yearly Share in Gross Value Added by Kind of Economic Activity at Current Price (DEPS, 2024)

employed persons, however public administration only accounts for an average of 11%[5] of Brunei's GDP during 2010-2023.

Table 5. Employed population by type of economic activity (Percentage) in Brunei Darussalam, 2020 and 2021

Employed population by type of economic activity	2020	2021	2022
Agriculture, Forestry and Fishery	1.3	1.4	1.5
Mining and Quarrying	5.6	3.8	4.7
Manufacturing	4.3	9.1	6.5
Electricity, Gas, Water Supply and Other Industrial Activities	1.4	1.5	1.4
Construction	12.2	9.2	8.9
Wholesale and Retail Trade	17.4	15.7	15.3
Accommodation and Food Service	5.2	6.0	7.6
Transportation and Storage	2.9	2.7	3.1
Information and Communication	2.2	2.4	2.2
Financial and Insurance Activities	2.2	2.0	2.4
Real Estate Activities	0.5	0.5	0.4
Professional, Technical, Administrative and Support Services	6.3	6.9	8.0
Public Administration	22.6	21.9	21.0
Education	7.3	7.0	8.2
Human Health and Social Work Activities	2.6	3.0	3.0
Other Service Activities	1.9	2.0	2.4
Activities of Households as Employers of Domestic Personnel	4.0	5.0	3.6

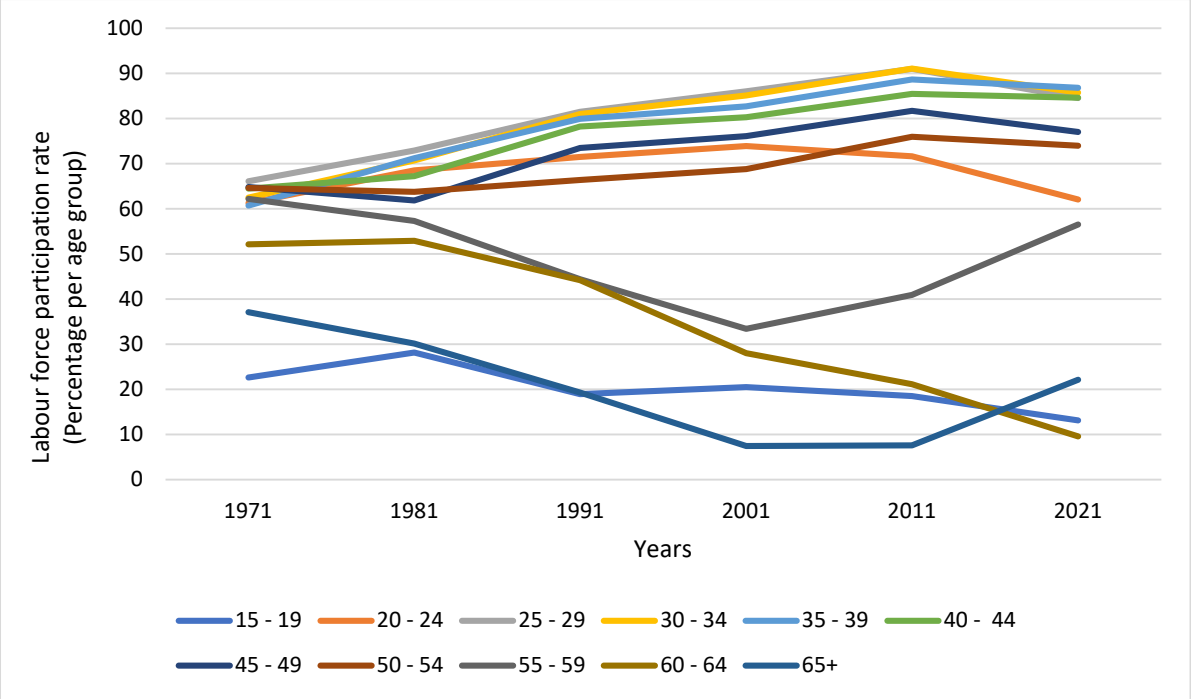
Source: Authors own calculations using statistics from the Department of Economic Planning and Statistics, Brunei Darussalam (n.d.-a)

Another reason for why the older working age population (50-59) has a positive relationship on productivity could be the increasing labour force participation rates of older population groups in Brunei. Table 5 shows how the labour force participation rate of the 50-59 age group dramatically increase between 2001 to 2021.This may be explained by the increase of Brunei's minimum retirement age from 55 to 60 in 2010. Interestingly, a similar trend of increased

[5] Authors own calculation using Yearly Share in Gross Value Added by Kind of Economic Activity at Current Price (Department of Economic Planning and Statistics, Brunei Darussalam, n.d.-d)

labour participation rates is observed for those over 65 between 2011 and 2021. It can be assumed that increasing retirement age, had a positive effect of labour participation even for those above the retirement age.

Figure 7. Labour force participation rate (Percentage per age group) in Brunei Darussalam, 1971-2021



Source: Department of Economic Planning and Statistics, Brunei Darussalam (n.d.-b)

Figure 7 presents the labour force participation rate in Brunei from 1971 to 2021. Although the unemployment rate for youths aged between 15 to 24 years lowered from 27.6% in 2011 to 18% in 2022, Figure 7 shows a downturn trend of their labour participation, in comparison to older age groups. This suggests that the younger population are not as employable as the older populations in Brunei.

5. Conclusion and Policy Implications

The phenomenon of population ageing has emerged as a significant concern in contemporary times. Several wealthy economies are entering a period of population ageing as a result of rising

life expectancy, declining death rates, and declining fertility rates (Harper and Leeson, 2009). The decrease in population growth has been evident since the mid-1970s, when the number of adults in the working-age population in many nations exceeded the number of children. The process is currently advancing swiftly in the developing world, and Brunei is not exempt from this trend. Brunei may seem advantageous as one of the highest GDP per capita in the world (35.81 thousand (IMF, n.d.)), with a welfare system that provides significant subsidies for Brunei citizens in education, healthcare, and housing (Brunei Press, 2023). However, with a consistently slow and stagnant GDP growth[6], and a relatively high unemployment rate, socio-economic issues may be exacerbated or generated from an ageing population (Cheong, 2019).

This research aims to analyze the macroeconomic implications of population ageing on labour productivity in Brunei. Examining the labour force participation rates among three distinct age groups from 1991 to 2021. The present investigation has identified a noteworthy correlation between demographic shifts and labour productivity. The findings of the study have substantiated a robust and enduring equilibrium connection between labour productivity and the age composition of the labour force. In contrast to prior research, it has been observed that middle-aged workers have a negative impact on labour productivity. Consistent with other studies, older employees exhibit a rise in productivity. Regarding this matter, the ageing process can have a beneficial impact on the economy of Brunei, however certain policies need to be implemented to support more participation of older adults in the labour market.

As a country expected to have more than 20% of the population aged over 65 by 2040, it is imperative to encourage high productivity amongst older workers who will eventually make up a significant proportion of Brunei's population. According to the findings of this study, a

[6] Observation based on the Year-on-Year Growth statistics presented by the Department of Economic Planning and Statistics, Brunei Darussalam (n.d.-c)

policy suggestion is for Brunei to raise its retirement age in order to maximize the use of its senior population. This is because research has demonstrated that older individuals are more productive than other working groups.

This is to not only encourage older adults to continue to contribute to Brunei's economy, but to address other significant socio-economic implications that may arise from an ageing population. Due to the significant demographic trends observed for Brunei, other policy recommendations are suggested if older adults are to be more included in the labour force.

Firstly, to consider the role of older women in the workforce. Although women in Brunei tend to outperform men in terms of education attainment; this is not realised in terms of employment (Cheong et. al., 2023). Bruneian women's labour participation rate is particularly low compared to men, even for women who have attained a bachelor's degree level education or higher (Cheong et. al., 2023, p. 5; Rizzo et. al., 2016, p. 92). A policy recommendation would be to encourage women's employment for all ages. Due to healthier lives and higher standard of living, older women are capable of working after retirement age, if there are sufficient employment opportunities, which would help in contributing to their financial security and the economy.

Secondly, to not only encourage employment for older workers but to ensure that available jobs support active ageing. As the proportion of population over 85 gets larger for Brunei, demand on healthcare is also expected to rise. This would be challenging, especially for countries whose existing institutions are, or would be, inadequate. Therefore, implementing an active ageing strategy in the workplace, and in the job market, would lessen the burden of healthcare. This would guarantee that economic contribution and financial security is attained through increased labour participation and productivity, without compromising older workers' health.

Additionally, the 4th industrial revolution can be harnessed for the advantage of older workers and active ageing, whilst stimulating the economy through STI and R&D.

Thirdly, due to the increasing old-age dependency ratio, the productivity of prime adults must be addressed in addition to the aforementioned policy recommendations. A policy recommendation is to boost the productivity of prime adults (30-49) so that enough financial support can be offered to older adults, and so they can also contribute to the Brunei's economy, which can help build government-supported programmes for vulnerable older persons.

In conclusion, this study has found results which can assist policymakers in addressing the implications of Brunei's changing population age structure of via its potential effects on labour productivity. Further studies to determine why prime adults (30-49) have a negative and significant relationship in terms of productivity in Brunei is recommended. In an era of rapidly changing age structures, ASEAN countries can replicate the study to examine how their changing population age structures may affect labour productivity.

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Appendix:

Table 2. ADF test results

Variable	Level	First Difference	I(d)
Productivity	-0.376	-8.41***	I(1)
YL	-1.372	-6.195***	I(1)
PL	-1.279	-5.549***	I(1)
AL	-0.971	-6.451***	I(1)
Trade	-1.012	-2.958***	I(1)
Capital	-1.575	-4.967***	I(1)

Note: *, ** and *** indicate the significance at 10, 5 and 1 percent level of significance, respectively

Inaugural ASEAN+3 Finance Think-tank Network (AFTN) Seminar
ASEAN+3 Macroeconomic Research Office (AMRO)
"Dawn of a New Age in the ASEAN+3?" (Digitalization, Length: 6K-10K words, Deadline: February 29, 2024)

Overcoming the Digital Divide in Finance for the Aging Population in South Korea on the Path toward CBDCs

June Park, PhD[1]

This paper investigates the policy prescriptions for digital financial inclusion for the aging population in South Korea. The research serves as a reference case study for digital transformation and increased e-payment systems for the aging population post-pandemic for the ASEAN+3 economies that are embracing digital finance and beyond, particularly with considerations for central bank digital currency (CBDC) pilots underway in the region. It finds that while the pandemic has prompted the elderly in South Korea to pursue contactless methods in their everyday life, and despite the accelerated speed of intermediary banks closing branches, the prevailing use of cash amongst the elderly continues, and recent policy prescriptions to encourage mobile banking by the elderly remains to bear fruit. Specific policy prescriptions are needed for this specific age group (60s-70s) to achieve population-wide digital financial inclusion, especially if CBDCs are to be adopted.

Keywords: South Korea, digital finance, aging, mobile banking, CBDC

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I. Introduction: Accelerated Digital Finance and the Aging Population in South Korea

Can generational gaps in mobile banking in a highly digitized economy be closed? How does financial digitization impact the aging population? What policies can help the aging population adopt digital payment methods, and how can they be improved or revised for digital financial inclusion of the elderly? This paper analyzes the landscape of digital finance in a specific economy within the ASEAN+3 region which is at the forefront of digitization with a sophisticated financial industry that has a rapidly aging population – South Korea.

South Korea faces the imperative for policies to address the question of 'digital' financial inclusion' than mere financial inclusion as in ASEAN economies, as the country shows high bank account possession rate (98.6%), but significant gaps across generations exist in the usage of mobile banking, leaving the population in the age range of 60s-70s vulnerable to the cyber risks that arise from mobile banking, while at the same time left behind in technological progress in digital finance. Indeed, as evidenced by its standing as one of the frontrunners of electronics production and the first economy to commercialize 5G connectivity (Massaro and Kim 2022), South Korea's digital environment is epitomized by high-speed internet[2], high internet usage rate (93%) as well as high smartphone usage rate (93.4%).

While digitization is a key driver of economic growth in South Korea as it is by far the most heavily wired country, its rapidly aging population has led to digital divide amongst different age groups and persisting use of cash by those in their 60s and 70s. During the pandemic, credit card usage rate in South Korea rose slightly amongst the elderly, and mobile banking app users 60s and above increased significantly (from 5,250,000 users in 2019 to 8,570,000 in 2021, in a 64.1% increase)[3] due to the shortened face-to-face banking operation hours. However, the digital divide amongst generations in mobile banking persist, with the elderly left behind amid fast-paced technological change utilizing smartphones and mobile banking apps. Such generational gaps continue to grow, as the closure of branches by commercial banks are ongoing (57 branches in 2019, 304 branches in 2020, and 79 branches in the first half of 2021[4]) to ensure profit margins – a continuing trend in tandem with shortened hours of operation opted by commercial banks since the pandemic.[5] Even though digitization in finance is accelerated, it is highly unlikely that South Korea will let go of cash payments in the next 10-20 years, due to the cultural aspects of preference of cash by the elderly.

For the Bank of Korea (BOK), the acceleration of digitization in finance has prompted the central bank to further explore the possibilities of the adoption of CBDCs in earnest, but without causing damage to the businesses conducted by intermediary banks.[6] The BOK's current stance

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[2] 'South Korea Median Country Speeds - January 2024,' Speedtest Global Index. https://www.speedtest.net/global-index/south-korea#mobile

[3] Figures by five major commercial banks in South Korea (Kookmin Bank, Shinhan Bank, KEB Hana Bank, Woori Bank, NH Bank), end of 2021.

[4] Estimates by Financial Services Commission, September 2021.

[5] As a social distancing measure to combat the pandemic, commercial banks and savings banks in South Korea had shortened operation hours from July 2021 by one hour (from 9:30AM to 3:30PM), but normalized hours from January 2023 (from 9:00AM to 4:00PM).

[6] Remarks by Changyong Rhee, Governor of the Bank of Korea. '2023 MOEF-BOK-FSC-IMF International Conference (ENG),' https://www.youtube.com/watch?v=LoT8cFR1fdA

is that it will therefore only explore wholesale CBDCs and not retail CBDCs, as it plans for the first-ever pilot test of CBDCs for the general public in South Korea in Q3 of 2024, and joins a number of central banks in Project mBridge at the Bank for International Settlements (BIS)[7] and launches Project Mubadala for CBDC interoperability test alongside the Monetary Authority of Singapore, Bank Negara of Malaysia, and the Reserve Bank of Australia.[8] The Bank of Korea has gone through a series of feasibility tests, policy deliberations[9], in addition to domestic pilot tests amongst financial institutions in partnership with tech companies, and Samsung is currently developing an offline-CBDC environment with the BOK.[10]

This paper does two things: first, in an effort to examine the policy options to close the generational gap in digital finance, the recent policy choices made by the financial authorities in South Korea toward digital financial inclusion of the elderly via mobile banking are investigated in detail, to gauge a specific circumstance in a digitized economy with an aging population – notably, it explores the ongoing policies taken by financial regulatory authorities FSS and the FSC via the Korea Federation of Banks (KFB) and 2) the BOK and intermediary banks in South Korea toward closing the gap amongst generations in the usage of e-payment systems, as digitization of finance accelerates post-pandemic; second, it reviews the paths taken by the Bank of Korea on CBDCs and forecasts public receptance, particularly from the perspective of the elderly population.

The paper contributes to the policy discussions on digitization of finance for economies in the ASEAN+3 region and beyond. As much as the ASEAN+3 economies may vary in the speed of aging, the level and speed of digitization of finance and the level of sophistication of the financial industry, the case study of South Korea is noteworthy for comparative analysis with other economies. The second section presents a case study of South Korea's policy efforts in digital financial inclusion, with survey research results from the BOK and the policy guidelines for elderly-friendly mobile banking apps by commercial banks. The third section looks at the BOK's stance on CBDCs with respect to potential responses – plausible unrest – from the elderly population, and the pilot test for the public planned for Q3 2024.

The paper concludes with some policy recommendations, emphasizing the need for the creation of an index of digital finance and aging across the ASEAN+3 economies based on three criteria: the level of digitization, aging, and the usage of e-payment systems (mobile banking). This would be for research purposes but ultimately for some canvassing of the digital financial landscape and homogenization in the region in the advent of CBDCs and accelerated digitization in finance. For such index to be constructed and coordinated amongst countries, each jurisdiction

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[7] 'Project mBridge: experimenting with a multi-CBDC platform for cross-border payments,' Bank for International Settlements, October 31, 2023. https://www.bis.org/about/bisih/topics/cbdc/mcbdc_bridge.htm

[8] 'Project Mandala: shaping the future of cross-border payments compliance,' Bank for International Settlements, November 15, 2023. https://www.bis.org/about/bisih/topics/cbdc/mandala.htm

[9] June Park. "South Korea's Critical Moment in Digital Currency Policymaking: Between Regulating Cryptocurrencies and Launching a Central Bank Digital Currency (CBDC)." KEI Academic Paper Series – On Korea, Vol. 15, March 3, 2022. Korea Economic Institute of America. Washington, DC. https://keia.org/publication/south-koreas-critical-moment-in-digital-currency-policymaking-between-regulating-cryptocurrencies-and-launching-a-central-bank-digital-currency-cbdc/

[10] June Park, "CBDC Global Pioneers: A Roadmap for Gulf Countries." February 8, 2024. Middle East Council on Global Affairs. Doha, Qatar. https://mecouncil.org/publication/cbdc-global-pioneers-a-roadmap-for-gulf-countries/

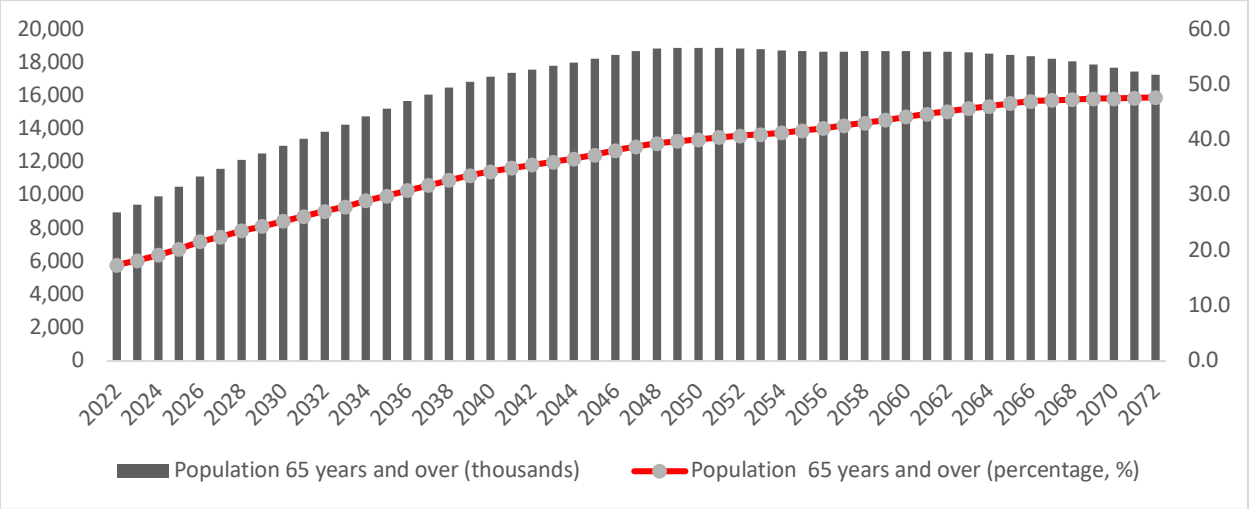
would need to conduct a nationwide survey of digital finance usage by central banks to participate in the effort, to canvass the level of need and policy change or adoption of digital financial inclusion methods pertaining to that specific economy.

II. South Korea: A Case Study of Digital Financial Inclusion of the Elderly

The Rapidly Aging Population in South Korea amid Record-low Fertility Rate

South Korea is on the path toward becoming the so-called 'super-aged' society and has one of the fastest aging populations (population aged 65+ have reached 16.1% of total population and will likely reach 26.1% by 2030, Statistics Korea) (Figure 1)[11], significantly higher than most other ASEAN+3 economies (Figure 2), and also has the lowest birth rate in the world (0.78, 2022 figures)[12] (The Lancet Regional Health – Western Pacific 2023) (Figure 3). There have been several media reports regarding the failure of South Korea's demographic policies.[13] [14] Efforts to reduce the gender gaps were called on by the IMF but domestic circumstances have not been changed.[15] [16]

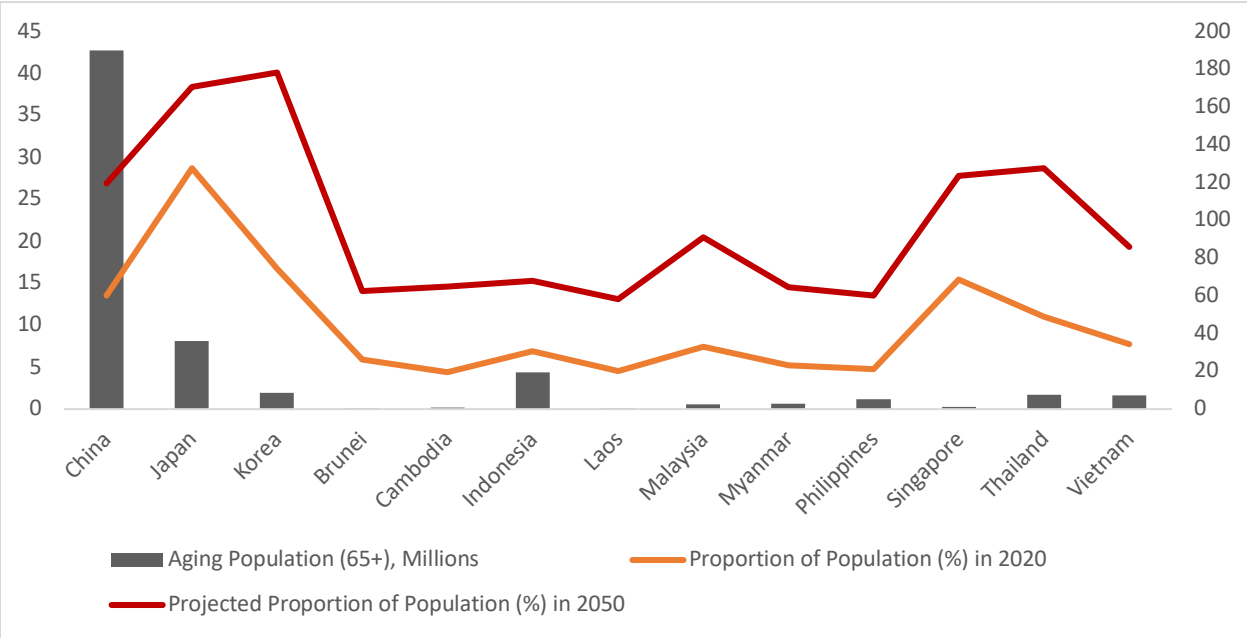
Figure 1. South Korea's Rapidly Aging Population (2022-2072, projected)
(Primary y-axis Unit: Thousands of people, Secondary y-axis Unit: Percentage)



Source: Compiled by author based on KOSIS, Statistics Korea (accessed and downloaded on February 27, 2027)

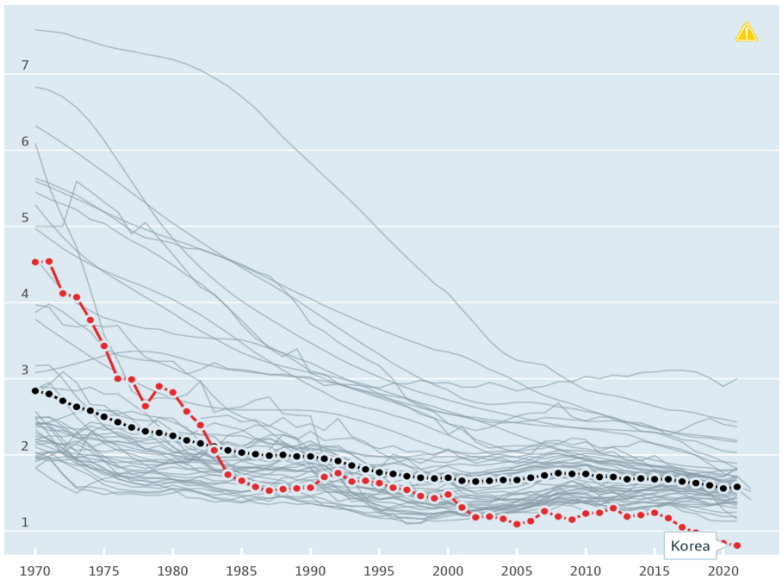
[11] 'Elderly population outgrows social safety net,' The Korea Times, January 8, 2023. https://www.koreatimes.co.kr/www/nation/2024/02/113_343139.html
[12] 'OECD Labour Force Statistics', OECD, 2022. https://www.oecd-ilibrary.org/employment/oecd-labour-force-statistics_23083387
[13] 'South Korea's birth rate has become a national emergency,' The Financial Times, January 29, 2024. https://www.ft.com/content/444a637b-9712-475b-8c14-9b147f4ff244
[14] 'South Korea has the world's lowest fertility rate. Seoul's mayor thinks he has a solution: A city-sponsored dating event,' Fortune, February 16, 2024. https://fortune.com/asia/2024/02/16/south-korea-worlds-lowest-fertility-rate-seoul-mayor-city-sponsored-dating-event/
[15] 'Republic of Korea: 2023 Article IV Consultation-Press Release; Staff Report; and Statement by the Executive Director for the Republic of Korea.' Asia and Pacific Department, International Monetary Fund, November 16, 2023. https://www.elibrary.imf.org/view/journals/002/2023/369/article-A001-en.xml
[16] 'S. Korea's fertility rate hit new world's record low in 2023,' The Korea Economic Daily, February 28, 2024. https://www.kedglobal.com/economy/newsView/ked202402280010

Figure 2. ASEAN+3 Economies: Aging Population (65 years and over)
and their proportions in 2020 and 2050 (projected)
(Primary y-axis Unit: percentage of population, Secondary y-axis Unit: Millions of people)



Source: Compiled by author based on World Bank Data, United Nations Population Division, ASEANstats
Notes: These figures are based on data available up to 2020. Projections for 2050 are estimates and subject to change based on demographic trends and policy interventions. The aging population in many of these countries is expected to increase significantly by 2050, posing challenges and opportunities for healthcare, social services, and the labor force. The orange line (2020) indicating proportion (%) of those 65+ of the total population will shift to the red line (2050), with each jurisdiction's figure indicated in the primary y-axis (left pane).

Figure 3. Fertility Rates: Total, Children/Woman (1970-2022)



Source: OECD Labour Force Statistics, 2023. The dotted black line is the OECD average.
https://data.oecd.org/pop/fertility-rates.htm

The social issue of rapidly aging population is compounded by the relative poverty rate (43.2 %) amongst the elderly population, evidenced by the 2022 OECD report which builds on previous work pre-pandemic by the OECD (OECD 2018).[17] Such trends are closely aligned with the difficulty of digital financial inclusion for the elderly, as access to digital technology would be constrained by the level of disposable income in South Korea. But for South Korean elderly citizens, smartphone possession rate has been on the rise during the pandemic. Indeed, smartphone plans can be costly depending on the model of the gadget, although there are some options for smartphone plans for the elderly offered by the three telecom companies. South Korea's SK Telecom, Korea Telecom, and LG U+ offer 5G connectivity mobile plans for those 65+ which come down to the range of 10,000-20,000 KRW per month after discount (Table 1).[18]

Table 1. Smartphone Plans for Seniors by Major 3 Telecom Companies in South Korea (Unit: KRW for plan price, Gigabytes for data amount and Megabytes per second for speed)

Monthly Rate	Additional Discount	SK Telecom (SKT)		Korea Telecom (KT)		LG U+ (LG U Plus)	
39,000	17,150					80 yrs +	10GB +1Mbps
41,000	18,650			80 yrs +	8GB +1Mbps		
42,000	19,450	80 yrs +	8GB +1Mbps	75 yrs +	9GB		
43,000	20,150					70 yrs +	10GB +1Mbps
44,000	20,900	70 yrs +	9GB +1Mbps	65 yrs +	10GB +1Mbps		
45,000	21,650	65 yrs +	10GB +1Mbps			65 yrs +	10GB +1Mbps
49,000	24,650			65 yrs +	15GB +1Mbps		

Source: The three telecom service providers in South Korea: SK Telecom[19], KT[20], LG U+[21]

However, affordability is not the core issue concerning digital financial inclusion for the elderly. The technical difficulties of smartphone usage by the elderly is another issue (Lee et al. 2024), as smartphone usage by senior citizens can be concentrated on camera and album usage as well as SNS messenger apps (i.e., Kakao Talk, which has nationwide usage), in addition to basic calling options and not necessarily for the usage of mobile banking apps. When it comes to mobile banking app usage, the elderly population have in large part cited their concerns of the following: data privacy (personal information leakage) as well as the lack of trust in managing banking affairs using a smartphone, and complexity of app usage as opposed to visiting a teller at a bank branch, and the difficulty of reading on their smartphones due to deteriorating eyesight with age.

