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Changes in the Demographic Structure and Economic Growth in East and Southeast Asia

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Abstract

The population of East and Southeast Asia has been ageing rapidly and will begin to decline ahead of other regions by 2040. By 2060, the elderly will comprise 40% of their total population, thus making them 'super-aged' societies. These regions are undergoing major demographic structure changes due to a rapid decline in birth rate and extension of life expectancy. While increased life expectancy and a lower percentage of youth population will have a positive impact on the economic growth in the short and long terms, a higher percentage of older people will have a negative impact in the long term. Additionally, growth in the labour force has a positive impact on the short-term and long-term economic growth. While ageing population will slow down economic growth in the long term, it is possible that this decline could be balanced by a higher labour force growth rate. Surviving in a super-aged society requires policies that proactively enhance economic growth.

Keywords: Demography, Ageing Population, East Asia, Southeast Asia
JEL Codes: J10, J11, J18

Changes in the Demographic Structure and Economic Growth in East and Southeast Asia

Maiko Kajimura

1. Introduction

The world is currently in the middle of a historically unique and irreversible process of demographic transition. Population ageing is occurring worldwide due to low birth rates and increased life expectancy. The United Nations (UN) predicts that by 2050, one in five people will be aged 60 years or above.

Ageing is an urgent issue for East and Southeast Asia,[1] as these regions are undergoing major demographic structure changes due to a rapid decline in birth rate and extension of life expectancy than other regions. Within the next few decades, most countries in these regions will surpass those in North America and Europe to become the world's most aged nations. This factor is expected to have a