[17] 'S. Korean seniors poorest in OECD: report,' The Korea Herald, December 19, 2023. https://www.koreaherald.com/view.php?ud=20231219000599

[18] '"어르신, 5G 요금제 비교해보고 쓰세요": 만 65~80 세 이상 대상...추가 할인 적용하면 월 1~2 만원대 이용,' ZDNet Korea, April 26, 2023. https://zdnet.co.kr/view/?no=20230426135912

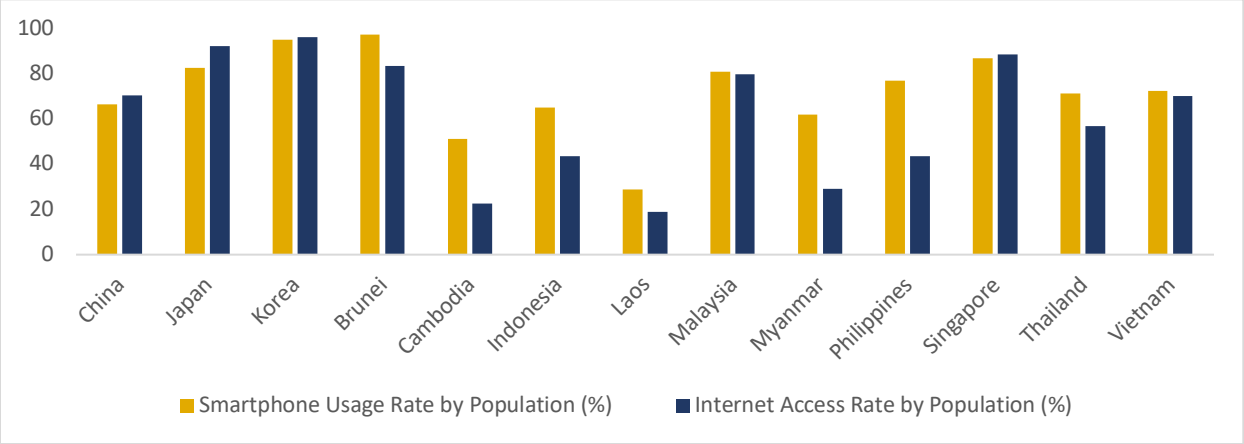
[19] SKT: https://www.tworld.co.kr/web/home

[20] KT: https://m.product.kt.com/mDic/productDetail.do?ItemCode=1558

[21] LG U+: https://www.lguplus.com/plan/mplan/5g-all/5g-senior/LPZ0000418

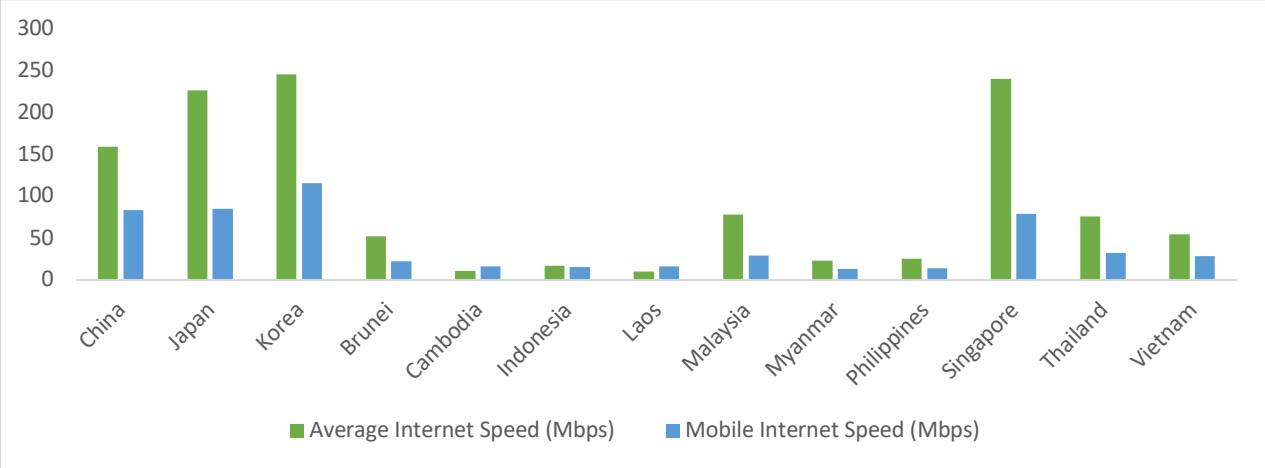
Comparatively, other ASEAN+3 economies portray a varying landscape in terms of digital infrastructure, based on the varying smartphone usage rates and internet access rates (Figure 4) and average internet speed and mobile internet speed (Figure 5). Comparatively, South Korea's digital infrastructure outplays other economies in the region based on these four criteria.

Figure 4. Smartphone Usage Rate (Percent) and Internet Access Rate by Population (Percent), ASEAN+3 Economies, 2021 present



Sources: Compiled by author based on We Are Social & Hootsuite Digital Reports, Statista, World Bank Data
Note: These figures are based on various sources including surveys, market research reports, and government data. Internet access rates can fluctuate over time due to factors such as infrastructure development, affordability, and technological advancements. While countries like Japan, South Korea, and Singapore have high internet access rates, some ASEAN countries are still working on improving access, especially in rural areas. The data for some countries may vary slightly between sources, and these numbers are estimates based on available data.

Figure 5. Average Internet Speed (Mbps) and Mobile Internet Speed (Mbps), ASEAN+3 Economies, 2021 present



Sources: Compiled by author based on Ookla's Speedtest Global Index, OpenSignal, Local Reports
Notes: These figures are based on various sources including Ookla's Speedtest Global Index, OpenSignal, and local reports. Average internet speeds can vary within a country based on location and infrastructure. South Korea, Japan, and Singapore typically have some of the fastest internet speeds globally, while some ASEAN countries are working to improve infrastructure and speeds. Mobile internet speeds are included for comparison, as mobile devices are often the primary means of internet access in many regions.

The Digital Financial Landscape in South Korea for the Elderly

The financial industry in South Korea has evolved very much toward digitization over the past decade, with e-payment apps and tools developed by commercial banks and FinTech companies or NBFIs (Non-Bank Financial Institutions) (Nam and Lee 2023). Digital financial literacy has also become one of the key drivers of wealth accumulation and well-being. Research results indicate that the inequality in the use of FinTech services, noting that those well-off utilize digital financial services more than those that are not (Choung, Chatterjee, and Pak 2023).[22]

COVID-19 became a catalyst to increased contactless payments in financial transactions, and has led to increased usage of instant messengers, online streaming services, and internet shopping (e-commerce), with expedited shipping for items and groceries upon completed online transactions (coined as 'delivery by dawn' or '새벽배송' in Korean by the online commerce companies Coupang, E-mart, G-Market and Oasis) becoming available nationwide. In the first pandemic year, the internet banking usage for those in their 60s was raised significantly (50.5%, an increase by 23.6%p).[23] However, these trends did not necessarily increase the rates of internet or mobile banking usage for those in their 70s, as cash usage persisted for the specific age group.

The pandemic also accelerated the process of commercial bank branch closures to ensure further profit margins as online deals and transactions grew, and the five major domestic banks closed more branches in Q1-Q3 of 2023 than in the entirety of the pandemic years from 2020 to 2022.[24] Many of the commercial banks in South Korea currently suffer from the lack of customers, but have been called on by the financial regulatory authorities to maintain a certain number of branches for those that are not savvy in online financial transactions via the internet or mobile banking apps on smartphones.

As early as from 2016 and onwards pre-pandemic, major banks in South Korea have adopted unmanned digital kiosks for banking to encourage 'self-banking' in a move to replace human tellers at bank branches have brought about frequent complaints from the elderly customers. As the digital kiosks cost 10 times the price of an automated teller machine (ATM), many banks weighed their costs of their installations and repair as opposed to retaining their teller staff.[25] With the advent of AI, more digital banking kiosks are adopting AI techniques, or involve the usage of biometric authentication (e.g., palm pulses, facial recognition) for customer log-in, complemented with human teller authentication over a video call prompted by the kiosk.[26]

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[22] The generational gap in digital financial literacy in South Korea was more pronounced before the pandemic, as indicated by the 2018 Digital Information Divide Survey. See '중·고령층 보험·금융소비자의 정보격차 실태와 시사점,' Korea Insurance Research Institute, May 27, 2019. https://www.kiri.or.kr/pdf/전문자료/KIRI_20190524_11633.pdf; also see Hyo-jung Lee, '디지털 금융 이용정도와 시사점,' 백상경제연구원, Seoul Economic Daily, August 2017.

[23] '2020 년 인터넷 이용 실태조사 발표,' Ministry of Science & ICT, March 3, 2021. https://www.msit.go.kr/bbs/view.do?sCode=user&nttSeqNo=3179980&bbsSeqNo=94&mId=113&mPid=112

[24] 'Korean bank branch closures accelerate as online deals grow,' The Korea Economic Daily, The Global Edition, February 19, 2024. https://www.kedglobal.com/banking-finance/newsView/ked202402190004

[25] '은행 디지털 키오스크로 '셀프 뱅킹' 경쟁,' ZDNet Korea, August 2, 2018. https://zdnet.co.kr/view/?no=20180802162213

[26] '[직접 써보니] 신한은행의 바이오 인증 활용한 '비대면 실명 확인 서비스',' Boan News, May 26, 2016. https://www.boannews.com/media/news_print.asp?idx=64368

Along with these trends of bank branch closures and replacement of human tellers with unmanned digital kiosks, the issue of mobile banking apps leading to digital financial exclusion of elderly population have been consistently raised, as commercial banks' promotional packages (e.g., higher rate of returns on financial products for deposits) have been available through mobile banking apps, creating an unintended discriminatory effect onto elders that do not utilize mobile banking by excluding them from such benefits.[27]

Efforts by the Central Bank: Surveys on Mobile Banking Usage, 2019, 2021

As the concerns regarding digital financial exclusion of the elderly grew in pre-pandemic years, the BOK took on the policy initiative in 2019 to survey the digital financial landscape in South Korea. The main content of the survey was based on the 2017 questionnaire on payment methods (credit cards, cash, check cards, pre-paid cards, digital currencies, mobile cards) and the 2018 survey on mobile banking services, and certain questions were adjusted to reflect the changes in the payment system environment in Korea. The survey's digital transaction section focused on mobile banking usage and easy transaction either via commercial banks or NBFIs (e-payments: i.e., Naver Pay, Kakao Pay, Samsung Pay, Toss). The 2,650 survey respondents were male and female adults aged 19+ collected from nationwide, with the sample size of 2,650 and the ± 1.9%p margin of error at the 95% confidence level, using a 'multi-stage stratified systematic sampling.[28] The key finding in the 2019 survey was that those in their 60s and 70s overwhelmingly preferred cash usage and face-to-face banking transactions compared to those in their 20s (debit cards) and 30s-50s (credit cards), and that amongst mobile banking services, the Korean population prefers mobile banking apps developed by major commercial banks to NBFI mobile banking apps (easy payment services or transfers.

The findings in the 2019 survey[29] served as the foundation of the survey conducted in 2021 by the Bank of Korea.[30] The 2021 survey results on payment systems and mobile banking usage were released in the third year of the pandemic, and reflected some changes due to contactless transactions, with 28.2 percent of the respondents in their 60s and 26 percent of the respondents in their 70s answering they have increased their frequency in mobile banking service usage. The main reason for them to resort to mobile banking was owing to the commercial banks/credit card companies providing mobile banking services, and those in their 60s-70s did not opt to choose mobile banking services that are provided by NBFIs (only 0.8% of the 60s did). Those aged 60+ continued to show preference of cash, as per the requirements of monthly disposable income

[27] '"모바일 뱅킹이 뭔가요"…노인들의 '디지털 소외',' Yonhap News, May 10, 2019. https://www.yna.co.kr/view/MYH20190510018600038

[28] 1st sample extraction by proportionate probability sampling at the district levels nationwide; 2nd sample extraction by systematic sampling of tens of households from the 1st samples; 3rd sample extraction by method of birth of appropriate individual respondent per household. 보도참고자료, 한국은행, '2019 년 지급수단 및 모바일 금융서비스 이용행태 조사' 발간, Bank of Korea, March 10, 2020. https://www.bok.or.kr/portal/bbs/P0000559/view.do?nttId=10056929&menuNo=200690

[29] '지급결제조사자료: 2019 년 지급수단 및 모바일금융서비스 이용행태 조사결과' Financial Transactions Bureau, The Bank of Korea, March 2020.

[30] '[보도참고자료] 한국은행, 「2021 년 지급수단 및 모바일금융서비스 이용행태 조사결과」 발간,' May 25, 2022. https://www.bok.or.kr/portal/bbs/P0000559/view.do?nttId=10070595&menuNo=200690&pageIndex=

(KRW 500,000) for credit card issuance under South Korea financial regulations[31] [32] and the lack of know-hows in using pre-paid e-payment cards. The findings of the 2021 survey in a nutshell are below in Table 2 – it was concluded through this survey that most of the South Korean population opted for credit cards and debit cards in their daily economic transactions, and that cash was the most common method of payment. The survey also revealed the increasing trends of mobile banking service usage and digitization of finance, and the anticipation of financial institutions and NBFIs increasing their mobile banking services from simple transactions such as account inquiry and transfers to loans and financial product purchases.

Table 2. Proportion of Population with Experience of Usage, by Payment Methods (Unit: Percent)

Category (Payment Methods)		Cash	Credit Cards	Debit Cards	Account Transfer	Prepaid Cards/ Digital currencies	Etc.	Mobile Cards
Total		96.6	82.6	56.0	40.9	9.2	12.2	24.0
Venue	Offline	96.6	82.0	54.1	-	8.4	8.2	21.4
	Online	-	65.7	29.0	40.9	3.6	8.3	18.0
Gender	Male	96.5	82.6	57.2	38.8	8.9	13.1	25.1
	Female	96.7	82.5	54.9	43.1	9.5	11.4	22.9
Age	20s	93.8	63.0	75.9	39.9	17.1	26.7	36.5
	30s	95.7	93.6	64.6	46.4	12.2	18.4	47.1
	40s	96.0	94.5	58.0	46.5	7.9	14.8	31.2
	50s	97.7	94.0	52.6	47.3	7.5	8.7	18.6
	60s	97.8	84.8	47.7	37.6	5.0	2.6	6.6
	70s	98.8	57.3	34.1	22.7	5.7	0.7	1.3

Note: Proportion of Respondents that have said yes to having used certain payment methods in the past month. The cells highlighted in blue show the variance of most frequently used payment methods by age groups.
Source: 지급결제조사자료: '2021 년 지급수단 및 모바일금융서비스 이용행태 조사결과,' Financial Transactions Bureau, Bank of Korea, May 2022.

A supplementary survey was conducted by the Bank of Korea in the final year of the pandemic in 2022, focusing on internet banking service usage trends in South Korea, to compare the trends in the first half of 2022 with the previous two years.[33] It showed that overall, internet banking (comprising of mobile banking) services were consistently on the rise, for both transfer of funds and loan request services, both by the major five commercial banks and NBFIs. The surveys conducted by the BOK from 2017 to 2022 indicated that there was no reversing of trends on the rise of digital finance in South Korea, in terms of both internet banking and mobile banking services. It was for certain that the elderly population aged 60s and over would be excluded in the digital expansion of finance, and thus the South Korean financial regulatory authorities began to take their policy moves for digital financial inclusion of the elderly population by ordering commercial banks to abide by new guidelines for mobile banking apps.

[31] '여신전문금융업법 시행령,' Financial Services Commission, revised December 12, 2023. https://www.law.go.kr/법령/여신전문금융업법%20시행령
[32] '신용카드 발급 및 이용한도 부여에 관한 모범규준,' Financial Supervisory Service (FSS), enacted October 15, 2012.
[33] '2022 년 상반기중 국내은행 인터넷뱅킹서비스 이용현황,' Financial Transactions Bureau, Bank of Korea, September 15, 2022.

Policy Guidelines by the Financial Regulatory Authorities

Shortly after the announcement of the 2021 survey results released in May of 2022 by the BOK, the South Korean financial regulatory authorities – the Financial Supervisory Service (FSS) and the Financial Services Commission (FSC) – put together a list of guidelines for commercial banks to follow in designing elderly-friendly mobile banking apps in an effort towards achieving digital financial inclusion of the elderly. The guidelines were announced on June 22, 2022 via the Seoul Financial Hub, a federation of commercial banks in South Korea through the customer protection bureau, under the title 'Guidelines for the Protection of Elderly Financial Customers Guidelines (은행권 고령금융소비자 보호지침)'.[34] There are three categories of 13 principles in total: the first category focuses on creating the 'elderly user mode' of mobile banking apps and allowing for easy access, in consideration of the characteristics of the elderly user (interface creation, such as in the large fonts options, and simplification of the services under the mode). The second category stipulates the obligation of banks to facilitate convenient usage of the apps through the elderly user mode. In the third category, it was advised that banks take proactive actions toward educating the elderly for mobile banking app use and to work towards preventing financial crimes targeting the elderly, which are of immediate need for resolving the risks of elderly user experience of mobile banking services.

Table 1. Principles of Guidelines on Creating Elderly-Friendly Mobile Banking Apps

Category	Principles
I. Regarding Elderly User Mode Creation and Access	1) Provide a "Elderly User Mode" for easy access for the elderly. 2) Minimize the routes for the user to enter "Elderly User Mode". 3) Allow for the "Elderly User" (or customer) to choose "Elderly User Mode" autonomously. 4) Minimize changes in the interface in the "Elderly User Mode" to maintain consistency of service in consideration of the elderly user's characteristics.
II. Regarding the Convenient Usage of Elderly User Mode	1) Construct the "Elderly User Mode" interface with consistency in structure and design for the convenient usage of the elderly user. 2) Allow for the elderly user to easily perceive and understand meanings of words used in the mobile banking transaction. 3) "Elderly User Mode" should consist of transactions that are frequently used by the elderly user. 4) Allow for the elderly user to perceive and understand the current stage of process in the mobile banking transaction. 5) Allow enough time and explanation for the elderly user in each mobile banking transaction stage. 6) Avoid providing too much information at once for the elderly user.
III. Miscellaneous	1) Provide educational materials for the elderly user to easily access and use mobile banking apps. 2) Prepare a system to prevent financial fraud on the elderly user and fortify their access to a reporting mechanism of such financial crimes. the access for report of such financial crimes. 3) Continue to consistently improve "Elderly User Mode".

Source: '고령자 친화적 금융앱 구성지침,' Seoul Financial Hub, June 22, 2022.

[34] '고령자 친화적 금융앱 구성지침,' Federation of Banks) via the Seoul Financial Hub, June 22, 2022 https://www.seoulfnhub.kr/bbs/board.php?tbl=bbs21_3&mode=VIEW&num=88&category=&findType=&findWord=&sort1=&sort2=&it_id=&shop_flag=&mobile_flag=&page=4

Efforts by the Commercial Banks on Mobile Banking Apps, Financial Education Centers

With the announcement of guidelines on elderly user mode for mobile banking apps for commercial banks in concerted effort by the FSS, FSC and the Korea Federation of Banks, 18 banks (7 commercial banks, 2 special banks, 6 regional banks, 3 internet banks) in South Korea launched elderly user modes in their apps by end of June 2023. The policy move largely reflects the need for elderly users in terms of revision of interface for convenience and access, as digitization of finance is accelerated and contactless banking proceeds with the closure of bank branches. The mode supports elderly users with the most used functions sought by them (e.g., fund transfer, balance inquiry, transaction history, etc) in simplified form (e.g., from icon to Hangeul explanations) with lessened number of clicks, and in larger font size.[35]

Other pertinent issues in digital finance leave the elderly vulnerable. In digital financial crime, the cyber-hacking of bank accounts or bank servers have increased gradually in South Korea. Financial scams target the elderly population is voice-phishing (vishing) calls or messages that compel users to withdraw or transfer funds through ATMs or bank tellers for ransom.[36] These scams are also common via cryptocurrencies, so the FSC took action in February 2023 in a public-private partnership involving the South Korean Police Agency, commercial banks, and Korea Internet & Security Agency (KISA).[37] South Korean banks have also introduced voice-phishing monitoring systems from January 2024.[38] The released 'elderly user mode' for mobile banking apps also contain interface that provide explanations on financial fraud as well as a reporting mechanism for elderly users as a prevention method.

There are other efforts by the commercial banks underway in South Korea, to provide know-hows to the elderly population on mobile banking by establishing financial education centers.[39] In an exemplary case, Shinhan Bank – one of the major five commercial banks in South Korea – has opened the center called 'Hak-yi-jae (학이재)' in September 2023,[40] with the support of the Incheon Municipality and policy backing by the FSS. The center provides digital financial mobile experience, mobile app solutions experience using educational tablets, and kiosk using experience in addition to seminars on preventive measures on digital financial scams and fraud (voice phishing, pharming, smishing) developed by the FSS.

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[35] '[보도자료] 복잡한 모바일뱅킹, 고령자(쉬운)모드를 이용해보세요,' Financial Services Commission, July 26, 2023.
https://www.fsc.go.kr/po010105/80475?srchCtgry=5&curPage=4&srchKey=&srchText=&srchBeginDt=&srchEndDt=

[36] 'Voice phishing scams are the target of new bank and phone rules ', Korea Joongang Daily, September 29, 2022.
https://koreajoongangdaily.joins.com/2022/09/29/business/economy/Voice-phishing-Scam-FSC/20220929151309606.html

[37] '[보도자료] 제 2 차 금융분야 보이스피싱 대책 발표 - 중대 민생침해 금융범죄 대응방안 당정협의회 관련 - ,' Financial Services Commission (FSC), February 28, 2023.
https://fsc.go.kr/no010101/79511?srchCtgry=&curPage=1&srchKey=&srchText=&srchBeginDt=&srchEndDt=

[38] '설 연휴 보이스피싱 범죄 24 시간 민관 합동 대응태세 구축,' February 7, 2024.
https://www.korea.kr/news/policyNewsView.do?newsId=148925677

[39] '신한은행, 노인에 키오스크 쓰는 법 알려준다,' Hankyung, February 19, 2024.
https://www.hankyung.com/article/2024021816591

[40] '신한은행, 디지털 금융 배우는 '신한 학이재' 개관, Electronic Times Internet, September 7, 2023.
https://www.etnews.com/20230907000292

III. Policy Projections for CBDC adoption and Anticipated Reactions from 65+

Many central banks are experiencing their need to research and develop CBDCs, and the pilot tests conducted by the BOK indicate that South Korean financial regulatory authorities have perceived the need for CBDC development, amid China's rampant push for the digital yuan and the volatility of cryptocurrencies as well as increasing competition with stablecoins. The concern with stablecoins is that if they are issued by an institution with a broad international network, the possibilities of cross-border capital movement volatility would increase and thereby impact monetary sovereignty. The digitization of finance has been occurring at unprecedented pace and given the already developed and much sophisticated financial transactions environment, the BOK while pursuing the path as the sole legal issuer of the digital KRW, has had to take caution so that CBDC development would not lead to disintermediation of banks and to see how it would fit in with the domestic circumstances.

After policy deliberations in the first year of the pandemic, the BOK conducted its inaugural CBDC pilot test between August 2021 and June 2022 utilizing Ethereum DLT environment, and as well as a pilot test with the FSS and FSC from July-December in 2022, concluding the first stage of tests.[41] The BOK is now in its second stage pilot test in partnership with Samsung Electronics to develop an offline CBDC environment, focused on wholesale CBDCs, and is poised to conduct a pilot test with the general public in Q3 2024.[42] The pilot test to be convened this year is in conjunction with the interoperability tests with BIS, under Project Mandala, which comprises of the central banks of Singapore, Malaysia, and Australia. Meanwhile, the BOK also observes the expansion of Project mBridge which began with the interoperability test amongst the central banks of China, Hong Kong, UAE, and Thailand.

In South Korea's case, the adoption of CBDCs is not simply a question of technological development, but a balancing act of pursuing multiple goals and values that are conflicting, such as between regulation and innovation (for the most part, data privacy and compliance), all the while having to ensure security and stability of the financial environment. The Bank of Korea Bank of Korea therefore has indicated its position to pursue wholesale CBDCs and tokenized assets instead of retail CBDCs and is treading very carefully in terms of the CBDC architecture, as a frontrunner's CBDC design may not necessarily reap the benefits and may divert from the global standard in the later stage.[43] The developments toward CBDCs by the BOK pose further questions for digital finance, as they may bring about issues of digital financial exclusion of the elderly. Should the BOK's future CBDC pilot tests should comprise of the public as participants in 2024, the potential concerns would be on the elderly population and their usage of CBDCs given the current difficulties in digital financial inclusion that are witnessed. These issues have yet to be addressed by the BOK on official terms and are likely to become clearer prior to the CBDC pilot test in Q3 2024.

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[41] Park, 2022. Ibid.

[42] Remarks by BOK Governor Changyong Rhee at the 2023 년 MOEF·BOK·FSC·IMF International Conference, December 15, 2023. '이창용 "CBDC 도입 논의 더 미룰 수 없어…새로운 디지털 환경에 대비",' Seoul Economy, https://www.sedaily.com/NewsView/29YIRULAUZ

[43] 'Central bank digital currency: what we have learned from a recent hands-on experiment,' Keynote Address by Chang Yong Rhee Governor of the Bank of Korea, IMF STI Peer-Learning Webinar, 28 September 2022. https://www.imf.org/-/media/Files/News/Seminars/2022/092822-Fintech-and-Financial-Inclusion-and-tje/english-presentation/keynote-address-imf-sti-webinar-cbdc-rhee-full.ashx

IV. Policy Recommendations for the ASEAN+3 Region

This paper has investigated the case of South Korea's challenges and policy efforts to overcoming digital financial exclusion of the elderly population in the 60s-70s age group. Based on the detailed findings of this paper, some food-for-thought in terms of policy recommendations for the ASENA+3 region can be provided as below.

1. National Survey of Digital Payments Methods per Jurisdiction

First, at the jurisdictional levels, nationwide survey of digital payment methods must be conducted prior to any policy prescription designing. Each ASEAN+3 economy has a different landscape and level of digital infrastructure, access to the internet, digital payment options, and most of all, the speed of aging. For instance, in the +3 countries, in China, instead of credit cards, QR codes have become the dominant method, and Alipay and WeChat pay are inclusive in the digital yuan pilot tests. In Japan, cash payments are still widespread and credit card payment is not the norm. CBDC development in Japan is proceeding but still in the nascent stage. South Korea's digital payment landscape by age group was uncovered by the BOK's surveys. By jurisdiction, the policy prescription towards digital infrastructure expansion and/or digital payment options would vary, and thus a nationwide survey would be necessary to capture the areas of improvement. Such survey results conducted by the central banks would be needed also to put together an ASEAN+3 research on aging and digital finance in the longer run. Such database should be constructed at the central bank level and shared with the AMRO office for a region-based research project.

2. Improvement of Digital Payment Methods for the Elderly based on the National Survey

In the case of South Korea, "Elderly User Mode" in mobile banking apps were designed by banks and implemented under the guidelines of the FSS, FSC and the FKB. Such may not be necessary in countries – emerging market economies in ASEAN – where financial inclusion is a more immediate task than digital financial inclusion of the elderly. In countries where aging is occurring rapidly, digital payment methods would need to be improved in consideration of the elderly users, with digital education centers established by the payment companies with policy backing by the financial regulatory authorities.

3. Need for Digital Financial Inclusion of the Elderly in CBDC Pilot Tests or Adoption

In ASEAN+3 economies where there is an aging population, and CBDC research and development or pilot tests are happening, or interoperability tests are occurring with other central banks via the BIS, central banks must design the CBDC prototype carefully in such a way that it is fit for the domestic economy, so as not to exclude the aging population. Currently, all ASEAN+3 economies are in a certain stage of CBDC research or development, or pilot stage, excluding Brunei, but the policy priority for considering digital financial inclusion of the elderly would be for aging economies. Other countries would need to work more on the CBDC prototype itself or the expansion and improvement of digital infrastructure.

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Smart Elderly Care Platforms in China: Practice, Challenges, and Policy Implications

—— A Case Study of Smart Elderly Care Platform in Taiyuan, China

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I. Introduction[3]

The Aging of Populations and its Economic and Social Implications published by the United Nations Department of Economic and Social Affairs in 1956 shows that when the proportion of the population aged 65 and above in a country or region exceeds 7% of the total population, this country or region is classified as an aging society. Additionally, the standards recognized by the first World Assembly on Ageing held by the United Nations in Vienna in 1982 imply that when the proportion of the elderly population aged 60 and above in a country or region exceeds 10% of the total population, it indicates that the country or region has become an aging society.

China's Fifth National Population Census in 2000 indicated that the proportion of the population aged 60 and above accounted for 13.26% of China's total population and the proportion of the population aged 65 and above accounted for 6.96%[4] of the total population, indicating China had become an aging society. As time went by, China's aging problem became increasingly prominent. What's more, China's Seventh National Population Census in 2020 suggested that the proportion of China's total population aged 60 and above had reached 18.70% and the proportion of China's total population aged 65 and above had reached 13.50%[5], indicating an acceleration in the aging of society. According to data collected by the National Bureau of Statistics of China in 2023, the

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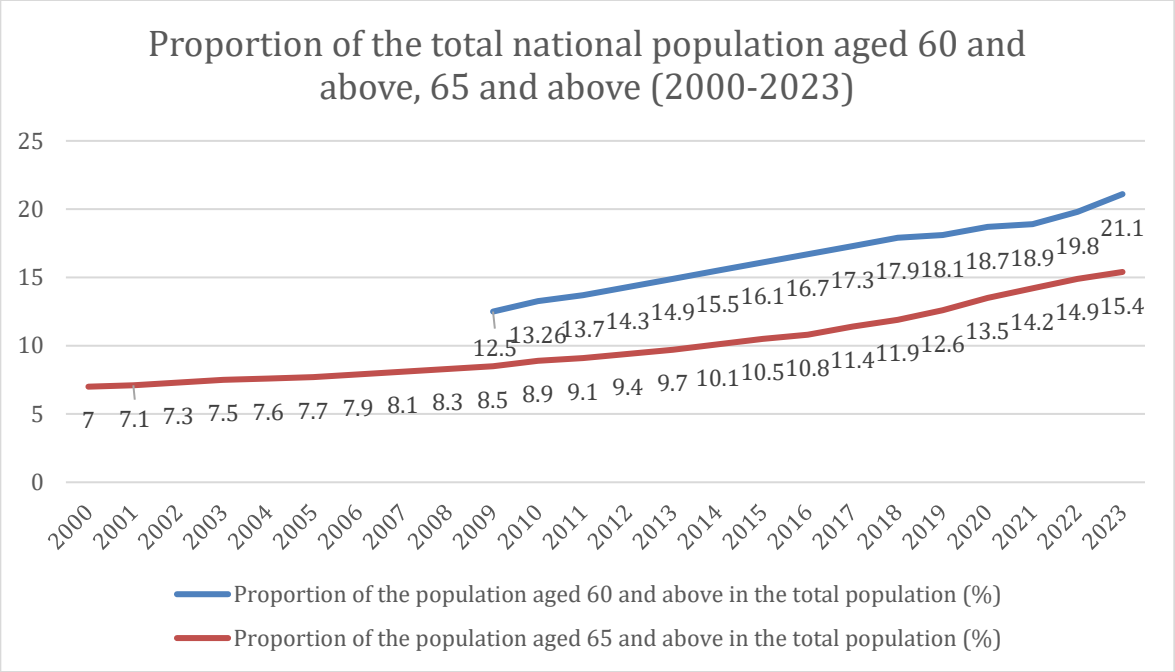
Disclaimer: The views expressed in this paper are solely those of the authors and do not represent the views of their respective institutions or the providers of the materials.
[4] https://www.stats.gov.cn/sj/zxfb/202303/t20230301_1919256.html.
[5] https://www.stats.gov.cn/zt_18555/zdtjgz/zgrkpc/dqcrkpc/ggl/202302/t20230215_1904001.html。

proportion of the population aged 60 and above accounted for 21.10% of China's total population and the proportion of the population aged 65 and above accounted for 15.40% of China's total population[6] (Figure 1), indicating the growing severity of societal aging. A joint forecast by the United Nations Population Fund China and the China Population and Development Research Center in 2022 shows that by 2050 the population aged 60 and above in China will account for 39.80% of China's total population and the population aged 65 and above in China would account for 30.80%[7] of China's total population, predicting that China's aging problem will become very serious. At the same time, according to data from the National Bureau of Statistics of China, both China's total population and number of births began declining in 2022. China's total population in 2022 was 1411.75 million, decreasing 850,000 from 2021, and the number of births in China in 2022 was 9.56 million, decreasing 1.06 million from 2021[8]. In 2023, China's total population was 1409.67 million, a 2.08 million decrease from 2022, and the total number of births in China was 9.02 million, a 540,000 decrease from 2022[9]. Because of these changes, China is facing increasingly prominent issues regarding elderly care. The burden of family care is constantly increasing and the contradiction between traditional care services and the growing demand for high-quality elderly care is becoming increasingly apparent. Therefore, there is an urgent demand to explore new elderly care models to better meet the needs of the elderly.

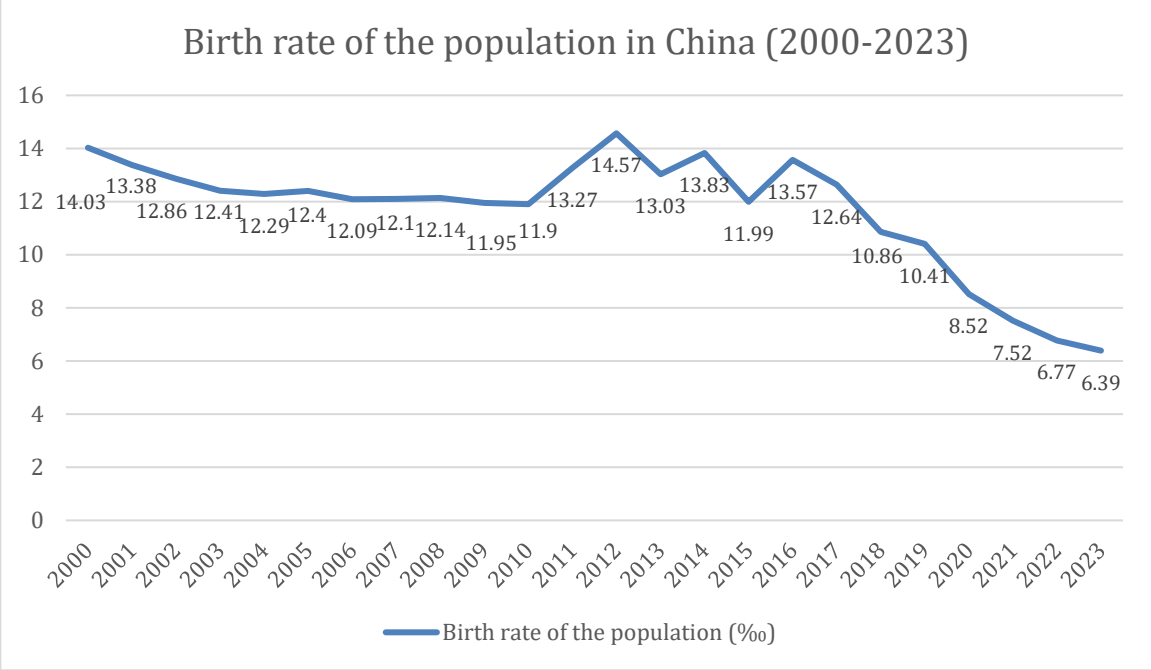
Figure 1. Changes in the Proportion of the Elderly Population in China about China's Total Population

[6] https://www.stats.gov.cn/xxgk/jd/sjjd2020/202401/t20240118_1946711.html。
[7] https://china.unfpa.org/sites/default/files/pub-pdf/chinas_population_projection_-_medium_variant_0.pdf。
[8] https://www.stats.gov.cn/xxgk/jd/sjjd2020/202301/t20230118_1892285.html。
[9] https://www.stats.gov.cn/xxgk/jd/sjjd2020/202401/t20240118_1946711.html。



Data source: National Bureau of Statistics, *Annual Report on the Development of the National Aging Affairs (2000-2023)*.

Figure 2. Birth Rate of the Population in China



Data source: National Bureau of Statistics

There is no globally recognized definition for smart elderly care. According to *the Smart Healthcare Industry Development Action Plan (2017-2020)* jointly issued by China's Ministry of Industry and Information Technology, Ministry of Civil Affairs, and National Health and Family Planning Commission in 2017, smart elderly care mainly refers to the use of new generation information technology products such as the Internet of Things (IoT), cloud computing, big data, and smart hardware to achieve effective connection and optimal allocation of health care resources for individuals, families, communities, institutions. This approach aims to promote the intelligent upgrade of healthcare services, thereby improving their quality and efficiency. Under this definition, smart elderly care is not only about using new technologies to improve elderly care services but also about promoting the transformation and upgrading of elderly care service models. It seeks to provide the elderly with more intelligent, convenient, and personalized elderly care services, thereby improving the elderly's quality of life and sense of happiness.

With the advent of the digital age, especially the emergence of new generation information technologies such as the Internet of Things, big data, cloud computing, artificial intelligence, blockchain, ultra-high-definition video, and virtual reality, it has become possible to provide accurate, efficient, and diversified smart elderly care services for the elderly (Sui Dangchen & Peng Qingchao, 2016; Zuo Meiyun, 2014; Zheng Shibao, 2014). This technological advancement has led to the development of the concept of smart elderly care, which has become a trending topic in academia.

Varnai et al. (2015) defined smart elderly care as the use of technology, innovation, and design in the public and private sectors to produce products, services, solutions, and systems to improve the quality of life of the elderly in three key areas: functional food, connected health and assisted living. Engineer et al. (2018) believe that smart elderly care emphasizes the elderly's acceptance and understanding of technology. Xi et al. (2014) stated that smart elderly care in China refers to the application of technologies such as the Internet of Things, information technology, big data, and cloud computing to elderly care to provide the elderly with smart care or a smart home environment, meeting their health and independent living needs, and ultimately improving their physical and mental health, and quality of life.

Information technology not only brings convenience to the lives of the elderly but also provides new possibilities for elderly care. For example, IoT technology can intelligently monitor and

control the home environment of the elderly, including smart security systems, health monitoring equipment, and other technology, thereby improving the safety and comfort of the elderly (Wu Xue, 2021; Lee and Kim, 2020; Zhang Liya and Song Xiaoyang, 2015). Big data and artificial intelligence technologies can analyze and predict the health data of the elderly, support personalized health management, and promptly detect health problems with interventions (Chen Youhua & Shao Wenjun, 2021; Jia Yan et al., 2020). Cloud computing technology can be utilized for the information management of elderly care services and facilitate information sharing and interaction among families, communities, and elderly care institutions (Zhang Bo, 2019; Wang Hongyu & Wang Xiaoyu, 2018). The application of blockchain technology can ensure the security and privacy protection of the personal information and medical data of the elderly (Bao Fanren et al., 2019; Wu Zhijie, 2022). Ultra-high-definition video and virtual reality technology offer the elderly various entertainment and socialization options, helping them maintain mental health and social activity. Thus, the new generation of information technologies has brought new opportunities for smart elderly care, adding possibilities to the lives of the elderly[10], and offering innovative solutions to the challenges of aging (Yamout et al., 2023).

In recent years, China has been actively promoting the construction of Digital China, with a significant focus on using digital technology to support the elderly (Zhang Lei & Han Yongle, 2017; Zhu Hailong, 2016). Many companies are developing electronic products and launching more digital products and application software specifically to meet the needs of the elderly (Geng Yongzhi & Wang Xiaobo, 2017). For example, Tencent News launched an aging-friendly "Care Edition" and in response to the elderly's shift in needs from "seeing" to "listening", Tencent News developed AI voice technology and other functions to enable "one-click listening to news" and allow voice input to post comments. Smart health care for the elderly primarily involves new-generation information technology products such as the Internet of Things, cloud computing, big data, and smart hardware to achieve effective connection and optimal allocation of health care resources for individuals, families, communities, institutions, and health care services. This approach promotes the intelligent upgrade of healthcare services, enhancing their quality and efficiency.

[10]The elderly referred to in this paper are those aged 60 and above.

II. China’s smart elderly care platform construction in decades

Currently, 31 provinces (autonomous regions and municipalities) in China are actively developing smart senior care platforms, although the names vary. Some areas refer to it as a smart elderly care service platform or a smart elderly care network platform, while other areas call it a smart health and elderly care service comprehensive information system platform, among other varying names. For simplicity, this paper collectively refers to them as smart elderly care platforms. The smart elderly care platform mainly refers to the use of information technologies such as IoT, the Internet, mobile Internet technology, intelligent calling, cloud technology, and GPS positioning technology to create a smart elderly care service model of "system + service + elderly + terminal". This model encompasses various forms of elderly care, such as institutional elderly care, home elderly care, and community daycare, enabling the elderly to enjoy professional and intelligent services at home. The smart elderly care platform aims to provide superior elderly care services for the elderly by effectively monitoring the elderly's physical condition, safety, and daily activities. It is designed to fully meet their needs in areas such as life, health, safety, and entertainment, thereby enhancing their overall quality of life.

1. Organizational Structure

At the central government level, according to the State Council's institutional setup, the Ministry of Civil Affairs is primarily responsible for national aging work and its two related responsibilities. The specific expectations are listed as follows: "Undertake the specific work of the National Committee on Aging. Organize the formulation and coordination of the implementation of policies and measures to actively respond to population aging. Guide and coordinate the work of protecting the rights and interests of the elderly. Organize the formulation of policies for the social participation of the elderly and organize their implementation.” Additionally, the Ministry of Civil Affairs is expected to “Organize the formulation and coordination of the implementation of policies and measures to promote the development of the elderly care industry. Coordinate the promotion, supervision, and guidance of elderly care services, formulate plans, policies, and standards for the construction of the elderly care service system and organize their implementation, and undertake the welfare of the elderly and the assistance of the elderly with special difficulties". The Ministry of Civil Affairs also receives assistance and cooperation from the National Development and Reform Commission, the Ministry of Human Resources and Social Security, the

Ministry of Education, the Ministry of Industry and Information Technology, the Ministry of Finance, the National Health Commission and other departments in carrying out relevant work on aging. At the local government level, the Civil Affairs Bureau or Department of Civil Affairs of each province (autonomous region, municipality directly under the central government) is mainly responsible for aging work, and they are supported by the Development and Reform Commission, Finance Department or Bureau, National Health Commission and other departments.

2. Policy and Regulations

At the central government level(Appendix1), the State Council, the National Development and Reform Commission, the Ministry of Human Resources and Social Security, the Ministry of Education, the Ministry of Industry and Information Technology, the Ministry of Finance, the Ministry of Housing and Urban-Rural Development, the National Health Commission and other departments have successively issued *Guiding Opinions on Actively Promoting the Internet+Action*, *Smart Elderly Care and Health Industry Development Action Plan (2021-2025)*, *Work Plan for Promoting the High-quality Development of Digital Technology for the Elderly* and other policies to support the development of smart elderly care and related industries. Among them, the Ministry of Civil Affairs, the Ministry of Finance, the National Development and Reform Commission, and ten other ministries issued the *Implementation Opinions on Encouraging Private Capital to Participate in the Development of the Elderly Care Service Industry* as early as 2015 regarding the participation of private capital in the development of the smart elderly care industry, supporting private capital to use the Internet, IoT, cloud computing and other technical means to connect the service needs of the elderly with the service supply of various social entities. In 2021, the Ministry of Civil Affairs and the China Development Bank issued the *Notice on Using Development Finance to Support the Construction of the Elderly Care Service System during the 14th Five-Year Plan Period*, proposing to use special development finance loans to support the construction of the elderly care service system, including smart elderly care services. In 2024, the National Financial Regulatory Administration issued the *Guiding Opinions on the Banking and Insurance Industries to Do a Good Job in the Five Major Financial Articles*, requiring “focusing on actual needs and accelerating the development of pension finance”.

At the local government level (Appendix 2), 31 provinces (autonomous regions and municipalities) across the country have also issued policies to support smart elderly care and platform construction

to ensure the intelligence, convenience, and efficiency of elderly care services. Some provinces and cities have explored the establishment of smart elderly care service platforms, such as Zhejiang's "Zheliyang" smart elderly care service platform and Guangxi's "Huikangyang" smart elderly care service platform. The elderly can enjoy the various services provided by smart elderly care platforms through mobile APPs, mini-programs, and portal websites.

III. The Practice of Smart Elderly Care Platform: A Case Study in Taiyuan, Shanxi Province

Currently, all provinces (autonomous regions and municipalities) across the country are constructing smart elderly care platforms. In 2016 and 2019, Taiyuan, Shanxi Province, was successively selected as one of the first pilot cities for home and community-based elderly care service reform in the country and a national demonstration city for smart and healthy elderly care, which has continued to explore smart elderly care platforms and is committed to addressing aging issues. Shanxi province has become a model city for the country, demonstrating its capabilities to solve elderly care problems, empower the elderly care industry, and drive the elderly care economy through information platforms.

1. The Smart Elderly Care Platform in Taiyuan

Taiyuan's Seventh National Population Census showed that the number of people aged 60 and above in the city reached 854,500 in 2020, accounting for 16.11% of the city's total population. To respond to the increasingly serious problem of an aging population, Taiyuan is actively building a smart elderly care platform to provide better services for the elderly.

1.1 Accurately Identifying Service Recipients

The Taiyuan Smart Elderly Care Platform uses data on the population over 60 years old collected by the Taiyuan Civil Affairs Bureau. The data is subdivided into different categories, such as empty-nest elderly, elderly living alone, elderly without self-care ability, and elderly enjoying old-age allowance, with relevant statistical data updated in real-time. This enables civil affairs bureaus, communities, nursing homes, and other service providers to promptly understand the needs of the elderly, accurately identify service recipients, and meet the needs of different elderly groups. Currently, the platform has collected data on about 529,000 empty-nest elderly people, 128,000

elderly people living alone, 153,000 elderly people living with their children, 40,000 elderly people living with other relatives, 3,076 elderly people who are suitable for aging, and millions of sensor monitoring data points.

1.2. Covering All Scenarios of Smart Elderly Care

The Taiyuan Smart Elderly Care Platform has multiple sub-platforms, including family elderly care bed management, home elderly care services, call services, and smart supervision of community canteens to build an "online + offline" service model (order online and enjoy services offline). By linking various elderly care services resources such as communities, service providers, and volunteer teams, we provide elderly people with services covering all aspects of their lives, including dining assistance, cleaning assistance, bathing assistance, walking assistance, medical assistance, and emergency assistance. This allows the elderly to obtain real-time, safe, convenient, efficient, and low-cost intelligent elderly care services, thereby improving their quality of life.

1.3. Full Cloud Supervision

The Taiyuan Smart Elderly Care Platform has realized important tracking and supervision functions. Firstly, it can provide 24-hour monitoring for the elderly to ensure their safety. Through smart bracelets, flood alarms, combustible gas alarms, and other equipment, the platform can timely monitor safety hazards such as smoke, gas, and water leakage to reduce the life risks of elderly people living alone. At the same time, it can monitor when an elderly living alone leaves their home, and after 24 hours it will automatically alert support to ensure the safety of the elderly; the platform can also use real-time monitoring of distress information to ensure that the elderly can get timely help in an emergency. Secondly, it supervises home-based elderly care services. The platform has established a supervision and follow-up mechanism, which enables the supervision of market service resources through the dispatching of orders, supervising, and following up, thereby improving the transparency and quality of services. Thirdly, the platform supports real-time viewing on mobile phones. The elderly's family members and relevant staff can watch the elderly's dynamics in real-time through their mobile phones and understand their conditions at any time. Fourthly, the platform provides one-stop closed-loop services to community canteens online, including government subsidy supervision, institutional service supervision, and meal assistance for the elderly, to achieve standardized and high-quality elderly care services.

2. Achievements of the Smart Elderly Care Platform in Taiyuan

The Taiyuan Smart Elderly Care Platform has effectively integrated artificial intelligence, IoT sensing technology, big data, and other advanced technologies to achieve significant results, creating a comprehensive three-dimensional elderly care service system.

All-Inclusive Data Analysis: The Taiyuan Smart Elderly Care Platform aggregates various data on daily electricity, water, and gas usage of elderly people living alone, among other key elderly groups. By modeling and monitoring usage patterns, it can predict abnormalities promptly and issue early warnings to ensure the safety of the elderly. All-Round Process Safety Monitoring: The Smart Elderly Care Platform equips the elderly with IoT intelligent sensing terminals. Through intelligent monitoring and early warning, it establishes a linkage mechanism with hospitals and communities to detect and solve problems as soon as possible, providing full-process safety monitoring. All-Encompassing Health Management: The Smart Elderly Care Platform analyzes health data and medication usage through the chronic disease management system, promptly grasping and confirming the current health status of the elderly to prevent accidents. All-Integrated Intelligent Services: To address the barriers elderly people face in using intelligent systems, the smart elderly care platform has built a voice service interface, connecting various related phone applications for safety, health, and consumption. When elderly people make a phone call, AI shall recognize their needs and invoke the corresponding services.

The Taiyuan Smart Elderly Care Platform has centralized upstream and downstream service providers in the elderly care industry into a unified service system, integrating, co-building, sharing, and interconnecting various service resources to the maximum extent possible to meet the needs of elderly people for convenient services in Taiyuan. The platform has so far integrated more than 500 community home-based elderly care service providers across the city, established 2,461 service points for the elderly, and formed 760 service teams, providing age-friendly equipment to 3,076 households. Each year, the platform serves over 12,000 elderly people, completing more than 210,000 meal assistance services, nearly 200,000 cleaning and bathing assistance services, over 100,000 walking assistance services, and more than 200,000 medical assistance services. In total, the six major assistance services exceed one million orders annually, with a total service value close to 100 million yuan RMB. These data and service statistics indicate that the Taiyuan Smart Elderly Care Platform has played a significant role in integrating resources, providing

convenient services, and promoting the development of the elderly care industry, offering valuable reference for smart elderly care services in other regions.

3. Challenges Faced by the Smart Elderly Care Platform in Taiyuan

3.1 Funding Supply Issues

The construction of the smart elderly care service platform requires enhanced financial support. The Taiyuan Smart Elderly Care Platform, led by the Taiyuan Municipal Civil Affairs Bureau, was developed and is maintained by China Science TopChance Waking Information Technology Co. Ltd. which has invested approximately 24 million yuan RMB in platform construction. Meanwhile, the Taiyuan Municipal Finance Bureau and Civil Affairs Bureau have provided around 10 million yuan RMB in project-based funding support. To meet the growing market demand for elderly care services, an additional 20 million yuan RMB is expected to be needed for the further improvement of the platform. Smart elderly care services require significant investment. As technology companies are involved in the construction of smart elderly care services, they need to cover costs related to technology application, function design, labor, platform development, testing, operation, and training to support platform construction. Moreover, the current construction of smart elderly care is primarily government-led, emphasizing corporate social responsibility, which reduces service efficiency and profitability. Furthermore, as elderly care is a crucial industry for public welfare, the construction, operation, and promotion of the platform require substantial human, material, and financial resources to ensure stable operation and efficient use. Therefore, ensuring robust funding support for platform construction is indispensable.

3.2. Shortage of Technical Personnel

The construction of the smart elderly care service platform requires the infusion of technical talent. In the development and operation of the Taiyuan Smart Elderly Care Platform, China Science TopChance Waking Information Technology Co. Ltd. has already gathered a full-cycle technical team including project managers, UI designers, front-end developers, engineers, database administrators, test engineers, and operations engineers. With digitalization as the foundational driving force, increasingly intelligent elderly care facilities present widespread applications of large language models and artificial intelligence technologies in the smart elderly care industry.

However, current enterprises lack sufficient investment in building and training technical teams, leading to a deficiency in professional and sustainable technical support. From a technical perspective, the continuous construction of the platform requires more specialized technical talent, such as AI engineers, data governance engineers, and data management professionals. By leveraging new technologies and professional talent, it is possible to achieve the cost-effective provision of intellectual labor in the big data era through large language models, to reduce operating costs, and improve efficiency. This will expand the range of intelligent elderly care applications and continuously diversify elderly care facilities.

3.3. Insufficient Platform Promotion

The usage rate of the smart elderly care platform needs to be further improved. Despite providing more convenient and precise services for the elderly, the platform's usage rate remains low. In Taiyuan, for example, only about 7% of the elderly population aged 60 and above have registered on the platform, with only about 32% of registered users using the platform monthly, and an average monthly usage rate of 0.7 times per user. This situation is particularly pronounced among the elderly who are not familiar with using smartphones, making it more difficult for them to access the services they need. This issue is especially significant among older elderly groups who urgently need elderly care services, as they may lack understanding and proficiency in smartphone and digital technology, leading to weak awareness and willingness to use the smart platform. Additionally, some elderly individuals may have memory decline or cognitive impairments, making it challenging for them to understand or remember how to use the platform. Furthermore, some elderly people and their families may worry about privacy leaks or financial losses when entering personal information or conducting online transactions on the smart platform, causing apprehension and resistance to using it.

3.4. Risks of Financial Sustainability

The construction of the smart elderly care service platform requires establishing marketization policies. The Taiyuan Smart Elderly Care Platform, led by the Taiyuan Municipal Civil Affairs Bureau and co-financed by the government and China Science TopChance Waking Information Technology Co. Ltd. faces a bottleneck in balancing platform investment costs and benefits in the digital transformation of elderly care and market development. The initial investment in technology, talent, and funds by enterprises has not yet formed a sustainable, operable, and

profitable elderly care model. Additionally, the development of elderly care services, products, and scenarios requires significant upfront investment, but the elderly population has only limited consumption capacity, with various services and products being priced low. This results in a long capital recovery period and high risks. There is a lack of a multifaceted operating mechanism that addresses the actual needs of the elderly care market by integrating government leadership, enterprise construction, capital involvement, and resource access. Consequently, the current elderly care platform faces operational difficulties due to a lack of R&D funding, insufficient service resources, and a deficient service market, requiring further market-driven innovation to balance the costs and benefits of digital elderly care construction.

3.5. Inconsistent Smart Elderly Care Standards

The construction of the smart elderly care platform cannot be replicated across regions. Although the Taiyuan Smart Elderly Care Platform has established a set of elderly care service standards based on data at the municipal level, as a national smart elderly care demonstration enterprise, China Science TopChance Waking Information Technology Co. Ltd. faces challenges in replicating its advanced experience to other regions, including Shanxi Province and beyond. The difficulty lies in how to unify elderly care standards with brother companies, elderly care service providers, and elderly care industry capital to enable standardized construction of smart elderly care. This is also a phased challenge in accelerating standardized elderly care construction at the provincial and national levels.

4. Next Steps for the Taiyuan Smart Elderly Care Platform

4.1. Enhancing Platform Utilization

By 2025, the Taiyuan Smart Elderly Care Platform aims to increase its utilization by leveraging the “community + home-based” elderly care service concept. It plans to deepen the coverage of “smart terminals + digital platforms” among elderly residents throughout the city. The goal is to provide precise services to 15% of elderly people aged 60 and above by utilizing wearable devices, smart warnings, one-touch calls, and Xiaodu smart speakers to enhance platform usage. Through proactive services, the platform is expected to achieve a daily usage rate of over 80% among the covered elderly. In terms of community cafeterias, the plan is to accurately connect 500 community

cafeterias citywide by the end of 2025, reaching a cumulative order count of 10 million and a total transaction volume of 1.2 billion yuan RMB.

4.2. Increasing Market Share

Building on the current foundation of the Taiyuan Smart Elderly Care Platform, and in line with the requirements and opportunities provided by the National Data Bureau for organizing and implementing pilot projects for basic elderly care service platforms, the platform will continue to expand the “Taiyuan experience” nationwide. By 2025, the platform aims to pilot its elderly care products in various counties and districts in Henan and Shanxi provinces, expanding its capabilities for customized digital services. Over the next three years, the platform will fully utilize call systems, age-friendly home modifications, community cafeterias, and home-based elderly care products and services, tailored to the 54 million yuan RMB scale of Taiyuan’s digital elderly care service platform. It plans to extend this “Taiyuan experience” to 10 cities across Shanxi Province with an investment of nearly 600 million yuan RMB. Over the next five years, the platform will explore market-driven models for elderly care services in first-tier cities, integrating industry, academia, and research. The aim is to achieve a market coverage rate of over 50% for the digital elderly care platform nationwide, further empowering the elderly care industry through digital services to maximize the benefits of digital products.

4.3. Enhancing Capital Integration for Platform Operations

In the future, the elderly care industry will become a crucial sector for boosting the national economy, as the “silver economy” wave is imminent. However, due to the currently low income and consumption levels of the elderly population, companies find it challenging to benefit from the elderly care economy. Therefore, over the next five years, data will be used as a driving force for elderly care services, capturing the operational opportunities brought by data elements. The platform will explore emerging digital service scenarios such as the integration of medical care and elderly care, family doctors, and health cabins. Elderly care services cover many aspects, and the key to digital transformation and operation lies in the deep integration of government, social capital, service resources, and the real economy with the digital economy. Therefore, focusing on all aspects of daily living, the platform will establish ecosystems for smart health and elderly care applications, medical service resources, entertainment services, daily living services, and the

elderly care economic industry, incorporating more capital to achieve sustainable growth in the elderly care economic industry.

IV. Policy Implications

With the support of relevant national policies, the construction of China's smart elderly care platforms is currently in a rapid development stage. Some provinces and cities have established smart elderly care platforms, providing elderly people with "six assistance" smart services such as real-time health status monitoring and telemedicine. However, they also face some challenges and need further improvement.

1. Establishing and Improving Cross-Departmental Coordination Mechanisms

The National Development and Reform Commission, the Ministry of Human Resources and Social Security, the Ministry of Education, the Ministry of Industry and Information Technology, the Ministry of Finance, the Ministry of Housing and Urban-Rural Development, the National Health Commission and other departments have issued policies to support smart elderly care and platform construction. However, there is a lack of cross-departmental coordination mechanisms, making it difficult to form an integrated and coherent development strategy and plan. To address this, the government can establish a cross-departmental coordination mechanism to promote the construction of smart elderly care platforms and establish a special coordination organization for this purpose.

2. Establishing Unified Standards to Improve the Quality of Smart Elderly Care Platforms

Although all local governments are actively promoting the construction of smart elderly care platforms, there are significant differences in technical standards such as platform interface design, main function settings, and data security protection. This lack of unified standards and specifications may result in uneven quality of smart elderly care platform construction. The first step to address this issue is to formulate unified technical standards and specifications, clarify the interface design, function settings, and data security requirements of the smart elderly care platform, and ensure that the platforms built in various regions can meet unified standards. The second step is to strengthen the supervision and management of platform builders, establish a sound evaluation mechanism, and adjust platforms that do not meet standard requirements. The third step is to strengthen the protection of data security, formulate unified data encryption and

privacy protection standards, and ensure the security and privacy of the elderly's personal information are not violated.

3. Achieving Integrated Management of the National Smart Elderly Care Platform

Currently, smart elderly care platforms are mainly concentrated at the municipal or district levels with relatively few provincial platforms, making data sharing and integrated elderly care services difficult. This may lead to the fragmentation and decentralization of smart elderly care services, resulting in information islands that affect the quality and efficiency of services provided by smart elderly care service agencies and the convenience of the elderly to access services. However, it may be possible to achieve shared integrated management of data and elderly care services in the medium and long term. On the one hand, it is necessary to strengthen information technology research, development, and innovation, and improve the technical level to solve the data sharing technical problems faced by the construction of a national integrated smart elderly care platform. On the other hand, it is also necessary to increase the cultivation and training of smart elderly care talents, improve their relevant skills and professional level, and provide a solid talent foundation for the integrated management of the smart elderly care platform.

4. Enhancing International Cooperation and Knowledge Sharing in Smart Elderly Care

To further promote the construction of smart elderly care platforms, China should actively carry out cooperation and exchanges in the field of smart elderly care. Learning from the experience of European countries, the United States, Japan, and other countries in the formulation of smart elderly care technology standards, fund support mechanisms, and elderly care talent training models, will accelerate the pace of construction. At the same time, collaborates with international financial organizations like the Asian Development Bank, which is actively carrying out project cooperation in the field of elderly care. The construction of China's smart elderly care platform should take advantage of the rich experience and resources accumulated by these institutions in this field along with their financial support, technical guidance, and policy research to jointly explore innovative models and best practices for smart elderly care services. This will promote the in-depth application of smart elderly care concepts on a global scale.

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Appendix 1: Policies on smart elderly care issued by the Central Government of China

Issuing Date	Issuing department	Document name	Content related to smart elderly care
2011-09-17	The State Council of the People's Republic of China	The 12th Five-Year Plan for the Development of China's Aging Affairs	Accelerate the construction of home-based elderly care service information systems, and conduct pilot projects for home-based elderly care service information platforms; establish a collaborative mechanism for the informatization of elderly affairs, set up platforms for aging information collection and data analysis, and improve the monitoring system for tracking the living conditions of the elderly in urban and rural areas.
2013-09-13	The State Council of the People's Republic of China	Several Opinions on Accelerating the Development of the Elderly Care Service Industry	Develop home-based network information services. Local governments should support enterprises and institutions in using technologies such as the Internet and the Internet of Things to innovate home-based elderly care service models, develop electronic commerce for the elderly, build home service network platforms, and provide services suitable for the elderly, such as emergency calls, housekeeping appointments, health consultations, purchase of goods on behalf, and service payments.
2015-02-03	Ministry of Civil Affairs, Ministry of Finance, National Development and Reform Commission, among ten ministries.	Implementation Opinions on Encouraging Private Capital to Participate in the Development of the Elderly Care Service Industry	Advance the informatization of elderly care services, and gradually implement dynamic management of elderly information. Support private capital in using technologies such as the Internet, the Internet of Things, and cloud computing to meet the service needs of the elderly and the service supply of various social entities. Develop remote medical services for elderly care institutions, develop electronic commerce for the elderly, and provide services

			such as emergency calls, housekeeping appointments, health consultations, purchase of goods on behalf, and service payments. In areas where conditions permit, electronic calling devices such as 'one-touch' can be provided free of charge to elderly individuals living at home.
2015-07-01	The State Council of the People's Republic of China	Guiding Opinions on Actively Promoting the 'Internet+' Action	Promote the development of the smart health and elderly care industry. Support innovation and application of smart health products and promote a new comprehensive quantified healthy living style. Encourage health service institutions to use technologies such as cloud computing and big data to build public information platforms, providing long-term tracking, forecasting, and personalized health management services. Develop third-party online health market research, consulting evaluation, and preventive management application services, and enhance the standardization and professionalism of operations. Relying on existing internet resources and social forces, and based in communities, build an elderly care information service network platform, providing home-based elderly care services such as nursing, health management, and rehabilitation care. Encourage elderly care service institutions to use mobile internet-based portable physical examination, emergency call monitoring, and other devices to improve the level of elderly care services.
2017-02-28	The State Council of the People's Republic of China	The 13th Five-Year National Plan for the Development of Aging Affairs	Implement the 'Internet+ Elderly Care' project. Support communities, elderly care service institutions, social organizations, and enterprises in utilizing information

		and Construction of the Elderly Care System	technologies such as the Internet of Things, mobile Internet, cloud computing, and big data. Develop applications for smart terminals and intelligent platforms for home and community elderly care services, information systems, apps, WeChat public accounts, etc., with a focus on expanding functions such as remote reminders and control, automatic alarms and handling, dynamic monitoring, and recording. Standardize data interfaces and build virtual elderly care homes.
2017-02-06	Ministry of Industry and Information Technology, Ministry of Civil Affairs, National Health and Family Planning Commission.	Action Plan for the Development of the Smart Elderly Care Health Industry (2017-2020)	Develop health and elderly care data management and service systems. Utilize information technology such as the internet, the Internet of Things, and big data to advance the integration of smart health and elderly care application systems, connect with medical institutions at all levels and elderly care service resources, establish dynamic monitoring mechanisms for elderly health, integrate information resources, and provide smart health and elderly care services for the elderly.
2017-07-27	Ministry of Industry and Information Technology, Ministry of Civil Affairs, National Health and Family Planning Commission.	Notification on Conducting Pilot Demonstrations for Smart Health Elderly Care Applications	Support the construction of several demonstration enterprises, including those that can provide mature smart health elderly care products, services, system platforms, or comprehensive solutions. Support the construction of several demonstration streets (townships), including the application of various types of smart health elderly care products to provide smart health elderly care services to residents within the jurisdiction. Support the construction of several demonstration bases, including promoting smart health elderly care products and services, forming industry agglomeration

			effects, and demonstrating leading effects in prefectural or county-level administrative regions.
2019-04-16	The State Council of the People's Republic of China	Opinions on Promoting the Development of Elderly Care Services	Implement the 'Internet+ Elderly Care' initiative. Continuously promote the development of the smart health elderly care industry, expand the application of information technology in the field of elderly care, establish a catalog for promoting smart health elderly care products and services, and conduct pilot demonstrations of smart health elderly care applications. Promote the in-depth application of new-generation information technologies such as artificial intelligence, the Internet of Things, cloud computing, big data, and intelligent hardware products in the field of elderly care services. Construct several 'smart elderly care homes' nationwide, promote IoT and remote intelligent security monitoring technologies, achieve 24-hour automatic security monitoring, reduce accidental risks for the elderly, and improve service experiences. Utilize the internet and biometric technologies to explore the establishment of a remote declaration and review mechanism for elderly subsidies. Accelerate the construction of the national elderly care service management information system, and advance integration with civil registration, medical care, social insurance, and social assistance information resources. Strengthen the protection of elderly people's identity and biometric information security.

2021-03-12	Central Committee of the Communist Party of China	Outline of the Fourteenth Five-Year Plan for the National Economic and Social Development of the People's Republic of China and the Long-Range Objectives Through the Year 2035	Develop the silver economy, develop aging-appropriate technologies and products, and cultivate new business forms such as smart elderly care.
2021-10-20	Ministry of Industry and Information Technology, Ministry of Civil Affairs, National Health and Family Planning Commission.	Action Plan for the Development of the Smart Elderly Care Health Industry (2021-2025)	Promote the research and development of new technologies for smart health elderly care; expand the supply of smart health elderly care products; strengthen smart health elderly care software system platforms; and enrich smart health services.
2021-11-26	Ministry of Civil Affairs, China Development Bank	Notification on Using Developmental Finance to Support the Construction of the Elderly Care Service System During the '14th Five-Year Plan' Period	Support the application of technologies such as the Internet, big data, the Internet of Things, cloud computing, artificial intelligence, and blockchain in elderly care service management, build community-based elderly care service information platforms, and guide elderly care institutions to rely on emerging technological means to construct "Internet+ elderly care services" and smart elderly care models. Support the research, development, promotion, and application of smart elderly care products, and develop aging-appropriate technologies and products, focusing on aging-appropriate rehabilitation aids, smart wearable

			devices, service robots, and accessible technology products.
2022-02-21	The State Council of the People's Republic of China	The 14th Five-Year National Plan for the Development of Aging Affairs and Elderly Care Service System	Advance "Internet+ medical health," "Internet+ nursing services," and "Internet+ rehabilitation services," and develop smart medical and care services aimed at homes, communities, and institutions. Promote the application of smart health and elderly care products.
2023-12-19	Ministry of Industry and Information Technology	Work Plan for Promoting High-Quality Development of Aging-Appropriate Digital Technology	Enhance the quality of supply for aging-appropriate digital technology products and services; deepen the aging-appropriate and accessibility transformation of Internet applications; strengthen the innovative application capability of aging-appropriate digital technologies.
2024-01-15	The State Council of the People's Republic of China	Opinions on Developing the Silver Economy to Enhance the Welfare of the Elderly	Create new business forms in smart health and elderly care. Perfect the promotion catalog of smart health and elderly care products and services, advance the integrated application of new generation information technologies, mobile terminals, wearable devices, service robots, and other smart devices in elderly care settings such as homes, communities, and institutions. Develop smart products for health management, elderly care monitoring, and psychological comfort, and promote the application of smart nursing robots, home service robots, smart anti-wandering terminals, and other smart devices. Encourage the use of virtual reality and other technologies to conduct exhibitions and experiences of elderly products and services.

Appendix 2: Policies Related to Smart Elderly Care Issued by Local Governments in China's 31 Provinces (autonomous regions, municipalities)

No.	Provinces(autonomous regions, municipalities)	Issuing Date	Issuing Department	Document Name	Content Related to Smart Elderly Care
1	Beijing	2023-11-01	The People's Government of Beijing Municipality	Implementation Opinions on Improving Beijing's Elderly Care Service System	Establish a Comprehensive Elderly Service Platform.
2	Tianjin	2022-10-14	Tianjin Municipal Civil Affairs Bureau	The 14th Five-Year Elderly Care Service System Development Plan and Long-Term Goals for 2035	Integrate the existing elderly care service systems (platforms) of the city and districts, connect with the Ministry of Civil Affairs 'Jinmin' Project, construct a citywide smart elderly care service platform, introduce information technology into all areas of elderly care services, achieve broad participation, information interconnectivity, resource sharing, and system integration, enabling one platform to manage the city' s elderly care services, one set of data to control the situation of elderly care services, one map to display elderly care resource information, and one smartphone to handle all elderly care service matters.
3	Hebei	2022-04-15	The People's Government of Hebei Province	The 14th Five-Year Plan for the Construction of the Elderly Care Service System in Hebei Province	Actively cultivate new business forms in smart elderly care and promote the deep integration of the Internet with elderly care services. Improve traditional elderly service methods, advance intelligent services to adapt to the elderly, and build a smart society that takes into account the needs of the elderly.

4	Shanxi	2022-04-13	The People's Government of Shanxi Province	Implementation Plan for Promoting the Healthy Development of Elderly Care and Childcare Services	Explore the construction of smart elderly care service platforms.
5	Inner Mongolia	2022-01-01	Inner Mongolia Autonomous Region's 13th NPC Standing Committee, 31st Meeting	Inner Mongolia Autonomous Region Elderly Care Service Regulations	Promote the construction of urban and rural home-based elderly care service information platforms, integrate various elderly care services resources such as medical, catering, domestic service, property management, and transportation, and provide services for home-based elderly such as emergency calls, health consultation, proxy shopping, housekeeping appointments, and fee payment.
6	Liaoning	2022-06-13	The People's Government of Liaoning Province	The 14th Five-Year Plan for Promoting the Healthy Development of Elderly Care and Childcare Services in Liaoning Province	Utilize resources such as the Internet, the Internet of Things, mobile terminals, information platforms, and public services to provide smart elderly care services such as emergency calls, safety monitoring, remote medical care, wireless positioning, housekeeping appointments, and service referrals.
7	Jilin	2023-02-22	Jilin Province Civil Affairs Department, Jilin Province Justice Department, Jilin Province Finance Department, Jilin Province Culture and Tourism Department, Jilin Province Health	Jilin Province Community-Based Home Care Service Reform Pilot Work Plan	Develop and improve the "smart elderly care platform," incorporating home-based elderly care services, intelligent monitoring, "tri-bed linkage," and aging-appropriate modifications into the platform management.

			Commission, Jilin Province Sports Bureau, Jilin Province Medical Insurance Bureau		
8	Heilongjiang	2022-4-29	Heilongjiang Province Civil Affairs Department	Heilongjiang Province Action Plan for Enhancing Basic Elderly Care Services in Home and Community Settings (2022—2024)	At the city (prefecture) level, construct a home and community smart elderly care network platform.
9	Shanghai	2022-12-06	Shanghai Municipal Civil Affairs Bureau	Shanghai Three-Year Action Plan for Advancing Smart Elderly Care Home Construction (2023—2025)	Utilize various intelligent care devices and information application platforms to provide services such as daily living, cleaning, position shifting, and smart care for the elderly. Encourage and support multiple elderly care institutions, chain operation organizations, and districts to integrate resources, and develop and construct a unified and efficient smart management information platform.
10	Jiangsu	2021-09-03	The People's Government of Jiangsu Province	Jiangsu Province's 14th Five-Year Elderly Care Services Development Plan	During the "Fourteenth Five-Year" period, the entire province will have built a three-level smart elderly care service platform accessible by all regions at the provincial, city, and county levels, realizing the joint construction and sharing of basic information about the elderly, information about elderly care institutions, home and community elderly care service organization information, and elderly care service credit information across the province.
11	Zhejiang	2021-04-28	Zhejiang Provincial Civil Affairs Department	Zhejiang Province Elderly Care Services Development '14th Five-Year' Plan	Utilize the Internet of Things, big data, and artificial intelligence technologies to build a unified provincial "Zhejiang Elderly Care" smart elderly care service

					platform following the "1+5+N" general framework.
12	Anhui	2020-05-28	Anhui Province Department of Economy and Information Technology, Anhui Provincial Civil Affairs Department, Anhui Provincial Health Commission, Anhui Province Department of Science and Technology	Anhui Province Smart Health and Elderly Care Industry Development Plan (2020-2025)	Accelerate the construction of the comprehensive information system platform for smart health and elderly care services across the province.
13	Fujian	2022-08-08	The People's Government of Fujian Province	Fujian Province '14th Five-Year' Plan for Elderly Affairs and Elderly Care Service System Development	Expand the application of information technology in the field of elderly care, continuously improving the construction and application promotion of the provincial elderly care service information platform.
14	Jiangxi	2022-01-01	Jiangxi Provincial People's Congress Standing Committee	Jiangxi Province Elderly Care Services Regulations	Support social forces in developing and promoting smart elderly care service platforms, utilizing the internet, IoT, cloud computing, and big data technologies to integrate market and social resources, facilitate supply-demand matchmaking, and provide services for the elderly such as emergency rescue, health

					management, service booking, and safety monitoring.
15	Shandong	2023-12-30	The People's Government of Shandong Province	Shandong Province High-Quality Development Action Plan for Elderly Care Services (2024—2026)	Establish a comprehensive smart elderly care service platform, strengthen the matching of service supply and demand, and create an elderly service scenario where the elderly have support, healthcare, activities, education, and joy.
16	Henan	2022-01-21	The People's Government of Henan Province	Henan Province '14th Five-Year' Plan for Elderly Care Service System and Healthy Aging Industry Development	Optimize home-based elderly care service models, supported by a smart elderly care service platform, to timely and accurately grasp the needs of the elderly. Through an offline resource integration platform, provide services such as meal assistance, bathing assistance, cleaning assistance, medical assistance, emergency assistance, and mobility assistance.
17	Hubei	2022-01-30	The People's Government of Hubei Province	Hubei Province '14th Five-Year' Plan for the Construction of the Elderly Care Service System	Advance the construction of smart elderly care information platforms, aggregating online and offline elderly care services, medical health, domestic nursing, and emergency rescue resources, precisely matching demands with supply, and providing the elderly with "menu-style" nearby convenient elderly care services.
18	Hunan	2022-07-15	Hunan Province Health Commission, Hunan Provincial Development and Reform Commission, Hunan	Hunan Province '14th Five-Year' Plan for the Development of Aging Affairs and Elderly Care Service System	Combine provincial medical care integration service platform construction and application promotion, and innovate smart medical care integration models for the new era.

			Provincial Civil Affairs Department		
19	Guangdong	2023-10-23	General Office of the CPC Guangdong Provincial Committee, The People's Government of Guangdong Province	Implementation Opinions on Promoting the Construction of the Basic Elderly Care Service System	Strengthen accessibility in information technology, rely on platforms like "Yue Province Matters" to optimize online service models, focus on high-frequency matters and service scenarios involving the elderly to optimize public services, government services, and lifestyle services, effectively solve the difficulties elderly people face in using digital technologies, and provide convenience for elderly people to access basic elderly care services.
20	Guangxi	2022-10-31	The People's Government of Guangxi Zhuang Autonomous Region	Guangxi Zhuang Autonomous Region '14th Five-Year' Elderly Care Service System Plan	By the end of 2025, fully establish the Guangxi smart elderly care service platform, integrating the elderly population information database, elderly care resource database, demand matching, and industry supervision.
21	Hainan	2022-12-31	The People's Government of Hainan Province	Hainan Province Three-Year Action Plan for the Development of Aging Affairs and Elderly Care Service System (2023—2025)	Encourage various enterprises to develop comprehensive service platforms that integrate information systems, professional services, and smart elderly care products.
22	Chongqing	2022-03-02	The People's Government of Chongqing Municipality	Chongqing '14th Five-Year' Plan for the Construction of the Elderly Care Service System (2021—2025)	Leverage the advantages of smart elderly care information platforms, integrate various elderly care service resources, enhance the collection, analysis, and utilization of big data, achieve precise matching of elderly care service demand and supply, and promote the rational allocation and efficient use of elderly care resources.
23	Sichuan	2019-03-14	Sichuan Province	Sichuan Province Smart Health Elderly Care Industry	Encourage and support social forces to use cloud computing and big data

			Economic and Information Technology Department, Sichuan Provincial Civil Affairs Department, Provincial Health Commission	Development Action Plan (2019—2022)	technologies to build elderly care information service platforms.
24	Guizhou	2023-12-11	The People's Government of Guizhou Province	Guizhou Province Implementation Plan for Promoting the Construction of the Basic Elderly Care Service System	Build the Guizhou smart elderly care service platform by 2025, enhance data collection, sharing, and comparison among departments, and promote precise identification and dynamic management of elderly people with special difficulties, such as those who live alone, are empty nesters, are left behind, are disabled, are severely disabled, or are from families with special family planning issues (hereinafter collectively referred to as elderly people with special difficulties).
25	Yunnan	2024-02-18	The People's Government of Yunnan Province	Yunnan Province Three-Year Action Plan for Promoting High-Quality Development of Elderly Care Services (2024—2026)	Accelerate the construction of the "Internet+" smart health elderly care service platform.
26	Xizang	2022-06	The People's Government of Tibet Autonomous Region	Several Measures for Promoting the High-Quality Development of Elderly Care Services	Advance smart elderly care services and strengthen the construction of the elderly care service talent team.
27	Shaanxi	2019-07-22	Shaanxi Province Department of Industry and Information	Shaanxi Province Smart Health Elderly Care Industry Development Implementation Plan	Build a smart health elderly care information service platform.

			Technology, Shaanxi Provincial Civil Affairs Department, Shaanxi Provincial Health Commission		
28	Gansu	2022-11-23	The People's Government of Gansu Province	Gansu Province '14th Five-Year' Plan for the Development of Aging Affairs and Elderly Care Service System	Construct a service management platform for the integration of elderly care resources, providing online service functions for the elderly such as housekeeping appointments, shopping and medicine purchasing, health management, medical appointment registration, and green referrals.
29	Qinghai	2020-04-29	The People's Government of Qinghai Province	Several Measures for Promoting the Development of Elderly Care Services in Qinghai Province	Build an information-sharing, interconnected elderly care service management and publicity platform.
30	Ningxia	2023-06-27	Party Committee of Ningxia Hui Autonomous Region, The People's Government of the Ningxia Hui Autonomous Region	Implementation Plan for Promoting the Construction of the Basic Elderly Care Service System	Integrate data related to the elderly from departments such as civil affairs, human resources and social security, health, and the Disabled Persons' Federation to form a data resource library for the elderly in the entire region, and improve the smart elderly care information platform.
31	Xinjiang	2023-08-15	The People's Government of the Xinjiang Autonomous Region	Implementation Plan for Accelerating the Construction of the Basic Elderly Care Service System	Promote the construction of a smart elderly care service platform and integrate it with the region's integrated government service platform. Facilitate the precise matching of basic elderly care services with basic elderly care service recipients, providing "menu-

					style" nearby convenient services for the elderly, gradually transitioning from "people seeking services" to "services seeking people."

Macroeconomic Implications of China's Population Aging:

A Dynamic OLG General Equilibrium Analysis

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Abstract

This paper investigates the macroeconomic impacts of China's population aging using a global computable general equilibrium model with overlapping generations. Incorporating the population projections made by the UN, the model finds that the expected demographic changes will reduce China's average annual economic growth rate by 1.1-1.4 percentage points over the next five decades. Per capita income growth would also slow due to a faster decline in the workforce relative to the population. Raising retirement ages is expected to mitigate the negative effect, but the magnitude of its impact is found to be limited.

Key words: China; Population aging; Overlapping generations model.

JEL code: C68, E21, J10

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I. Introduction

China's reform and opening-up over the past four decades, along with favorable demographic dynamics, have propelled rapid economic growth, elevating it to the status of an important global economic power. However, the population dynamics has turned from positive to negative in China. After working age population (ages 15–64) peaked in 2013, China's total population fell by 850,000 people in 2023 to 1.41 billion, marking its first drop since 1961. In 2023, the country's population fell for a second consecutive year, dropped by 2.08 million, or 0.15 percent. The declining fertility rates and increased longevity led to rapidly aging population. Elderly population aged 65 and above reached 209.78 million by the end of 2022, accounting for 14.9 percent of the total population, making China an "aged society" by UN standards.

The dramatic demographic shift is expected to persist in the coming decades, bearing significant economic and social consequence. Population aging reduces labor supply and lowers labor productivity. Investment is likely to be depressed by rising capital-labor ratio and lower return to capital relative to return to labor. As pension and healthcare expenditures escalate alongside the rising proportion of elderly citizens, the social security system may face long term financial challenges, calling for structural reform in the labor market and public finance.

Started with the seminal work of Auerbach and Kotlikoff (1987), there has been a tradition to use the large-scale numerical overlapping generations (OLG) models to analyse the economic impacts of demographic transitions and the associated fiscal policy.[2] In recent years, OLG models have also been utilized to investigate China's population aging issue. Cheng (2003) simulates the effects of fertility changes on Chinese economy using a general equilibrium OLG model. It shows that low fertility rates lead to lower returns to capital and higher returns to labor, suggesting that the fall in demand for capital due to labor shortage is greater than the fall in supply due to the dissaving of the elderly. Moreover, the paper finds no significant link between demographic structures and per capita income growth.

Some recent studies focus on the effects of social security reform within the context of China's demographic transition. Song et al. (2015) employed an OLG model with endogenous labor supply

[2] See, for example, Auerbach and Kotlikoff (1987) and Kotlikoff, Smetters and Walliser (2007) for the U.S., Auerbach et al. (1989) for four OECD countries (the U.S., Japan, Germany, and Sweden), Miles (1997) for the U.K. and European countries, Ríos-Rull (2001) for Spain, Muto, Oda and Sudo (2016) for Japan and Kwon (2017) for Korea.

to analyze the welfare and intergenerational distributional effects of alternative pension reforms in China. Their findings suggest that a fully funded reform harms current generations with marginal gains to future generations. He, Ning and Zhu (2019) develop an OLG model with idiosyncratic income risks to study the impacts of population aging and pension reform on savings and the labor supply in China. Their results indicate that the pension reform and rapid aging together can explain approximately 60 percent of the increases in household saving rate and labor supply from 1995 to 2009.

This paper aims to provide a quantitative analysis of the potential macroeconomic consequences of China's demographic shifts in the coming decades. A two-region global general equilibrium model is used to simulate the scenarios of demographic changes and possible policy adjustments in China. The major conclusion of the simulations is that population aging will weaken the outlook of China's economic growth and put pressures on public finance. The simulations indicate, under the UN's medium variant population projection, China's annual average growth rate over the next fifty years would be trimmed by 1.1 percentage points because of the expected contraction in population and workforce. The growth deceleration would escalate to 1.4 percentage points under an alternative population projection with low variant fertility. Per capita income growth would also be slower as the supply of productivity-adjusted effective labor shrinks faster than population. Fiscal position is expected to deteriorate as pension burden would increase by roughly a half due to the demographic changes. As raising retirement ages can only mitigate the negative effect to a limited extent, more structural reform to enhance labor productivity and ensure fiscal sustainability will be needed to address the challenges of population aging.

The paper is organized as follows. Section 2 overviews China's demographic trends. This is followed by a description of the OLG model and the parameter values used in this paper. Section 4 discuss the simulation scenarios and presents simulation results. The final section offers conclusions.

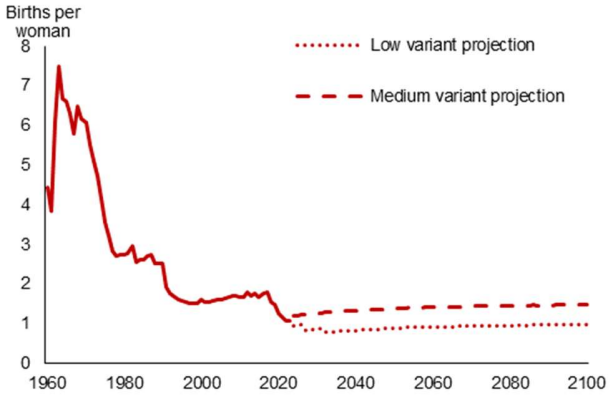
II. Demographic Trends

The simultaneous decline in fertility and mortality, both historically and in the future, will significantly reshape China's demographic landscape. Prior to the well-known one-child policy that came into effect in 1979, China had already enforced stringent family planning policies in the early 1970s (Zhang, 2017). As a result, China's total fertility rate (TFR) declined drastically from 5.7 in 1969 to 2.7 in 1978. With the introduction of the one-child policy, the TFR fell below the replacement

rate of 2.1 in early 1990s and further declined to 1.6-1.7 in the first two decades of this century (Figure 1). Despite the relaxation of one-child policy in 2013 and 2016, China TFR continued to fall, plummeting to 1.09 in 2022 (Li, Wang and Zhang, 2023). The COVID-19 pandemic may have caused some short-term disruption in family planning and distorted the fertility rate. However, even before the pandemic, China's TFR was already below 1.5 in 2019, a level known as the threshold of "low fertility trap".

The UN's "medium variant" baseline projection assumes the China's fertility rate will reverse its declining trend, rising to 1.39 in 2050 and 1.44 in 2100 (Figure 1). However, this projection diverges from historical evidence. In most of China's neighbouring economies in East Asia, the TFR continues to fall along with income growth even it is already at very low level. Under an alternative low variant fertility projection, fertility is projected to be 0.25 children below the fertility in the medium variant over 2022-26, 0.4 children over 2027-31, and 0.5 children over 2032-2100. This assumption may be more realistic in light of the prevailing low birth rates in East Asian economies - Korea, Hong Kong, Taiwan and Singapore all currently have TFRs at or well below one.

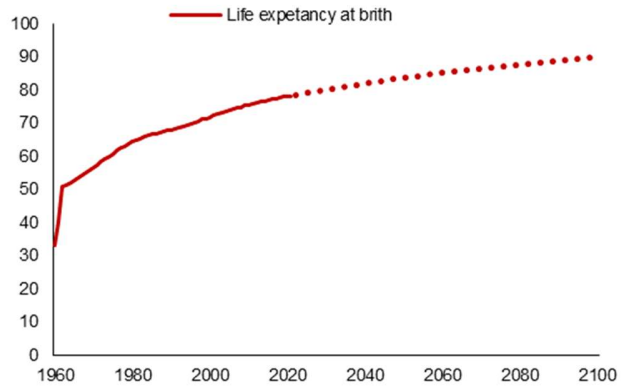
Figure 1. Total Fertility Rate of China, 1960-2100



Source: UN Population Statistics and Projections

Mortality is another important variable to affect population dynamics. Reflecting the improved medical care and living standard, China has witnessed a rapid increase in longevity since the inception of reform and opening-up. Life expectancy at birth has surged from 63.2 years in 1978 to 78.1 years in 2020. With expectations of continued reductions in mortality rates, the UN predicts that China's life expectancy at birth will ascend to 83.8 years by 2050 and to 90.2 years by 2100 (Figure 2).

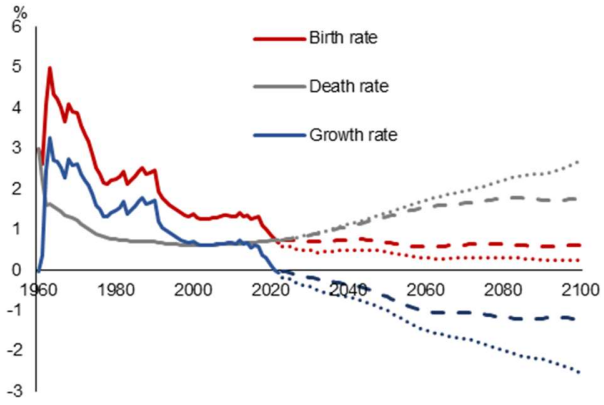
Figure 2. Life Expectancy of China, 1960-2100



Source: UN Population Statistics and Projections

Figure 3 presents the historical and projected evolution of birth, death and growth rates of China's population. Over the past sixty years, China's birth rate has declined from its peak of 5 percent in 1963 to 0.68 percent in 2022. Looking forward, even assuming a modest recovery in fertility rate, the birth rate is projected to continue to drop in the coming decades. Moreover, despite rising life expectance, the death rate is projected to rise quickly as the population ages. Consequently, total population is expected to shrink significantly. Population growth rate is projected to decline from -0.06 percent in 2022 to -0.7 percent in 2050 and -1.2 percent in 2100, while the low variant scenario suggests an even sharper population decline.

Figure 3. Birth, Death and Growth Rates of China's Population, 1960-2100

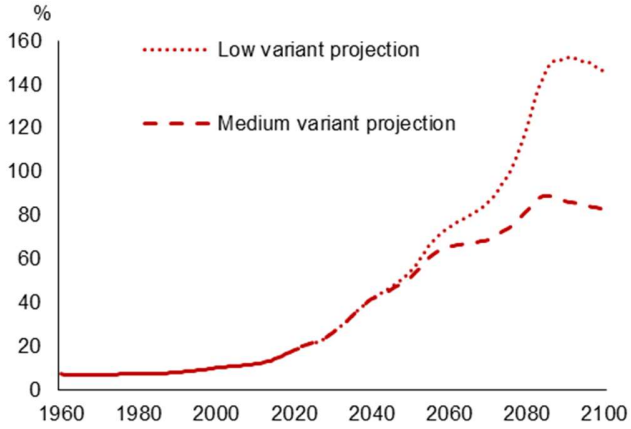


Source: UN Population Statistics and Projections
* The dashed line represents medium variant fertility projection and the dotted line represents low variant fertility projection.

With the long-term decline in fertility and mortality, population aging will be more pronounced. Under the UN's medium variant projection, the proportion of working-age population

decreased from its peak of 74.5 percent in 2010 to 68.1 percent in 2022, and the elderly population aged 65 or above increased from 8.9 percent to 14.9 percent of total population. Over the same period, old-age dependency ratio climbed from 11.9 percent to 21.9 percent, contributing more than two-thirds of the rise of the total dependency ratio. The UN population projections expect China's old dependency ratio continue its rapid rise over the next six decades, reaching its peak between 2085 and 2090 at around 90 percent under the medium variant scenario and 150 percent under low variant scenario (Figure 4).

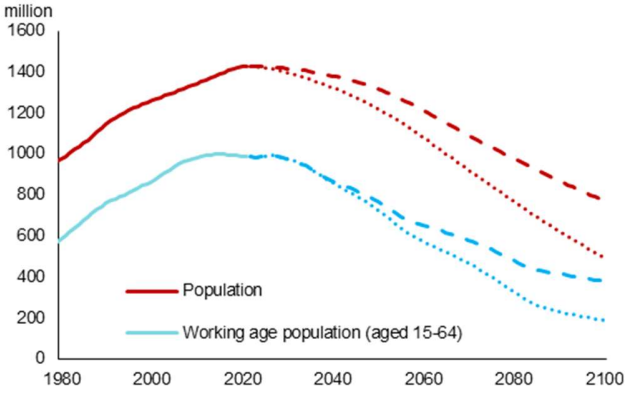
Figure 4. Old Age Dependency Ratio of China, 1960-2100



Source: UN Population Statistics and Projections

The significant decline in China's labor supply amid population aging is striking. According to the UN's medium variant projection, China's total population is expected to decrease by 7.5 percent from 2020 to 2050 and by 45.8 percent by 2100. However, the fall in its working-age population is even more pronounced, with a decrease of 22.3 percent by 2050 and 61.8 percent by 2100 (Figure 5). The low variant projection forecasts a much sharper decrease in the working-age population in the long run, with a decline of 26.4 percent by 2050 and 80.8 percent by 2100.

Figure 5. Population and Working Age Population of China, 1960-2100



Source: UN Population Statistics and Projections
* The dashed line represents medium variant fertility projection and the dotted line represents low variant fertility projection.

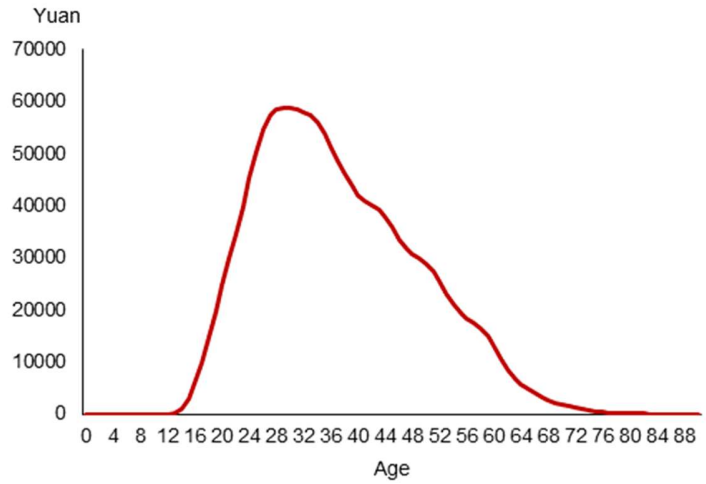
III. A Dynamic OLG General Equilibrium Model

To investigate the impacts of China's demographic transition on macroeconomic variables, we build a general equilibrium life-cycle model with realistic demographic structure. The model divides the world economy into two regions - China and the rest of world. Each region is populated by 70 generations with uncertain life spans. The agents raise children and supply labor inelastically. They are rational, forward-looking and face no liquidity constraints. In addition to intended bequest, agents leave unintended bequest due to mortality risk and imperfect annuity markets. A representative, perfectively competitive firm in each country produces output using labor and capital. Installing new capital is assumed to be costly and the investment behavior is described by Tobin's q-theory. Final demand is allocation between domestic and imported goods using the Armington (1969) assumption. Capital is fully mobile internationally. Exchange rates and interest rates are jointly determined by the interest parity condition. A stylized pay-as-you-go (PAYG) pension plan is incorporated into the model to mimic the actual pension schemes in both China and the rest of the world. The model is calibrated to the economic and population data of 2020 and runs from 2020 to 2300 to ensure reaching a steady state.

A key channel through which the population changes affect the economy in this model is the age profile of individual's labor earnings and savings. Age-earning profiles are often hump-shaped, reflecting the changes in labor force participation and the relative productivity over the life cycle. Because of the individual's desire to smooth consumption over its lifetime, the age-saving profiles are also often hump-shaped: young agents save little in anticipation of rising future income, but

progressively increase their savings as they age and decrease when retirement is approached. In China, the age-earning profile is heavily skewed toward younger ages with peak at age 30, as the young people with rising amounts of education disproportionately benefit from the urban-based, high-pay job opportunities brought by economic growth (Figures 6) (Lee, 2019). Different from the prediction of standard life-cycle theory, China's urban households have a U-shaped age-saving profile, where the saving rates are higher for younger and older households.[3] Following Curtis, Lugauer and Mark (2015), we introduce a variation of the Barro and Becker (1989) preference in which parents derive their utility from both own consumption and their children's consumption into our OLG model. This specification helps the model to replicate a U-shaped saving pattern throughout people's working life as reflected in China's data.

Figure 6. Labor Income by Age, China, 2014



Source: National Transfer Accounts database. www.ntaccounts.org

3.1 Structure of the model

In the model the long-term steady state rate of output growth is exogenous at rate g, which is driven by labor-augmenting technological change. Long term population growth is assumed to be zero. For a clear separation of endogenous dynamic from exogenous trend, the model specification is simplified by detrending all variables into stationary variables through division by the quantities of

[3] The U-shaped age-saving relation in urban China was empirically documented in Chamon and Prasad (2010) and Song and Yang (2010). Possible explanations for this abnormal saving pattern include precautionary savings (Chamon and Prasad, 2010; Chamon, Liu and Prasad, 2013), housing market (Bussière et al., 2013), effects of demographic structure and one-child policy (Curtis, Lugauer and Mark, 2015; Ge, Yang and Zhang, 2018; Choukhmane, Coeurdacier and Jin, 2023), bequest (Almås, Freddi and Thøgersen, 2020), and marriage squeeze (Nie, 2020).

efficiency units of population. For notational simplicity, the time subscript *t* and region subscript *s* are omitted in what follows if this does not lead to confusion.

(1) Households

The modeling of household behavior follows the life-cycle approach. Agents are born at age 1 and live a maximum of 70 years, corresponding to adult ages 20 through 89. The probability of surviving between age *j* and age *j*+1 is s_j. All agents have identical preference over consumption that are given by the following utility function:

$$\sum_{j=1}^{70} \beta^j \left(\prod_{i=1}^{j} s_i\right) u\left(c_j, c_j^c, b\right) \tag{1}$$

where β is the subject discount rate. The period utility function $u\left(c_j, c_j^c, b\right)$ takes a Barro and Becker (1989) functional form which is additively separable among consumption of parents, c_j , consumption of children, c_j^c and bequest, b:

$$u\left(c_j, c_j^c, b\right) = \frac{c_j^{1-\gamma} + \rho_j^{-\gamma} b_j^{1-\gamma}}{(1-\gamma)} + \mu\left(n_j^c\right)^{\eta} \frac{\left(c_j^c\right)^{1-\gamma}}{(1-\gamma)}, \qquad \begin{matrix} \rho_j = 0, \ \forall j \in \{1, \cdots, 69\}; \\ \rho_j = 1.5, \ j = 70 \end{matrix} \tag{2}$$

where γ is the coefficient of relative risk aversion and $1/\gamma$ is the intertemporal elasticity of substitution. ρ is the preference parameter for intended bequest. $\mu < 1$ and $\eta < 1$ determine the degree to which parents care for their children. n_j^c is the cohort-specific number of dependent children expressed on a per person basis. It is determined by a constant fertility profile by age and the time-variant total fertility rates.

The agent maximizes (1) subject to the following sequence of period budget constraints for each age *j* = 1, …, 70:

$$\begin{aligned} PC \cdot \left(c_j + n_j c_j^c\right) + (1+g) a_{j+1} \quad &= \left(1 - \tau_n - \tau_p\right) l_j \varepsilon_j w + z + B_j \\ &\quad + (1+r)\left(a_j + b^u + b\right) \end{aligned} \tag{3}$$

together with $c_j \geq 0$, $c_j^c \geq 0$, and $a_{j+1} \geq 0$ if *j*=70. In (3) resources are derived from asset holdings a_j, labor endowment l, a lump-sum transfer *z*, pension benefits *B* for pensioners, an unintended bequest b^u and an intended bequest *b*. Assets pay an interest rate *r*. Labor receives a real wage $w \cdot \varepsilon_j$ and is taxed at labor income tax rate τ_n and payroll tax rate τ_p, where the efficiency parameter ε_j reflects the efficiency difference across age. In the absence of annuity markets, assets

of individuals who die in each period are assumed to be distributed to all living individuals as lump sum transfer b^u. Expenditures on the left-hand side of (3) include purchase of consumption goods and acquisition of assets for the next period. *PC* is the tax-inclusive consumer price. There are no liquidity constraints, so the assets in (3) can be negative, although the terminal wealth must be non-negative if the agents survive up to terminal period (*j*=70).

(2) Firms and Technology

Production technology is characterized by a Cobb-Douglas function with two private factors of production (aggregate labor *L* and private capital K_p) and public capital, K_g:

$$Y = AK_p^{\kappa} L^{\theta} K_g^{1-\kappa-\theta}, \quad 0 < \theta < 1,\ 0 < \kappa < 1, \kappa + \theta < 1 \tag{4}$$

where *Y* is gross output and *A* is total factor productivity. κ and θ represent share parameters of private capital and labor in output, respectively.

In each period, the firm decides on the intensities of labor input, taking as given price of labor and the current stock of public and private capital, to minimize their cost. Thus, the firm employs factors according to marginal productivity rules.

$$R = \kappa A K_p^{\kappa-1} L^{\theta} K_g^{1-\kappa-\theta} \tag{5}$$

$$w = \theta A K_p^{\kappa} L^{\theta-1} K_g^{1-\kappa-\theta} \tag{6}$$

where *R* is marginal product of private capital and *w* is the wage rate. As the production function exhibits decreasing returns to sale for private inputs, the firm earns a profit, Π, equal to the return to public capital.

$$\Pi = (1 - \kappa - \theta) \cdot Y \cdot P \tag{7}$$

where *P* is the price of the goods.

The firm alters its private capital stock through investment I_p to maximize the value of firm, *V*, defined as the present value of net cash flow. By assuming a quadratic and homogenous adjustment cost function, the investment expenditure J_p, can be defined as:

$$J_p = \left[1 + \frac{\psi}{2}\frac{I_p}{K_p}\right] \cdot I_p \cdot PA \tag{8}$$

where *PA* is the price of composite goods and reflects the replacement cost of capital. The dynamic

optimization problem of firms leads to the following two arbitrage conditions: (i) marginal cost of new investment is equal to the shadow price of installed capital, i.e. Tobin's *q*:

$$\partial(J_p)/\partial(I_p) = q, \quad i.e. \quad \frac{I_p}{K_p} = \frac{1}{\psi}\left(\frac{q}{PA} - 1\right) \tag{9}$$

and (ii) returns to financial and real investment are identical:

$$\begin{aligned} r_t q_{t-1} &= (1-\tau_k)\left(R_t + \frac{\Pi_t}{K_{p,t}}\right) + \tau_k \cdot \delta \cdot PA_t \\ &+ \frac{\psi}{2}\left(\frac{I_{p,t}}{K_{p,t}}\right)^2 \cdot PA_t + (1-\delta)q_t - q_{t-1} \end{aligned} \tag{10}$$

where δ is the depreciation rate of capital and τ_k is the corporate income tax rate. The right-hand side of (10) defines the total return to capital, including the after-tax marginal product and capital gains.

(3) Government

The model specifies a general national government. At each period, the government purchases of goods and services, *G*, and public investment in infrastructure, J_g are financed through tax revenue and debt issuance, *D*. The government budget constraint at period t is:

$$\begin{aligned} G_t + J_g + z_t \cdot N + (1+r_t)D_t &= \tau_k(R_t - \delta \cdot PA_t)K_{p,t} + \tau_k \Pi_t + \tau_m PM_t M_t \\ &+ \tau_n w_t L_t + \tau_c PA_t(C_t + G_t) + (1+g)D_{t+1} \end{aligned} \tag{11}$$

The left-hand side of (11) represents uses of government revenue, where $N = \sum_{j=1}^{70} n_j$ is the number of total population. Government purchases *G* are assumed to be unproductive and generate no utility to households. Government revenue in the right-hand side of (11) includes corporate income tax, labor income tax, consumption tax, tariff for imports *M*, and newly issued debt. Corporate income tax is levied on the profits of firms net of depreciation. *PM* is the import price.

The public investment is also assumed to entail adjustment costs similar to (8).

$$J_g = \left[1 + \frac{\psi}{2}\frac{I_g}{K_g}\right] \cdot I_g \cdot PA \tag{12}$$

Government also faces no-Ponzi-game constraint, i.e. $lim_{T\to\infty}(D_T/\prod_t^T(1+r_t)) \leq 0$, implying that the present value of government expenditure must be less than or equal to the present value of revenue plus the initial stock of government debt. To ensure the intertemporal budget

constraint holds, we fix the ratio of *G* and *D* to GDP throughout the transition period and let the personal income tax rate or lump-sum transfer to the households endogenous to balance the period budget.

(4) Social Security

There is a simple pay-as-you-go system in this model. Individuals start to receive pension benefits after retirement, which are financed by payroll tax. The pension scheme is independent of the government's regular budget and needs to satisfy its own intertemporal budget constraints. The total pension contribution, *S* is defined as:

$$S = \tau_p wL \tag{13}$$

The pension benefits for generations older than retirement age, *B* is defined as:

$$B_j = \vartheta_j \cdot AVE_j, \qquad j > \Upsilon_j \tag{14}$$

where ϑ_j is the generation-specific replacement ratio and Υ_j is the age of retirement for generation *j*. The average of earning over the working time, AVE_j is defined as:

$$AVE_{j,t} = \sum_{k=1}^{\Upsilon_j} l_{j,t-(j-k)} \varepsilon_j w_{t-(j-k)} \Big/ \Upsilon_{j,t}, \qquad j > \Upsilon_{j,t} \tag{15}$$

The pension scheme is assumed to be self-financing and maintain balanced budget annually, i.e.:

$$S = \sum_{j=1}^{70} B_j n_j \tag{16}$$

The payroll tax rate τ_p adjusts endogenously each year to satisfy the budget constraint of the scheme.

(5) Foreign trade and international payment

Demands are for composites of foreign and domestic goods. A CES function is utilized to specify the aggregation of composite goods, implying that products are differentiated by region of

origin, i.e. the Armington assumption (Armington, 1969).

$$C + G + (J_p + J_g)/PA = \left[(1-\alpha^m)(Y-X)^{(\sigma-1)/\sigma} + \alpha^m(M)^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)} \quad (17)$$

where C denotes the aggregate consumption and X denotes exports.

The corresponding price index PA is the combination of the price of imports, PM and the producer price of domestic good, P. It is specified as a unit cost function.

$$PA = [\alpha_m^{\sigma}(PM)^{1-\sigma} + (1-\alpha_m)^{\sigma}(P)^{1-\sigma}]^{1/(1-\sigma)} \quad (18)$$

Import price of region s, PM_s is determined by region s's exchange rate, ER_s, import tariff and the producer price of its trading partner, P^*.

$$PM_s = P^* \cdot ER_s(1+\tau_{m,s}) \quad (19)$$

Exchange rate ER is determined by an adjusted uncovered interest rate parity condition.

$$(1+r_{t+1}) = (1-\Gamma_{t+1})(1+r^*_{t+1}) \cdot \frac{ER_{t+1}}{ER_t} \quad (20)$$

where r^* is foreign interest rate and Γ is the transaction fee for foreign borrowing or lending. The transaction cost is a function of the average net asset position of the whole economy, following the IMF's Global Economic Model (GEM) (Pesenti, 2008):

$$1-\Gamma = \left(1-\varphi^{b1}\frac{exp(\varphi^{b2}[ER\cdot F/GDP-fss])-1}{exp(\varphi^{b2}[ER\cdot F/GDP-fss])+1}\right)\frac{\beta^*}{\beta} \quad (21)$$

where F indicates net foreign asset and fss is the desired net foreign asset positions expressed as a ratio of GDP. φ^{b1} and φ^{b2} are parameters with $0< \varphi^{b1} <1$ and $\varphi^{b2}>0$.

(6) Aggregation

Total consumption equals the sum of consumption by each cohort:

$$\sum_{j=1}^{70}\{n_j(n_j^c c_j^c + c_j)\} = C \quad (22)$$

Aggregate labor input is given by:

$$\sum_{j=1}^{70}\varepsilon_j l_j n_j = L \quad (23)$$

The clearing condition in the capital market requires that total national wealth, including total private wealth and government net wealth, equals the value of domestic firms plus net foreign

asset, denominated in U.S. dollar.

$$\sum_{j=1}^{70} a_j n_j - D = ER \cdot F + V \quad (24)$$

Net foreign asset F is determined by current account balance and subjects to the following clearing condition:

$$F_{chn} + F_{row} = 0 \quad (25)$$

(7) Equilibrium

For a given government policy $\{G_t, D_t, J_{g,t}, \tau_n, \tau_k, \tau_m, \tau_c, \vartheta_j\}_{t=0}^{\infty}$ and $\{K_{p,0}, K_{g,0}, F_0,\}$, the model's dynamic competitive equilibrium is the sequences of price$\{w_t, R_t, ER_t, r_t, q_t, P_t, PA_t, PC_t\}_{t=0}^{\infty}$ and allocations $\{b_t, b_t^u, c_t, c_t^c, K_{p,t+1}, K_{g,t+1}, Y_t, \Pi_t, C_t, J_{p,t}, I_{p,t}, I_{g,t}, X_t, M_t, F_{t+1}, z_t, S_t, B_t, \tau_{p,t}\}_{t=0}^{\infty}$ for each region such that:

(1) The allocation solves the dynamic program (1)-(3) for all agents, given the prices and government policy.

(2) The allocation satisfies (5) – (10) to maximize the profits of firms.

(3) The allocation and government policy satisfy the budget constraint of the pension scheme given the prices.

(4) The allocation and payroll tax rate satisfy the budget constraint of the pension scheme (16) given the prices.

(5) M_t satisfies the first order conditions of the optimization problems of minimizing the costs of composite goods.

(6) Capital and labor markets clear, that is (23) and (24) satisfied.

(7) Unintended bequests equal lump sum transfers b^u.

3.2 Model calibration

The calibration of a dynamic model with the assumption of perfect foresight involves finding a set of data that covers all periods of the model and is consistent with the intra-period and intertemporal equilibria. This set of data needs to replicate the data of the base year and could serve

as the dynamic benchmark equilibrium of the model. The dynamic calibration assumes that the economy in the base year is in a temporal equilibrium along a dynamic adjustment path, which is more appropriate than assuming a stationary steady state for a fast-growing economy like China.

The model is calibrated to macro and population data of 2020. Most elasticity parameters and dynamic adjustment parameters are drawn on the existing literatures on dynamic models in determining their values. Table 1 summarizes the major parameters of the model.

Table 1. Benchmark parameters of the model

	Definition	Value
$1/\gamma$	Intertemporal elasticity of substitution	0.50
β	Households subjective discount rate	1.012*
ρ	Preference parameter for intended bequest	1.5
μ	Weight on children	0.58
η	Concavity for children	0.76
σ	Elasticity of substitution between imports and domestic goods	2.50
δ	Depreciation rate of physical capital	0.06
ψ	Capital adjustment cost parameter	2.00
φ^{b1}	Parameter governing short-run dynamics of net foreign assets	0.1
φ^{b2}	Parameter governing short-run dynamics of net foreign assets	0.2
g-1	Long-term growth rate of the global economy	0.02

Source: Authors' assumptions on the basis of existing similar studies.
*The subjective discount rate is set to generate the targeted long-term interest rate of 4.2 percent.

In calibrating the household sector, the value of the intertemporal elasticity of substitution is set at 0.5 (γ=2), which is close to the upper end of the range of empirical estimates. The time preference parameter β is chosen to generate a steady-state real interest rate of 4.2 percent. This value of 1.012 is high, but individuals also effectively discount the future due to the incorporation of survival probabilities s. The parameters characterizing the weight parents put on utility from children's consumption, μ and η, are taken from Curtis, Lugauer and Mark (2015). The age profile of fertility is also taken from Curtis, Lugauer and Mark (2015). The age-specific labor endowment ε is calculated based on the life-cycle labor income profile obtained from the National Transfer Accounts (NTA) project.

The output shares of public capita, 1- κ- θ, is 0.14 for the world and 0.07 for China (Arslanalp et al., 2010; World Bank, 2017). The output share of capital and labor, κ and θ, are calculated from the base year national account data. The value of capital adjustment cost parameters is taken as 2, which corresponds to the low end of some empirical estimates. The depreciation rate of physical capital is set at 6 percent per year. Following the literature of trade models, the elasticity of substitution

between imports and domestic goods, i.e., the Armington elasticity, is set to be 2.5. All tax rates, including payroll tax rates, are calibrated from the base year tax and pension revenues.

IV. Model Simulations

4.1 Impacts of the Population Transition

To quantify the impacts of the future population changes, we first establish a counterfactual reference scenario in which population in China is assumed to be stationary. Specially, the reference scenario assumes that the death rate is constant at its 2020 level and the death rate is equal to the birth rate. Then the population projections of the UN medium variant and low variant are introduced as the demographic shocks. The differences between the two demographic shock scenarios and the reference scenario reveals the effects of demographic transitions in China.

The impacts of China's demographic changes on its macroeconomy are summarized in Figure 7, which present the simulation results as deviations from the reference scenario. Compared to the baseline of stationary population, the GDP level in 2070 is estimated to decrease cumulatively by 40.5 percent under the scenario of medium variant projection and 52.2 percent under the scenario of low variant projection. Per capita GDP also declines, as the productivity-adjusted effective labor supply falls by more than the population. Due to differences in labor productivity across age cohorts, the aging of the labor force will lead to a larger decline in labor measured in efficiency unit. In growth terms, demographic changes projected by the UN's medium variant scenario will reduce China's annual growth of GDP and per capita GDP by 1.09 and 0.86 percentage points, respectively, from 2021 to 2070 compared to the baseline. Under the low variant scenario, the deceleration in the growth of GDP and per capita GDP is even greater, at 1.40 and 1.05 percent, respectively. Nevertheless, the adverse impacts of the low variant scenario compared to the medium variant scenario become apparent only after 2040, owing to the delayed impact of declining fertility rates on the labor force.

Figure 7. Macroeconomic Effects of China's Population Shifts for China

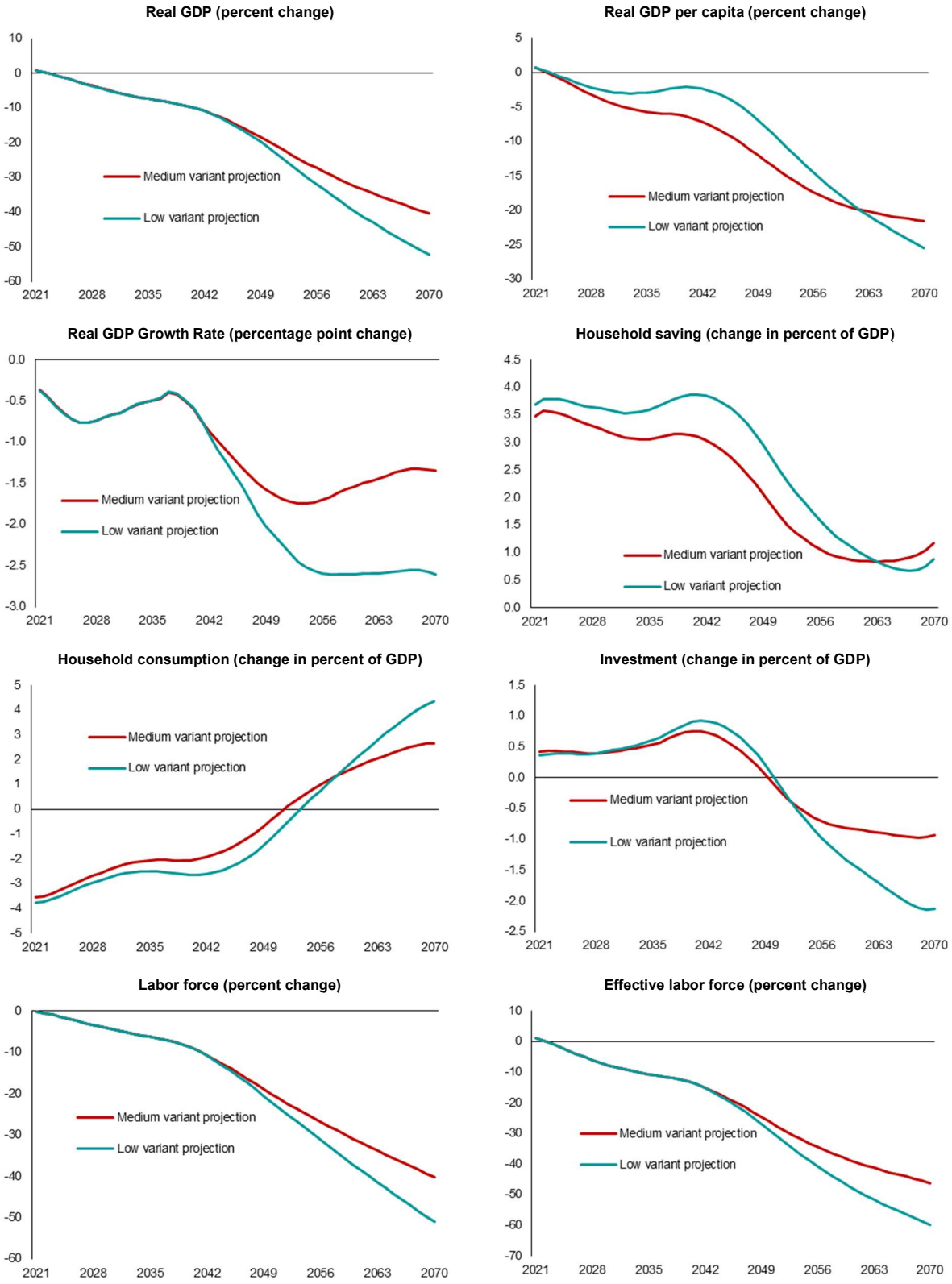
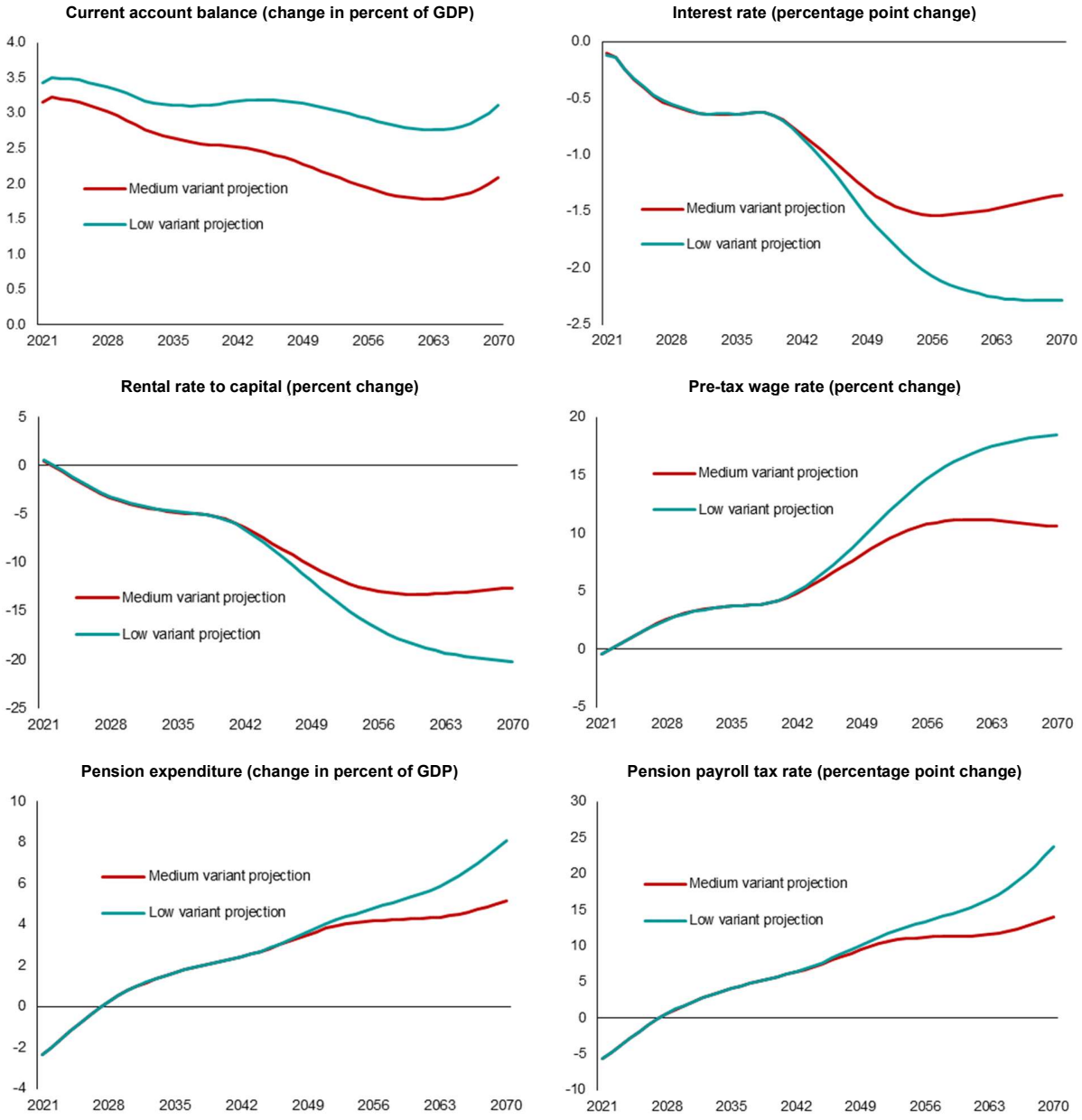


Figure 7. Macroeconomic Effects of China's Population Changes (cont'd)



Source: Model simulations

The severity of demographic shocks on China's economic growth will vary over time. As post-famine baby boomers reach the age of 65 and above, China's aging will accelerate, resulting in a reduction of about 0.75 percentage points in annual growth from 2026 to 2028. Subsequently, as fewer people enter retirement age, this growth deceleration caused by demographic transition will moderate in the 2030s. However, GDP growth is likely to deteriorate notably after 2040 as the

continuous reduction in new, young workforce entrants leads to a rapid decline in labor supply. By 2050, demographic shifts could lower China's growth rate by as much as 1.63 percentage points in the medium variant scenario and 2.11 percentage points in the low variant scenario. Following 2055, the growth deceleration is projected to be more moderate under the medium variant scenario, but remaining above 2.5 percentage points under the low variant scenario.

Despite the higher proportion of elderly people amid the demographic transition, household savings as a ratio to GDP would increase by an average of 3.2 percentage points during 2021-2040 in the medium variant scenario and 3.9 percentage points in the low variant scenario. Two reasons accounts for the uptick of saving rate in the initial stage of population transition. First, lower fertility reduces spending on the consumption of children. Secondly, the anticipated longer time in retirement due to increased longevity effectively lowers households' discount rates. The rise in savings translates into reduced consumption spending, which is expected to decline by an average of 2.6 percentage points and 2.9 percentage points as a ratio to GDP during the same period under the two alternative population projections.

With more and more individuals entering retirement, the share of retired dissavers within the population increase, exacerbating the negative impact of population aging on household savings. The simulation results indicate that the demographic-induced increases in the household saving rate will taper off after 2045, decreasing to less than one percentage point by 2060. Consequently, in comparison to the baseline scenario, the ratio of household consumption to GDP is expected to rise after 2050-55 under the two scenarios of UN population projection. The increase in savings also exerts downward pressure on interest rates. The decrease in China's interest rate is projected to widen from 0.1 percentage points in 2020 to 0.6 percentage points in 2030, stabilizing thereafter until 2040. Beyond 2040, the rapid decline in the influx of young workers will further depress both economic growth and interest rates.[4]

A lower interest rate relative to the rest of the world spurs outflows of capital. As a result, China's current account balance to GDP ratio is estimated to be 2.4 percentage points higher on

[4] This finding on real interest rate contrasts with the arguments in Goodhart and Pradhan (2020) but is consistent with research findings of Kruger and Ludwig (2007), Carvalho, Ferrero and Nechio (2016), and Aucler et al. (2021), among others.

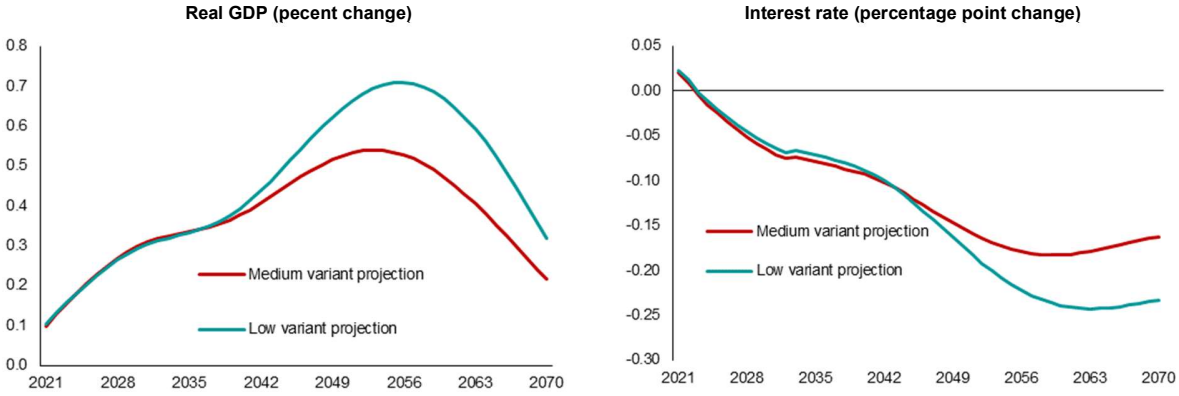
average during 2020–2070 under the medium variant scenario and 3.1 percentage points higher under the medium variant scenario when compared to the reference scenario.

Two offsetting forces determines the impacts of demographic changes on investment. As labor forces diminish, the capital-labor ratio rises, causing a decrease in the return to capital relative to the return to labor. Consequently, this reduces firms' incentives to invest. On the other hand, declining interest rates encourage investment by lowering its costs. The simulation results suggest that investment as a share of GDP would increase between 2020 and 2050, but decline thereafter. As the effects to declining labor force continue to unfold, the return of capital would fall more sharply after 2042, gradually dominating the impacts of the lower interest rates.

Population aging is expected to impose a significant pension burden for China. Compared to the reference scenario, pension expenditure as a percentage of GDP is projected to expand by 5.2 percentage points under the medium variant scenario and 8.1 percentage points under the low variant scenario. This increase would necessitate additional government financing—for example, by raising taxes or issuing more bonds—to fill the resulting gap. Under a defined-benefit PAYG scheme, the contribution rate for the current generation of workers in 2070 would need to be hiked by 14.1 percentage points and 23.8 percentage points, respectively, to balance the pension fund.

China's population changes will impact the rest of the world primarily through the channel of capital flows. The outflow of China's savings driven by demographic effects, which is projected to be 2 to 3 percent of China's GDP, is expected to depress the global interest rate by 0.15-0.25 percentage points in the 2060s (Figure 8). These augmented capital inflows and reduced interest rates boost investment and stimulate economic growth in the rest of world, albeit only to a modest extent.

Figure 8. Macroeconomic Effects of China's Population Shifts for the Rest of the World



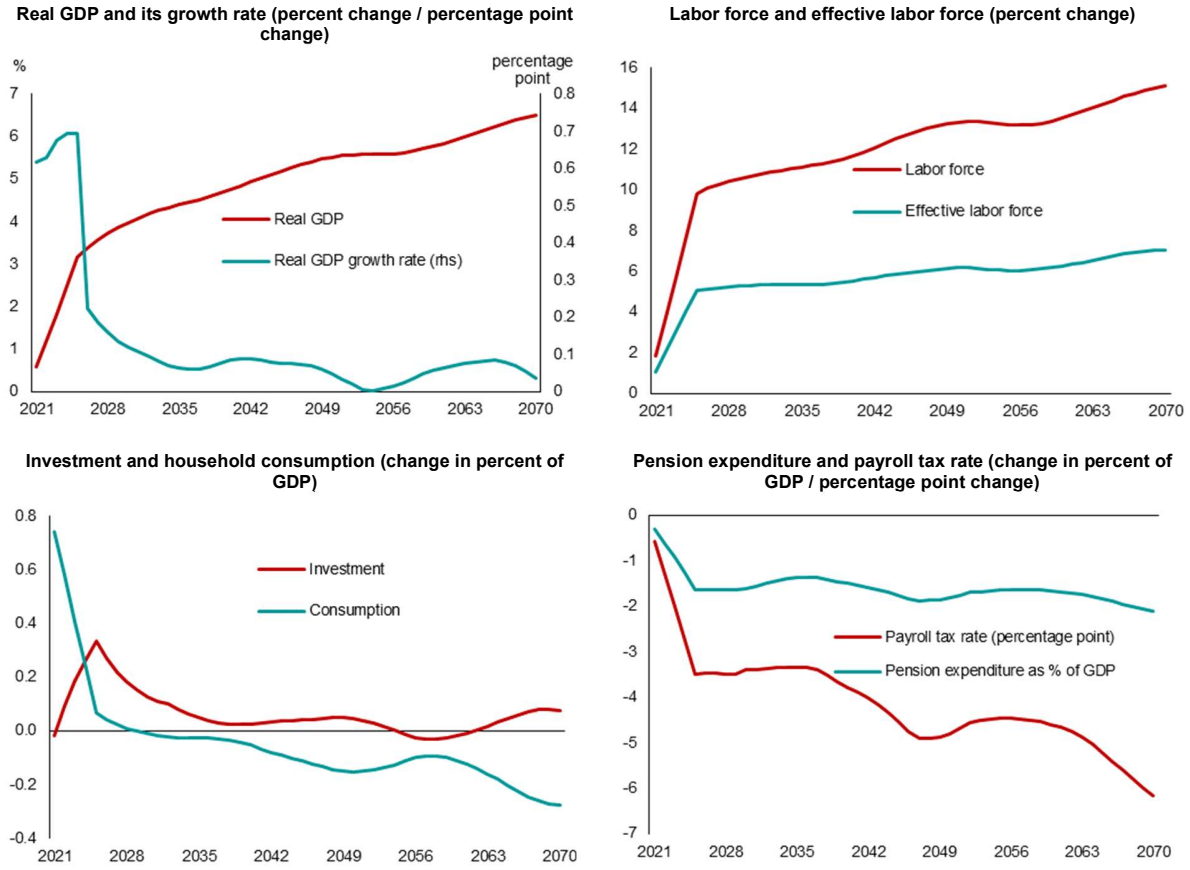
Source: Model simulations

4.2 Impacts of Raising Retirement Age

Formulated in 1950s, China's current retirement policy features some of the world's lowest retirement ages: 50 years for female blue-collar workers, 55 years for female office workers, and 60 years for men. With life expectancy experiencing significant growth, raising the retirement age has emerged as a viable policy solution to address China's aging population issue. To examine the potential implications of such a policy reform, this sub-section simulates a scenario in which the policy shock of retirement age change is added to the scenario of medium variant population projection. Specially, the policy shock assumes a gradual increase of 5 years in the retirement age in China over the period of 2021-2025.

Figure 9 presents the major simulation results of this scenario. Postponing the retirement age by five years would increase the labor supply, which is projected to surge by 10.1 percent in 2025 and by 15.1 percent in 2070. As the new entrants to the labor force are older with lower productivity, the rise in effective labor is more modest, amounting to approximately half of the increase in the labor force. The annual average growth rate of real GDP would be raised by 0.66 percentage points in the initial five years of raising retirement age, but this gain would be gradually diminished to 0.03 percentage points over the long term. In anticipation of higher lifetime income, young generations of workers increase their current consumption expenditure, leading to an increase in the consumption share of GDP in initial years. However, this trend is projected to wane over time. The postpone of the retirement age essentially redistributes income from pensioners to workers who pay lower payroll taxes. As pensions have higher marginal propensities to consumption, the overall household consumption as a percentage of GDP would decline modestly in the long run. The reform will help improve the sustainability of the PAYG pension system. Over the long run, total pension expenditure as a percentage of GDP is expected to decrease by 2.1 percentage points and the payroll tax rate would be reduced by 6.2 percentage points. However, these adjustments only partially offset the impacts of expected demographic shifts in China.

Figure 9. Macroeconomic Effects of Raising Retirement Age for China



Source: Model simulations

V. Conclusions

This paper quantitatively explores the macroeconomic impact of China's population transition using a multi-region overlapping generations model. The simulations indicates that China's economic growth would decelerate notably in the face of demographic shifts over the coming decades. The shrinking workforce, coupled with an increasing proportion of the elderly population, will exert downward pressure on labor supply, consumption, and interest rate. Moreover, the strain on public finance is expected to intensify.

The findings underscore the urgency of implementing structural reforms to mitigate the adverse effects of population aging. Raising the retirement age is a potential policy intervention to bolster labor supply and alleviate the burden on the pension system. However, the benefits it brings are limited compared to the upcoming demographic shocks. Moreover, such reforms must be

carefully designed to balance the needs of current and future generations, considering their differential impacts on various demographic cohorts.

Some important limitations of this study are worth noting. First, the model used in this study assumes constant age-specific labor participation rates. Incorporating labor-leisure choice to endogenize labor supply would enable the model to better capture the impacts of wage and tax policies on labor supply. Second, the model overlooks institutional details of China's complex pension system. A more realistic modeling of China's pension scheme would improve the model's ability to simulate social security reform, thereby enhancing the policy relevance of the simulations. These point to the directions for further research.

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Analysis of Fiscal Policy in Dealing with the trend of Aging Population in China

Xu Wen[1]

Abstract: The ageing of China's population and the accompanying trend towards longevity and sub-replacement fertility will inevitably have an impact on economic and social development. For this reason, it is necessary to implement a national strategy to actively address population ageing. The trend of population ageing has multiple fiscal implications. It is generally recognized that population ageing will lead to lower growth in fiscal revenues and higher fiscal expenditures, which in turn will affect fiscal sustainability. Population ageing may also affect the effects of fiscal policy, increasing the risk responsibility of Governments and fiscal risks while creating more uncertainty. In coping with population ageing, fiscal policy should focus on mitigating the impact of ageing by promoting high-quality development of the population, reasonably determining the Government's risk responsibility in coping with ageing, and reasonably formulating fiscal policy related to elderly care and fertility problem, so as to inject more certainty into coping with population ageing.

Key words: Aging Population; Fiscal Policy; Fiscal Risk

I. Introduction

Population ageing is an inevitable trend in China's demographic development. Data indicate that China has now entered a moderately aging society. In 2023, the proportion of China's population aged 60 years and over was 21.1 per cent, and the proportion of those aged 65 years and over was 15.4 per cent. In the coming period, the number and proportion of the elderly population will further increase. At the same time, China's birth population and birth rate show a downward trend. China's population will grow negatively by 2.08 million people in 2023, and the birth rate will drop from 14.03 per thousand in 2000 to 6.39 per thousand in 2023.

The trend of population aging, longevity and sub-replacement fertility will have an impact on all aspects of the economy and society in the future, and this paper tries to analyze the impact of population aging on the sustainable development of finance, and puts forward the ideas of fiscal policy and related policy recommendations to adapt to the trend of population aging.

II. Impact of the trend of population ageing on fiscal sustainability

Population aging will be a norm in our future society. In order to adapt to this development trend, it is necessary to fully understand the impact of population ageing on economic and social development and finance, especially on fiscal revenues, fiscal expenditures and the effects of fiscal policies, as well as the reform

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of the relevant fiscal and tax systems. Overall, population ageing brings more uncertainty to public finance and increases fiscal risks.

(i) Impact of population ageing on fiscal revenues

Relevant studies have shown that the impact of population aging on fiscal revenue is mainly realized through the impact on the economy. And how much population aging will affect the economy or fiscal revenue depends on changes in the structure of labor supply, residents' propensity to save and consumption.

The relevant impact mechanisms are as follows: first, the labor force. When the degree of population ageing exceeds a certain threshold, it will directly lead to a decline in the working population and an increase in the cost of labour, resulting in a slowdown in economic growth and a reduction in the productivity of labour, which in turn triggers a decline in the growth rate of fiscal revenues; The second is residents' savings. Depending on the propensity of residents to save will have a positive or negative impact on fiscal revenues, and is the result of the combined effect of the two. If consumers have a higher propensity to save during their working years and increase their consumption during their retirement years, aging will help stimulate the development of the pension and healthcare industries, which will increase fiscal revenues. If consumers have a higher propensity to save in an aging society for precautionary motives, this will lead to a decline in consumption demand across society and a slowdown in fiscal revenue growth. International experience shows that population ageing significantly reduces the national savings rate and the savings rates of major sectors; The third is consumption. It is in the process of population ageing that there are differences in the changes in consumption of different age structures of the population, and the impact of population ageing on consumption demand is the result of the combined effect of the above changes. It is generally recognized that population ageing will lead to a relative decline in future consumption levels.

Taken together, the impact of population ageing on economic growth is generally negative, i.e., a weaker increase in the level of consumption, which is detrimental to the growth of labour and capital inputs. Correspondingly, the impact of population ageing on fiscal revenues is also negative overall, slowing down the growth of fiscal revenues.

Looking specifically at the quantitative relationship between population aging, economic growth and fiscal revenues in China, the relationship between population aging and fiscal revenues and economic growth in the period 1994-2023 shows an X-shaped relationship, if other factors are not taken into account (see Figure 1). Taking 2007 as the cut-off point, the growth rates of GDP and fiscal revenues increased with the aging of the population before 2007, while the growth rates of GDP and fiscal revenues showed a downward trend with the aging of the population after 2007. Looking more specifically at the relationship between the number of people in the labor force, the old-age dependency ratio, and the growth rate of fiscal revenues, the old-age dependency ratio also shows an X-shaped relationship with the labor force population and the growth rate of fiscal revenues over the period 1994-2022 (see Figure 2), but it differs at the point of intersection. The labor force

population only began to decline in 2015, while the growth rate of fiscal revenues began to decline before that.

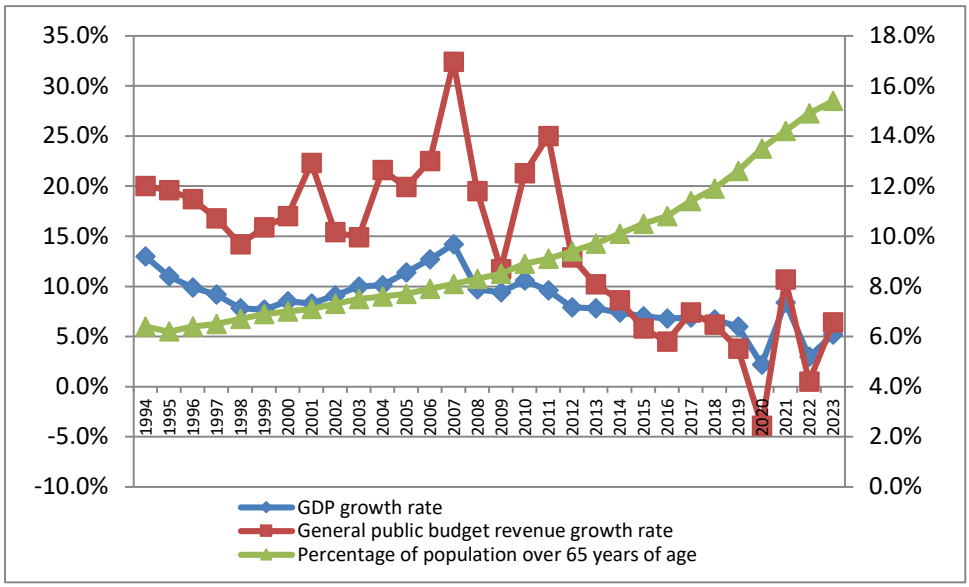

Figure 1 Relationship between population aging and fiscal revenue and economic growth, 1994-2023

Source: China Statistical Yearbook 2023, Statistical Bulletin of the People's Republic of China on National Economic and Social Development 2023.

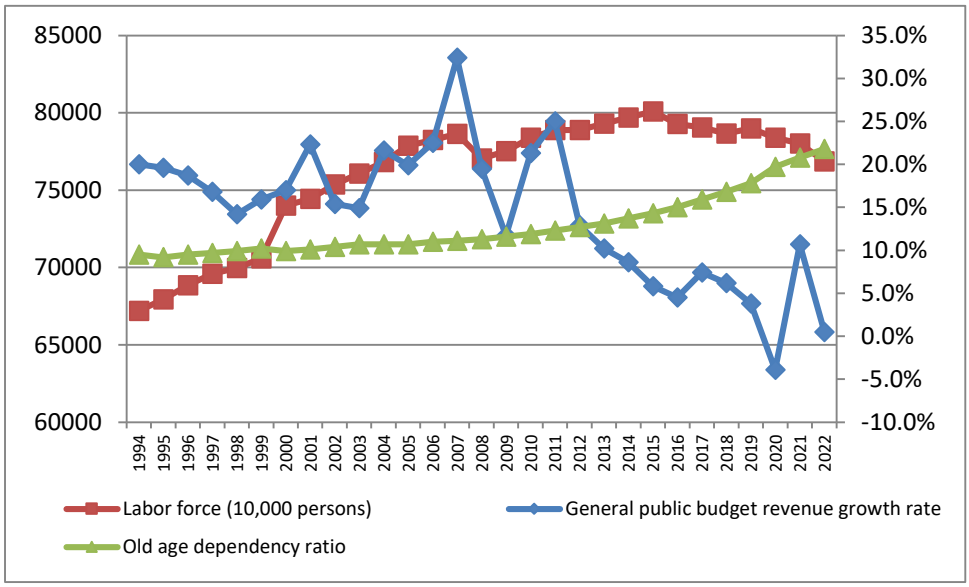

Figure 2 Relationship between the number of labor force, old age dependency ratio and growth rate of fiscal revenue, 1994-2022

Source: China Statistical Yearbook(1995-2023).

(ii) Impact of population ageing on fiscal expenditure

In terms of the impact of population aging on fiscal expenditures, the conclusions of related studies are basically consistent. That is, as the degree of population aging increases, the demand for public services in the areas of old-age

pension, medical care, long-term care and other areas increases, which correspondingly increases the fiscal expenditures in these areas. At the same time, due to the rigidity of fiscal expenditures on old age, medical care, long-term care and other areas, as the level of social security treatment rises, the level of protection for the elderly in all aspects is getting higher and higher, and the related fiscal expenditures related to the elderly are also gradually increasing. The increase in fiscal expenditures under population ageing coexists with a decline in the growth rate of fiscal revenues, which can lead to problems of fiscal sustainability.

Looking specifically at our country, first, the level of fiscal expenditure on pension insurance subsidies will continue to rise. China's basic pension insurance includes three components: basic pension insurance for enterprise employees, pension insurance for public institutions and basic pension insurance for urban and rural residents; the Treasury bears the responsibility of underwriting the fund shortfalls of the first two systems, and bears the responsibility of subsidizing the premiums and the basic pensions of the residents' basic pension insurance. In 2022, the fiscal subsidies to the basic pension insurance fund for enterprise employees, the pension insurance fund for institutions and the basic pension insurance fund for urban and rural residents will be 704.382 billion RMB, 547.901 billion RMB and 333.770 billion RMB, respectively. Judging from the trend of development, the pressure on fiscal expenditure on the aforementioned basic pension insurance is also gradually increasing;

Second, the level of fiscal expenditure on health care inputs for the elderly will continue to rise. As life expectancy increases, medical consumption expenditures and care costs for the elderly will continue to rise, and fiscal subsidies for basic medical insurance, long-term care insurance, and basic public health care for the elderly will all increase. In 2022, fiscal subsidies for the Employees' Basic Medical Insurance Fund and the Urban and Rural Residents' Basic Medical Insurance Fund will amount to 12.749 billion RMB and 623.114 billion RMB, respectively. In addition, in order to encourage employment for the elderly, fiscal expenditure on supporting employment and social participation for the elderly will increase.

Figure 3 gives the relationship between population aging and the growth rate of fiscal expenditure in China from 1994 to 2023. It can be seen that fiscal expenditure also shows an X-shaped relationship with population aging, and there is no tendency for the growth rate of fiscal expenditure to accelerate with population aging. The same result is also found in the growth rate of fiscal expenditures on social security and employment, health and wellness, which are closely related to population aging. This is due to the fact that the growth rate of fiscal expenditures is generally in line with the growth rate of fiscal revenues, but the growth rate of fiscal expenditures on social security and employment, and health and wellness has been greater than the growth rate of fiscal expenditures as a whole since 2013.

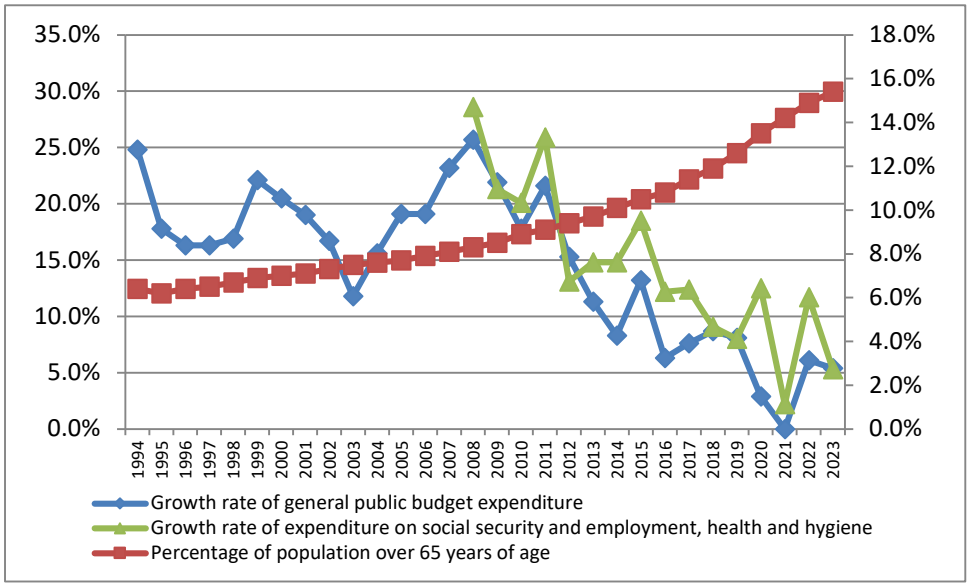

Figure 31 Relationship between population aging and growth rate of fiscal expenditure, 1994-2023

Source: China Statistical Yearbook 2023, Fiscal Expenditures and Revenues 2023, all years.

(iii) Other fiscal implications of population ageing

In addition to affecting fiscal balances and fiscal sustainability, population ageing also has implications for other aspects of finance. Relevant studies show that population aging affects the effects of fiscal policy. For example, Luo Meijuan and Long Teng (2021) argue that the impact of population aging on the effect of fiscal stimulus is not significant during periods of economic expansion. The positive effects of government fiscal stimulus on individual consumption and on private investment and employment during economic contraction are weaker in aging societies relative to non-aging societies.

Population ageing also affects some tax types and tax systems. Population ageing can lead to changes in the structure of different tax types and tax bases through its impact on the structure of income, savings and consumption. Population aging means that more working-age people leave the labor market, leading to an increase in the cost of labor for the whole society as well as a shrinking of the individual income tax base, thus reducing the tax contribution to the treasury. For example, Duan Huixin and Zhao Weimin (2022) concluded through empirical results that population aging has an obvious inhibitory effect on personal income tax revenues, with the most obvious weakening on wage and property personal income tax.

III. Fiscal policy ideas to adapt to the trend of population ageing

Population aging is an irreversible inevitable phenomenon and social reality in China in a long period of time. Instead of dealing with population aging, fiscal policy should be adapted to population aging. In this regard, fiscal policy should focus on mitigating the impact of ageing by promoting high-quality development of the population, reasonably determining the Government's risk responsibility in coping

with ageing, and perfecting fiscal policy that adapts to the trend of ageing and promotes high-quality development of the population, so as to inject more certainty into adapting to the ageing of the population.

(i) Fiscal policy should be geared towards promoting high-quality development of the population

From a dynamic perspective, population ageing is a dynamic process in which the proportion of older persons in the total population is increasing. However, population ageing does not necessarily mean that the demographic dividend will be lost, because the demographic dividend involves not only the total amount of the workforce, but also the quality of the workforce and involves the number of talented people. With population ageing becoming a norm, the focus is on the need to consider the issue of upgrading the quality of the population and the level of human capital in the light of China's actual national conditions, thereby achieving a balanced demographic structure. At the same time, with the development of digitalization, the perspective of analyzing purely from the quantity of labor force is no longer adapted to the new stage of economic and social development. On the one hand, it is still possible to slow down the decline of the labor force population under longevity by implementing gradual delayed retirement, etc. On the other hand, it is also possible to improve the quality of births and the quality of upbringing under sub-replacement fertility. In other words, fiscal policy needs to adapt to and mitigate the effects of ageing by promoting quality population development.

In adapting to the aging of the population and sub-replacement fertility, fiscal policy should lead the paradigm shift from "object-oriented" to "people-oriented", organically integrating the focus of fiscal policy with the comprehensive development of human beings, and effectively solving the problem of allocating public service resources attached to the identity of people of different ages, so as to better play a leading role in coping with the trend of population aging. To integrate the focus of fiscal policy with comprehensive human development, effectively address the allocation of resources for public services attached to the status of people of different ages, and give better play to the pioneering, stabilizing and safeguarding roles of finance in responding to the trend of population ageing.

As population ageing has implications for all age groups, fiscal policy should not focus solely on increasing the level of welfare for the elderly. Fiscal policy should start from the goal of the safe, harmonious and sustainable operation of an ageing society, focusing on the problem of elderly care and fertility and taking into account the relationship between different groups of people, including the old, the middle-aged, the young and the young. At the same time, fiscal policy should promote the high-quality development of the population through the establishment of an effective mechanism for "intergenerational equalization".

(ii) Rationalizing fiscal responsibility for risks in coping with ageing

Today's society is a risky society, and the trend of population aging also adds uncertainty and risk to the risky society. Population aging not only involves the risk of longevity in old age, but also involves the risk of sustainable fiscal operation. From the perspective of public risk, the government or the treasury needs to intervene in

the public risk formed by the spillover of individual risk. For this reason, in the process of population ageing in China, it is necessary to clarify the risk responsibilities of the Government, enterprises and individuals in areas related to population ageing, and to make clear the risk responsibilities that the Government should bear, so as to inject more certainty into the adaptation to population ageing.

From the perspective of the areas involved in population ageing, such as old-age pension, medical care, long-term companionship, childbirth and childcare, there is a need to rationally determine the positioning of finance in them. For example, the reform of the pension insurance system, including basic pension insurance, enterprise (occupational) pensions and individual pensions, involves the handling of the responsibility relationship between the Government, enterprises (units) and individuals (families), and it is necessary to clarify the responsibility of each party in terms of the risks associated with the reform, and to clarify the responsibility and positioning of the treasury in the reform of the pension insurance system. In this regard, a self-balancing mechanism for the basic pension insurance fund can be improved, limiting fiscal responsibility to a certain extent, and the structure of fiscal expenditure can be adjusted proactively and in a timely manner to appropriately increase fiscal input. Similarly, with regard to medical insurance, as the population ages, the proportion of the elderly in the use of medical insurance funds will gradually increase, and there is also a need to further clarify the responsibility and positioning of the fiscal sector in medical insurance.

(iii) Coordination of fiscal policy and other economic and social policies in the context of population ageing

The impact of population ageing not only involves the operation of finance, but also permeates all areas of the economy and society, and the response to population ageing is even more a complex systematic project. Therefore, under the premise of strengthening the integration and coordination of population and economic and social issues, it is not only necessary to intervene at the level of fiscal policy, but also necessary to consider the adjustment and improvement of fiscal policy from the perspective of the entire economic and social policy, as well as to strengthen the coordination between fiscal policy and other policies. The coordination of fiscal policy with population policy, financial policy, industrial policy and employment policy will contribute to the formation of an economic and social policy system that is in line with the trend of population ageing.

IV. Relevant Policy Recommendations

Based on the population trends in China for the new era, and in accordance with the goal of promoting the high-quality development of the population, we should make a forward-looking prediction of the sustainable impact and risks of the treasury under the aging of the population, promote the reforms of the various fiscal and tax systems in phases in accordance with the actual situation, and reasonably formulate the relevant fiscal and tax policies, so as to further enhance the ability to cope with the trend of aging.

(i) Examining the fiscal risks associated with population ageing

The public finance is the end of general risk taker, and the risks arising from population ageing will be ultimately borne by the Treasury. For this reason, it is necessary to reasonably study the impacts and risks of population ageing on the treasury in a phased manner, paying attention not only to the sustainability risks of government's revenues and expenditures brought about by population ageing, but also to the risks arising from other aspects.

Firstly, we should study and judge the negative impact of population aging on macroeconomic growth, as well as the changes in tax base structure and tax sources brought about by the impact of income, savings and consumption structure, and effectively adapt to the impact of population aging on revenues through the reform of tax and other income systems; secondly, we should study and judge the increase in expenditures that may be caused by population aging, with a focus on making good estimates of the demand for fiscal expenditure items such as basic pension insurance, basic medical insurance and basic pension services, and taking reasonable measures to safeguard them on the basis of clear expenditure demand; Thirdly, it is necessary to study the effects of relevant fiscal and taxation policies and formulate fiscal and taxation policies that adapt to the trend of population ageing, so as to avoid the weakening of the effects of the policies; Fourth, it is necessary to study the different manifestations of the effects and risks of population ageing in regions and between urban and rural areas, and pay attention to such issues as the imbalance of fiscal resources between regions and the imbalance of inputs between urban and rural areas.

(ii) Promoting the reform of the fiscal and tax system to adapt to the trend of population ageing.

The fiscal and tax system is an important basic system for promoting the long-term balanced development of the population, and not only do a good job of guaranteeing fiscal funds and fiscal and tax policies, but also reform the fiscal system, fiscal system and fiscal mechanism to adapt to the aging of the population, so as to promote a better and faster realization of the goals of promoting the long-term balanced development of the population. Effective breakthroughs in fiscal systems, institutions and mechanisms will provide basic institutional support for the process of adapting to the ageing of the population and further enhance the fiscal capacity to cope with the ageing of the population.

At present, China has put forward the strategic plan of "planning a new round of fiscal and tax system reform". The new round of reform of the fiscal and tax system needs to take full account of the trend of population ageing and make it an important prerequisite for reform. For example, from the point of view of social insurance, which is the main area involved in population ageing, the reform of the social insurance system should become an important element of the new round of reform of the fiscal and tax system.

(iii) Focusing on improving fiscal and tax policies to promote high-quality development of the population

With regard to the key issues involved in population ageing, such as elderly care and fertility problem, it is necessary to focus on the need to promote the high-quality

development of the population, and to continue to improve the relevant fiscal and tax policies in the areas of elderly care, childbearing and education, so as to play a more effective role in the regulation of policies.

First, improving fiscal and tax policies on pension insurance and services, and reducing the fiscal pressure on old-age security. In order to reduce the fiscal pressure of increased expenditure on old-age protection, it is recommended to build a high-quality and full-employment work system, stabilize the labor participation rate of key groups, implement delayed-retirement reforms at an appropriate time, and actively promote the employment of the elderly; adapt to the structural transformation of the needs of the elderly, cultivate the development of the silver-hair economy, and combine the enhancement of the well-being of the elderly with encouragement of consumption upgrading of the elderly population and the expansion of domestic demand; and accelerate the construction of a multi-level and multi-pillar pension insurance system and increasing the reserves of pension wealth for the whole society.

In terms of tax and other incentive policies, it is suggested that while improving the tax policies related to the "three-pillar" pension insurance system, the tax incentives for pension services and pension protection products should be further improved to support the development of the silver-hair industry, promote ageing-appropriate scientific and technological innovations in related fields, and promote the research and development and production of pension appliances, as well as the integration of medical care and nourishment, construction of facilities such as smart elderly care, popularization of community care for the elderly, and tourism service facilities for the elderly.

Secondly, improving the fiscal and tax policies for promoting fertility. China has decided to optimize its fertility policy to promote the long-term balanced development of the population. From an international perspective, although fiscal and tax policies to promote fertility do not necessarily achieve the effect of raising fertility levels, fiscal and tax incentives are still needed to slow the decline in fertility, and related fiscal and tax policies for fertility have become a common international practice. It is necessary to construct a reasonable mechanism for sharing the costs of childbearing through the improvement of childbearing support policies, such as fiscal incentives and tax concessions, and to emphasize the accessibility and affordability of childbearing and childcare services. At the same time, the development of a system of universal childcare services should be supported through fiscal and tax policies, and the supply of services should be continuously optimized and the level of services constantly upgraded.

Thirdly, further improving education-related fiscal policies. An important way to improve the quality of the population and strengthen the accumulation of human capital is education, and the construction of a strong education nation should be insisted on as a strategic project for the high-quality development of the population, so as to comprehensively improve the quality of the population's science and culture, health, ideology and morality. In this regard, it is necessary to respond to an ageing and childless society, deepen the reform of the fiscal system and mechanism for

education, adjust the structure of education funding, restructure education funding, increase spending on pre-school education, and provide strong support for the development of vocational education, so as to realize the universal sharing of high-quality education resources, cultivate innovative talents, and build a learning society.

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Ageing, Health Needs and Financial Coverage: Some Insights from the Philippines

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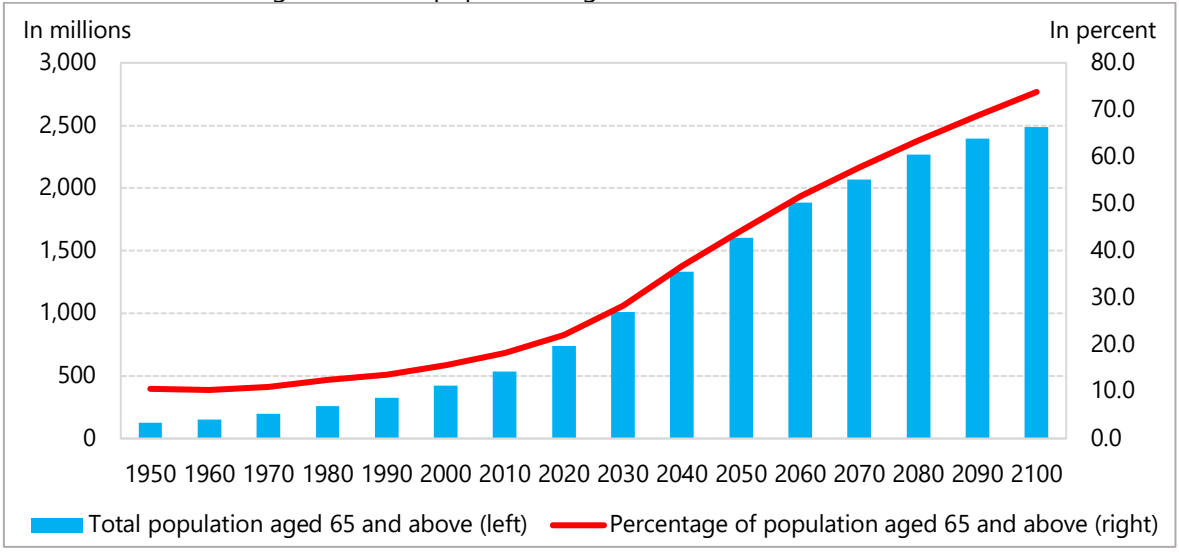
1. Introduction

The world's population is ageing. Almost every country is seeing the percentage of people aged 65 years or above in their population increasing at a faster rate than those of younger age.[1] The proportion of this age cohort to global population is expected to more than double from 761 million in 2021 to 1.6 billion in 2050 (Figure 1). By 2050, the number of individuals aged 65 years or above across the world will be twice the number of children under age 5 and almost equivalent to the number of children under 12 years (UN DESA, 2022). The ageing trend is deemed as one of the most significant social transformations of the 21st century (UN, n.d.). It is considered irreversible and can have wide-ranging implications for countries. It affects nearly all sectors of society, including labor, demand for goods and services, financial markets, insurance and pension systems as well as family structures.

Figure 1 World population aged 65 and above: 1950 – 2100*/



**/ Population estimates for 1950 – 2021 and projections using medium fertility variant for 2022 – 2100.*
Source of data: United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022, Online Edition.

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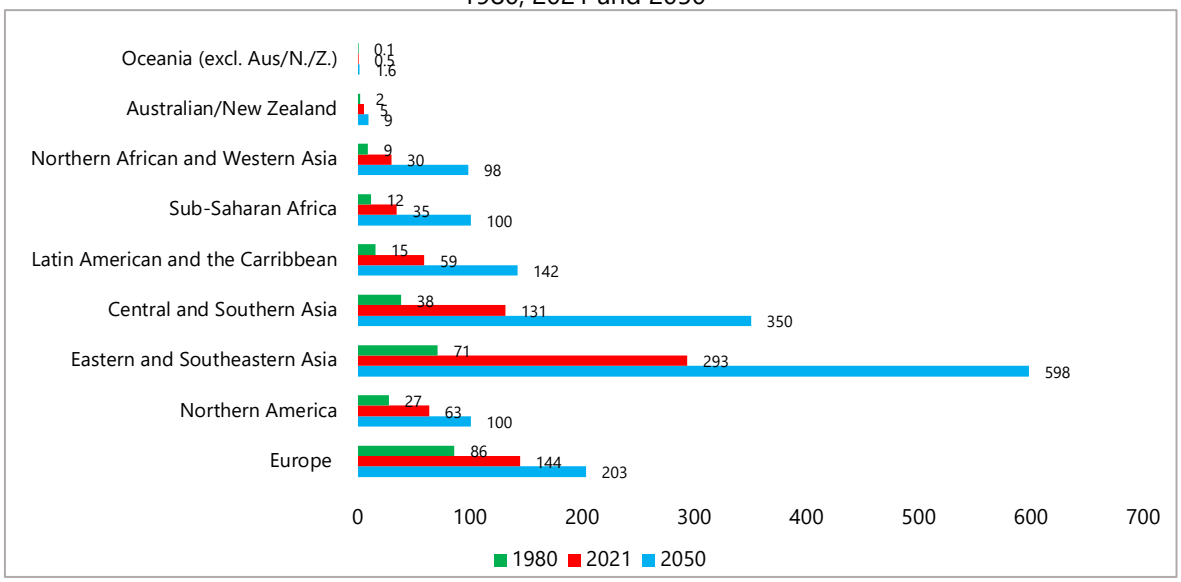
Disclaimer: The views expressed in this paper are those of the authors and do not represent the official position of the Bangko Sentral ng Pilipinas.

[1] The United Nations uses chronological age to determine age groups, typically defining an "older person" as being aged 60 or 65 years and older (UN DESA, 2020).

Lower mortality rates, longer life spans and continued decline in fertility rates have been cited as key contributing factors to the shift in the population distribution towards the older ages. People are able to have longer and healthier lives given the advances in medical science and better health care systems. Moreover, access to better education and family planning allowed women to participate more in the labor market and pursue their own careers paths. This led to lower fertility rates and smaller family sizes.

In 1980, Europe accounted for 10 of the countries with the oldest populations and for 86 million of the world's total aged population. By 2050, the geography of the world's oldest population is expected to shift from Europe to Eastern and Southeast Asia. The latter region is projected to comprise an estimated 598 million of the global population of people aged 65 and above and to have 5 of the 10 countries with the oldest populations in the world.

Figure 2 Total number of people aged 65 and above in the world and by regions, in millions: 1980, 2021 and 2050*/

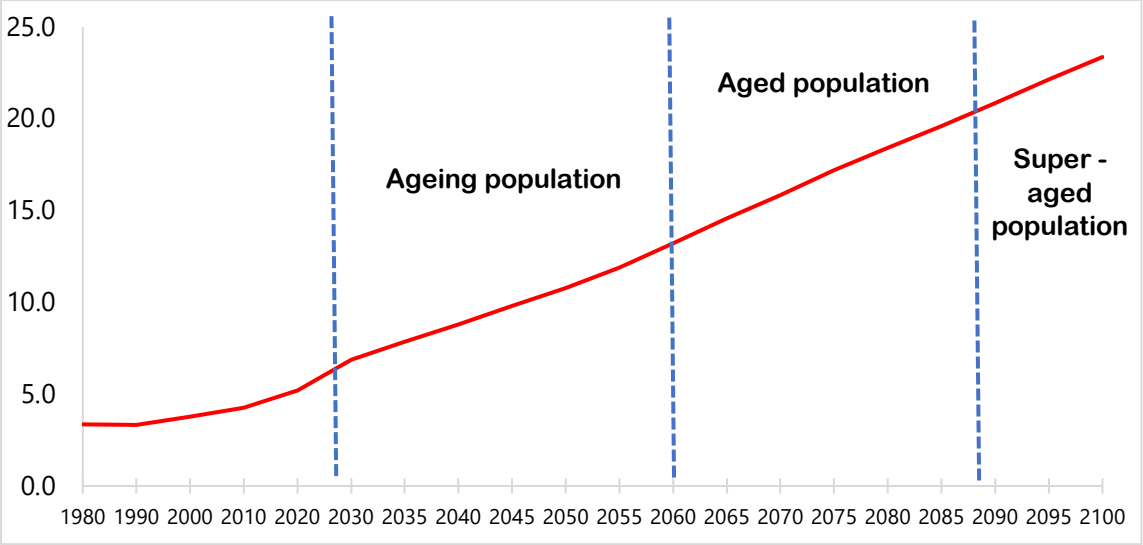


*/ Population estimates for 1980 and 2021; projections using medium fertility variant for 2050.
Source of data: United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022, Online Edition.

Similar to the global trend, the Philippines is also experiencing an increasing share of older people in its population. According to UN DESA (2022), the country is expected to have an ageing population by 2031 (i.e., at least 7 percent of the population is aged 65 and above) and, in due course, become an aged society by 2063 (i.e., at least 14 percent of the population is aged 65 and above).[2]

[2] Demographic researchers classify countries into four categories based on the share of the aged 65 or above in the population. These are young (less than 7 percent), aging (7 – 13 percent), aged (14 – 20 percent), and super-aged (more than 21 percent) (Miksa, 2015).

Figure 3 Proportion of aged 65 and above in the population: Philippines 1980 – 2100*/



**/ Population estimates for 1980 and 2021; projections using medium fertility variant for 2050.*
Source of data: United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022, Online Edition.

We present in this research note the current situation of the Filipino elderly with regard to their economic and health status. Additionally, we assess whether they are financially protected in terms of their capability to sufficiently cover their essential needs, particularly their health and medical needs. We also document the various policies and programs that are being implemented to assist the older people in the country. We offer some policy recommendations to improve the conditions of the older people in the Philippines.

2. Situationer on the elderly in the Philippines

The Expanded Senior Citizens Act (RA 9257) defines senior citizens in the Philippines as those aged 60 or above. Based on the 2020 Census of Population and Housing (CPH) by the Philippine Statistics Authority (PSA), there are an estimated 9.2 million senior citizens in the country, with the females outnumbering the males by a million (Table 1). The number of senior citizens in the country increased by 22.4 percent in 2020 relative to those registered in the 2015 Census of Population.

Table 1 Number and percent to all ages of household population and sex ratio by selected age group: Philippines, 2015 and 2020

Age groups/year	Number (in millions)			Percent to all ages (%)			Sex ratio
	Both sexes	Male	Female	Both sexes	Male	Female	
				2020			
All ages	108.7	55.0	53.6				
0 – 4 years	11.1	5.7	5.4	10.2	10.4	10.0	107
0 – 14 years	33.4	17.3	16.1	30.7	31.4	30.1	107
5 – 24 years	42.8	22.0	20.8	39.4	39.9	38.8	106
15 – 30 years	31.4	16.0	15.4	28.9	29.1	28.7	104
15 – 49 years	57.0	29.1	27.9	52.4	52.9	51.9	105
15 – 64 years	69.4	35.3	34.1	63.9	64.1	63.6	103
18 years and over	68.9	34.5	34.4	63.4	62.7	64.2	100
60 years and over	9.2	4.1	5.1	8.5	7.5	9.5	80
65 years and over	5.9	2.5	3.4	5.4	4.5	6.3	73
				2015			
All ages	100.6	50.8	49.8				
0 – 4 years	10.8	5.6	5.2	10.8	11.0	10.5	10.7
0 – 14 years	32.1	16.6	15.6	32.0	32.7	31.2	107
5 – 24 years	40.8	20.9	19.9	40.6	41.2	40.0	105
15 – 30 years	29.4	14.9	14.5	29.2	29.4	29.1	103
15 – 49 years	52.9	26.9	26.0	52.6	52.9	52.2	103
15 – 64 years	63.7	32.2	31.5	63.3	63.4	63.2	102
18 years and over	62.3	31.0	31.2	61.9	61.1	62.7	99
60 years and over	7.5	3.3	4.2	7.5	6.6	8.5	79
65 years and over	4.8	2.0	2.8	4.8	3.9	5.6	72

Sources: Philippine Statistics Authority (PSA), 2020 Census of Population and Housing and 2015 Census of Population

Senior citizens accounted for 8.5 percent of the household population in 2020, higher than the 7.5 percent (7.5 million) recorded in 2015. It is projected that the percentage of senior citizens to total population will increase to 11.1 percent by 2030 and to 19.6 percent by 2055.[3,4] An underpinning factor for the projected increase in senior citizens is the predicted gains in life expectancies. In 2020, life expectancies at birth for males and females at birth were 66.2 years and 73.3 years, respectively. By 2050, the estimated life expectancy at birth for males is 74.6 years and for females is 81.3 years; representing gains of 8.4 years for males and 8.0 years for females from 2020. With an increase in the number of senior citizens, the aging index in the Philippines (i.e., the proportion of persons aged 60 years and over per 100 persons under the age of 15 years) rose by 4.2 points in 2020 to 27.6 percent from 23.4 in 2015.

[3] Based on the assumption that the national total fertility rates (TFR) of 1.9 children in 2021 will be sustained until 2055.

[4] For comparison purposes with UN data, the PSA projects that the share of Filipinos aged 65 or above will increase from 5.4 percent to 2020 to 7.4 percent in 2030 and to 14 percent in 2055.

Almost 96 percent of senior citizens in the country are considered literate in that they can read and write simple messages in Filipino (the national language) or in the dialects. Majority of them have at least elementary level as their highest level of education.

The COVID-19 pandemic affected all sectors of society. However, its severity was felt more by vulnerable groups like the elderly. The pandemic exacerbated existing inequalities and heightened concerns over access and adequacy of social safety nets for older people. Moreover, mobility restrictions and lockdowns implemented during the COVID-19 pandemic resulted in mental health issues for older people (Banerjee, 2020; De Leo and Trabucchi, 2020; Liotta et al., 2020; Meng et al., 2020). During the pandemic, Filipino senior citizens faced important challenges including insufficient income sources, difficulties in accessing essential needs, lack of physical space and negative perceptions (Capahay, 2021).

The impact of the COVID-19 pandemic on the economic status of Filipino senior citizens is reflected in increases in the magnitude of poor elderly and in the poverty and subsistence incidence indicators for the older age cohorts following the pandemic. Based on the 2021 Family Income and Expenditure Survey (FIES), the number of senior citizens with per capita income less than the per capita poverty threshold (i.e., magnitude of poor senior citizens) rose to 1.02 million in 2021 from 0.83 million in 2018 (Table 2). Nonetheless, the latest figure is still lower than the 1.13 million recorded in 2015. Relatedly, the poverty incidence among Filipino senior citizens, or the proportion of senior citizens to the total number of senior citizens with per capita income less than the per capita poverty threshold, increased to 10.3 percent in 2021 compared to 9.1 percent in 2018. Meanwhile, the share of senior citizens to the total number of senior citizens with per capita income less than the per capita food threshold (i.e., subsistence incidence) declined to 2.2 percent in 2018, lower than the 4.7 percent registered in 2015. However, the subsistence incidence increased to 2.8 percent in 2021 following the COVID-19 pandemic.

Table 2 Poverty statistics and subsistence incidence among Filipino senior citizens: 2015, 2018, 2021

Indicators	2015	2018	2021
Magnitude of poor senior citizens (in million)	1.13	0.83	1.02
Poverty incidence among senior citizens (percent)	14.4	9.1	10.3
Subsistence incidence among senior citizens (percent)	4.7	2.2	2.8

Source: Preliminary results of the 2021 Family Income and Expenditure Survey (FIES)

The growing share of senior citizens in the population involves an increasing demand for health care and related services. It also puts focus on the importance of social security, insurance and pension to meet the needs of senior citizens. Using the Bangko Sentral ng

Pilipinas (BSP) 2018 Consumer Finance Survey (CFS)[5], Cacnio et al. (2023) assessed how financially protected are the senior citizens in the Philippines in terms of social security coverage. They find that social security coverage in the Philippines has improved over the past decade. However, the ageing rate outpaces the rate of increase in social security coverage. Most of the survey respondents receive insurance and pension benefits that are just enough to meet their minimum basic food needs. Senior citizens often suffer from various health conditions, take different maintenance medications and interacts more with health care providers (Reyes et al., 2019). Accounting for the health and medical needs for the Filipino elderly increases the gap between their social security coverage and expenses.

3. Data and methodology

In this section, we assess whether Filipino senior citizens are able to cover their basic health and medication needs. We use a unique data set coming from the PSA's 2018 FIES and the Department of Health's 2018 Electronic Drug Price Monitoring System (EDPMS) which includes a 40,505 sample of senior citizens (i.e., 60 years old and older) and 580,135 reported quarterly medicine prices from 3,618 sample drugstores nationwide, respectively. The 2018 data is used to match the results of the baseline Longitudinal Study of Ageing and Health in the Philippines (LSAHP) conducted in the same year. We also used the most updated Clinical Practice Guidelines (CPG) of physicians and pharmacists on prescribing and dispending medicines to identify the drug of choice for each type of disease.

3.1 Creating a profile of a Filipino senior citizen

To answer our research question, we created a representative of a typical senior citizen in each region of the Philippines. We provided some differentiation by considering if they have private, government, and no social security pension.

3.1.1 Identifying the healthcare condition of a typical senior citizen

To be able to calculate the basic medication needs of the aged population, we use the top 5 diagnosed illnesses of the Filipino population 60 years old and older noted in the LSAHP. These are Hypertension (45.5%), Diabetes (12.6%), Angina/Myocardial infarction (12.2%), Renal or urinary tract ailments/kidney (11.8%), and Respiratory Illness (asthma, emphysema) (8.5%). The residual percentage from these values are considered not having any type of these illnesses. Since these conditions require maintenance medicines that they need to take at least once a day, we assumed that these are their basic and most necessary healthcare expense. We then used the CPG for each illness mentioned above to identify which are the usual medicines prescribed. We also took the least number

[5] The BSP CFS is a nationwide triennial survey that covers the financial state of households. It asks questions on households' financial and nonfinancial assets (e.g., savings, investment, debts, real property, income, and expenditures). The 2018 BSP CFS surveyed a total of 14,860 households.

of frequency/ies each medicine is required to be taken. According to the CPG and upon validation from a practicing physician and pharmacist, we listed the following medicines that are usually given to each type of disease in Table 3. We also included a conservative frequency and of taking laboratory tests and consultation from a physician that each senior citizen needs to follow to update their prescription or medical records.

Table 3 List of medicines and frequency per illness according to Philippine Clinical Practice Guidelines.

Illness	Active Pharmaceutical Ingredient	Usual Frequency (times per day)
Hypertension	Losartan	1
	Carvedilol	2
Diabetes	Metformin	2
Angina	Isosorbide Mononitrate	1
Myocardial Infarction	Aspirin	1
	Clopidogrel	1
Renal or urinary tract ailments/kidney	Ketoanalogues	3
Respiratory Illness (Asthma, Emphysema)	Salbutamol	3
	Laboratory Test	Once every 3 months
	Consultation	

Sources: Philippine Clinical Practice Guidelines and interview with a physician and a pharmacist.
** Note that this list only includes the usual first-line drugs to manage these illnesses. It does not include other types which might be more targeted or with special mechanisms of action for specific needs.*

3.1.2 Computing for the annual basic medical cost of a typical senior citizen

We computed the annual basic medical cost using the following cost function equation.

$$C_m = (F_{l,c} + \sum_{i,j=1}^{n} (wvQ)_{i,j})\ x\ 365$$

Wherein C_m is the total annual basic cost of medical needs; $F_{l,c}$ is the fixed cost of the standard laboratory test and consultation fee; w is the weight indicated by the percentage of the population of having an illness i; and v is the variable cost on the quantity Q based on the usual frequency of drug j associated to i.

3.1.2 Building the senior citizen's income statement

Since the FIES is a good representation of the entire population, we computed for the average and median annual income and expenses of senior citizens in each region. This includes their age, total income (i.e., includes salary,

wage, remittance, pension, etc.), total expenditure (i.e., includes food, healthcare, and other non-food expenses), and net income.

We also computed for the regional median prices of medicines using the EDPMS. Since there are branded, generic, and combination of medicines available in the market, we aggregated each group of drugs based on their Active Pharmaceutical Ingredient (API) or the main component of the drug that is responsible for managing a certain condition. The use of the median price is to account for some high value medicines which are outliers particularly those that are considered branded or innovator drugs.

3.2 Can Filipino senior citizens financially cover their basic medication needs?

Annexes 1, 2, 3 and 4 provide the computed income statements. Based on these, Filipino senior citizens across all regions, on average, can afford their annual expenses (including medication needs) only if they are receiving additional income (e.g., wages or remittances). The annual basic medication needs of senior citizens are about 30 percent higher than the average pension, two times higher for the average private pension, and about 35 percent of the average government pension. Those without pension are solely relying on wages and remittances to cover their expenses. By incorporating food and other non-food expenses, Filipino senior citizens might not financially cover their basic medication needs.

However, it is worth noting that despite government pension being able to cover the computed basic medication costs of a Filipino senior citizen, only about 10 percent of the sample population in the 2018 FIES are under the Government Service Insurance System (GSIS). Private pensioners under the Social Security System (SSS) account for about 24 percent, and majority of the sample at around 66 percent are not covered by any of these two major social security establishments. Thus, a large share of Filipino senior citizens continues to work or engage in income generating activities to augment their incomes. Others depend on the remittances that they receive to meet their annual expenditure needs.

4. Policies and Programs for Filipino Senior Citizens

There are several government legislations and social protection programs for senior citizens in the Philippines (Table 4). These policies and programs aim to ensure that Filipinos 60 years old and older are provided with the necessary support, privileges, and benefits.

Table 4 Policies and Programs for Filipinos at least 60 years old

Policy/Program	Entitlements
Republic Act (RA) 9994 or the Expanded Senior Citizens Act of 2010	1. All Filipinos aged 60 years old and above are entitled to 20 percent discount and exemption from value added tax (VAT), if applicable[6], on the sale of goods and services from all establishments. 2. Exemption from the payment of individual income taxes who are considered minimum wage earners. 3. Grant of a minimum of 5 percent discount relative to the monthly utilization of water and electricity supplied by the public utilities, provided that the individual meters are registered under the name of the senior citizen. 4. Non-contributory pension for Indigent Senior Citizen in the form of monthly stipend.
Contributory pension to GSIS and SSS	Retirement benefits from the government (GSIS) or private (SSS) social security institutions, if applicable.
Mandatory coverage under PhilHealth	The National Health Insurance Program provides mandatory coverage for senior citizens to ensure affordable, acceptable, available, and accessible health care services.
Other Government Assistance (as amended by RA 11916)	The government shall provide the following assistance to senior citizens: employment, education, health, social services, housing, access to public transport, incentive to foster care, and other social safety nets

While these policies and programs are already in place, Reyes, C.M., et al. (2019) noted the need to improve the access of senior citizens to their rights and privileges. Female senior citizens and members from the lower deciles have low access to these programs. At the same time, not all senior citizens are aware of such existence of these policies put in place by the government.

[6] VAT is 12 percent. Senior discount is only applied to VAT-exempt sales from goods and services provided by VAT-registered establishments.

5. Some concluding thoughts

The Philippines is no exception when it comes to the ageing population trend observed in various countries. Such development can have extensive implications for the country. The increasing share of senior citizens (i.e., aged 60 years and above) in the Philippine population involves an increasing demand for health care and related services. It also puts pressure on social security, insurance and pension to meet the needs of the aged population. Previous studies have shown that the insurance and pension benefits of Filipino senior citizens are just enough to meet their minimum basic foods needs. Senior citizens often suffer from various health conditions, take different maintenance medications and interacts more with health care providers. Accounting for these kinds of expenses increases the gap between the social security coverage of senior citizens and their needs. In our analysis, we find that Filipino senior citizens are able to afford their annual expenses (including their medication needs) only if they are receiving additional income (e.g., wages or remittances). Solely relying on their pension incomes will not suffice to meet their needs.

There are several social protection programs and policies for senior citizens in the Philippines. These policies and programs aim to ensure that Filipinos 60 years old and older are provided with the necessary support, privileges, and benefits. Nonetheless, there is room to improve these policies and program to better address the needs of senior citizens, including improving access, raising awareness of these programs and ensuring their timely delivery. It has been observed that female senior citizens and those from lower deciles have low access to these programs. The government should ensure that these groups are able to benefit equally from these policies and programs. There is also a need to increase awareness about these programs. Importantly, the government should ensure the timely delivery of the benefits from these programs. Social pension constitutes, on average, almost one-third of senior citizen's household income used for food, medical costs and other household expenses.

The ageing trend is deemed irreversible and mitigating its potential effects on societies and economies entail policy interventions that would strengthen the social and financial security of older people and ensure that are able to have healthy and fulfilling lives.

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Annexes

A.1 Average Annual Income Statement of the Filipino Senior Citizens, by Regions
(in Philippine Peso)

Region	Ilocos	Cagayan	C. Luzon	CALA BARZON	Bicol	W. Visayas	C. Visayas	E. Visayas	Zamb.	N. Mindanao	Davao	SOCC SKARGEN	NCR	CAR	BARMM	CARAGA	MIMA ROPA
Average Age	70	69	69	68	70	70	69	70	68	69	69	68	68	69	67	69	69
INCOME																	
Wages	43,350	46,500	85,835	95,700	26,950	50,388	59,272	24,000	30,000	48,182	46,800	39,130	196,872	47,975	-	36,960	26,750
Remittance (abroad)	66,978	33,960	48,449	39,703	17,183	41,786	41,986	24,320	21,440	28,370	17,784	24,107	34,726	27,908	10,898	19,723	21,712
Remittance (domestic)	22,855	17,973	16,906	19,752	29,429	22,948	22,702	28,003	23,864	18,978	18,086	17,923	16,508	20,570	10,023	21,005	27,119
Pension	25,614	15,511	24,416	32,830	21,931	27,969	28,558	24,516	21,651	27,811	17,388	16,433	36,351	26,545	4,218	25,295	17,730
Gov't	92,783	75,135	71,395	90,843	42,953	30,880	84,275	97,462	106,809	34,417	74,364	58,665	50,699	95,073	43,884	59,044	82,747
Private	27,444	37,021	42,308	52,264	18,912	24,023	44,203	67,973	32,766	49,280	38,734	20,958	39,253	33,773	53,306	14,397	33,773
Others																	
Total Income	**309,436**	**278,203**	**352,694**	**368,912**	**232,828**	**300,059**	**333,269**	**248,403**	**251,120**	**265,382**	**235,213**	**255,898**	**494,894**	**320,853**	**166,900**	**240,752**	**245,102**
EXPENSES																	
Food	86,402	73,397	114,226	105,668	83,397	87,451	80,951	79,121	75,241	76,841	73,395	82,105	135,043	75,324	74,393	77,949	71,711
Non-Food	113,357	96,741	168,561	175,999	104,611	130,906	132,641	111,195	86,302	110,798	84,411	104,155	246,229	122,921	51,599	106,219	93,556
Med. Cost*	26,019	21,625	21,967	17,911	22,320	18,472	20,623	26,082	22,072	23,826	22,571	21,368	20,951	24,437	19,694	18,242	21,616
Others																	
Total Expenditure	**199,759**	**170,137**	**282,787**	**281,667**	**188,008**	**218,357**	**213,592**	**190,316**	**161,544**	**187,639**	**157,806**	**186,260**	**381,272**	**198,245**	**125,992**	**184,169**	**165,268**
Net Income	**109,677**	**108,066**	**69,907**	**87,245**	**44,820**	**81,702**	**119,677**	**58,087**	**89,576**	**77,743**	**77,407**	**69,638**	**113,622**	**122,608**	**40,908**	**56,583**	**79,834**
Net Income (less wage, remittance)	**(24,506)**	**(2,367)**	**(141,283)**	**(131,714)**	**(32,342)**	**(50,610)**	**(43,283)**	**(18,236)**	**10,272**	**(44,787)**	**(21,763)**	**(23,222)**	**(309,134)**	**26,155**	**19,987**	**(21,105)**	**4,253**

Sources: 2018 Family Income and Expenditure Survey, Authors' Computation
**Med. Cost is the computed annual basic medical cost of a typical Filipino senior citizen*
***Other income and expenses were not accounted to condense the income statement.*

Annex A.2 Average Medical Annual Income Statement of the Filipino Senior Citizens with Private Pension, by Regions
(in Philippine Peso)

Region	Ilocos	Cagayan	C. Luzon	CALA BARZON	Bicol	W. Visayas	C. Visayas	E. Visayas	Zamb.	N. Mindanao	Davao	SOCC SKARGEN	NCR	CAR	BARMM	CARAGA	MIMA ROPA
Average Age	71	71	71	69	72	71	70	71	70	70	69	69	70	70	69	71	70
INCOME																	
Wages	99,580	121,136	146,594	187,418	89,002	97,045	155,532	131,870	102,346	130,106	115,704	93,638	255,962	129,857	65,551	77,869	70,656
Remittance (abroad)	69,820	36,207	62,594	54,597	18,998	46,678	63,690	34,170	25,128	45,766	32,250	26,056	40,436	42,394	13,298	20,153	40,380
Remittance (domestic)	23,739	20,199	18,027	19,419	29,163	22,542	19,885	30,053	22,731	21,381	16,116	19,886	16,837	21,641	12,520	20,839	30,197
Priv. Pension	27,444	37,021	42,308	52,264	18,912	24,023	44,203	67,973	32,766	49,280	38,734	20,958	39,253	33,773	53,306	14,397	33,773
Others																	
Total Income	**334,897**	**327,307**	**428,411**	**475,214**	**250,751**	**313,782**	**473,338**	**426,630**	**354,611**	**402,698**	**347,873**	**271,106**	**536,836**	**401,813**	**217,176**	**217,707**	**319,831**
EXPENSES																	
Food	84,926	76,368	120,175	116,277	86,673	90,370	97,632	100,252	81,393	96,221	89,263	82,483	135,928	78,740	81,773	72,413	79,522
Non-Food	128,324	114,546	209,471	237,716	117,067	144,366	216,626	202,664	115,880	183,507	129,431	114,102	273,229	169,648	81,464	94,217	136,072
Med. Cost	26,019	21,625	21,967	17,911	22,320	18,472	20,623	26,082	22,072	23,826	22,571	21,368	20,951	24,437	19,694	18,242	21,616
Others																	
Total Expenditure	**213,250**	**190,913**	**329,646**	**353,993**	**203,740**	**234,736**	**314,258**	**302,916**	**197,273**	**279,728**	**218,694**	**196,584**	**409,156**	**248,388**	**163,237**	**166,630**	**215,595**
Net Income	**121,647**	**136,393**	**98,765**	**121,220**	**47,011**	**79,047**	**159,079**	**123,714**	**157,338**	**122,970**	**129,179**	**74,521**	**127,679**	**153,424**	**53,939**	**51,077**	**104,236**
Net Income (less wage, remittance)	**(71,491)**	**(41,148)**	**(128,450)**	**(140,213)**	**(90,152)**	**(87,219)**	**(80,028)**	**(72,378)**	**7,134**	**(74,283)**	**(34,891)**	**(65,059)**	**(185,555)**	**(40,468)**	**(37,430)**	**(67,783)**	**(36,998)**

Sources: 2018 Family Income and Expenditure Survey, Authors' Computation
**Med. Cost is the computed annual basic medical cost of a typical Filipino senior citizen*
***Other income and expenses were not accounted to condense the income statement.*

Annex A.3 Average Medical Annual Income Statement of Filipino Senior Citizens with Government Pension, by Regions
(in Philippine Peso)

Region	Ilocos	Cagayan	C. Luzon	CALA BARZON	Bicol	W. Visayas	C. Visayas	E. Visayas	Zamb.	N. Mindanao	Davao	SOCC SKARGEN	NCR	CAR	BARMM	CARAGA	MIMA ROPA
Average Age	73	72	71	71	72	71	71	72	69	70	69	68	71	71	72	70	71
INCOME																	
Wages	121,255	175,341	164,928	172,602	97,112	115,491	223,250	220,795	173,827	86,200	118,091	110,495	246,990	192,480	63,269	159,560	121,962
Remittance (abroad)	76,581	44,172	76,554	42,745	29,834	36,578	71,341	65,313	73,474	34,674	33,230	53,608	33,956	34,605	42,219	33,920	44,477
Remittance (domestic)	19,707	25,756	17,329	20,433	27,772	28,968	17,374	24,104	18,019	24,357	26,107	16,822	21,115	19,390	16,225	23,932	31,614
Gov. Pension	92,783	75,135	71,395	90,843	42,953	30,880	84,275	97,462	106,809	34,417	74,364	58,665	50,699	95,073	43,884	59,044	82,747
Others																	
Total Income	**499,862**	**541,148**	**540,396**	**533,990**	**340,666**	**339,765**	**642,350**	**663,042**	**608,159**	**298,686**	**483,618**	**402,405**	**559,015**	**611,570**	**278,024**	**456,533**	**472,169**
EXPENSES																	
Food	98,817	93,768	132,154	121,976	98,535	90,557	119,623	130,654	123,086	82,115	101,349	104,514	133,885	99,175	78,590	109,981	100,909
Non-Food	186,581	197,679	257,363	282,286	161,753	156,089	261,736	312,313	231,410	127,924	203,579	195,044	273,789	222,485	89,394	219,563	194,617
Med. Cost	26,019	21,625	21,967	17,911	22,320	18,472	20,623	26,082	22,072	23,826	22,571	21,368	20,951	24,437	19,694	18,242	21,616
Others																	
Total Expenditure	**285,399**	**291,447**	**389,517**	**404,262**	**260,288**	**246,646**	**381,359**	**442,968**	**354,496**	**210,039**	**304,928**	**299,557**	**407,673**	**321,660**	**167,984**	**329,545**	**295,525**
Net Income	**214,463**	**249,702**	**150,878**	**129,728**	**80,378**	**93,119**	**260,991**	**220,074**	**253,663**	**88,647**	**178,690**	**102,848**	**151,342**	**289,911**	**110,039**	**126,988**	**176,644**
Net Income (less wage, remittance)	**(3,081)**	**4,432**	**(107,932)**	**(106,052)**	**(74,339)**	**(87,918)**	**(50,973)**	**(90,138)**	**(11,657)**	**(56,584)**	**1,261**	**(78,077)**	**(150,720)**	**43,435**	**(11,673)**	**(90,423)**	**(21,409)**

Sources: Family Income and Expenditure Survey, Authors' Computation
**Med. Cost is the computed annual basic medical cost of a typical Filipino senior citizen*
***Other income and expenses were not accounted to condense the income statement.*

Annex A.4 Average Medical Annual Income Statement of the Filipino Senior Citizens with No Pension, by Regions
(in Philippine Peso)

Region	Ilocos	Cagayan	C. Luzon	CALA BARZON	Bicol	W. Visayas	C. Visayas	E. Visayas	Zamb.	N. Mindanao	Davao	SOCCSKARGEN	NCR	CAR	BARMM	CARAGA	MIMAROPA
Average Age	69	68	68	68	68	68	69	69	68	68	68	67	67	69	67	66	68
INCOME																	
Wages	102,811	94,224	146,827	158,506	76,873	119,226	114,126	66,969	70,941	98,555	77,242	88,410	269,471	101,273	40,016	97,323	75,959
Remittance (abroad)	65,238	32,685	41,252	34,947	12,914	40,133	33,807	19,302	15,301	22,545	12,747	20,494	30,124	22,901	9,932	17,356	16,352
Remittance (domestic)	23,137	16,837	16,552	19,768	30,138	20,468	23,879	28,126	24,676	16,905	18,261	16,643	15,042	20,483	9,746	20,427	26,128
Pension	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Others																	
Total Income	**286,882**	**247,129**	**309,627**	**319,142**	**194,551**	**279,419**	**270,471**	**190,006**	**188,982**	**221,988**	**189,533**	**235,776**	**445,006**	**266,409**	**161,589**	**219,047**	**211,925**
EXPENSES																	
Food	86,158	71,127	110,201	100,709	77,792	85,037	73,129	71,941	69,081	70,642	67,434	80,298	134,416	71,849	73,885	77,658	67,928
Non-Food	102,206	84,923	146,800	146,306	83,224	112,979	101,042	82,111	64,314	88,475	65,345	91,229	217,271	98,263	49,295	94,175	76,700
Med. Cost	26,019	21,625	21,967	17,911	22,320	18,472	20,623	26,082	22,072	23,826	22,571	21,368	20,951	24,437	19,694	18,242	21,616
Others																	
Total Expenditure	**188,364**	**156,050**	**257,001**	**247,015**	**161,016**	**198,016**	**174,172**	**154,053**	**133,395**	**159,117**	**132,779**	**171,527**	**351,687**	**170,112**	**123,180**	**171,832**	**144,629**
Net Income	**98,518**	**91,079**	**52,626**	**72,127**	**33,535**	**81,403**	**96,299**	**35,953**	**55,587**	**62,871**	**56,754**	**64,249**	**93,319**	**96,297**	**38,410**	**47,214**	**67,297**
Net Income (less wage, remittance)	**(92,668)**	**(52,667)**	**(152,005)**	**(141,094)**	**(86,390)**	**(98,424)**	**(75,512)**	**(78,443)**	**(55,332)**	**(75,133)**	**(51,496)**	**(61,299)**	**(221,318)**	**(48,360)**	**(21,284)**	**(87,892)**	**(51,142)**

Sources: Family Income and Expenditure Survey, Authors' Computation

**Med. Cost is the computed annual basic medical cost of a typical Filipino senior citizen*

***Other income and expenses were not accounted to condense the income statement.*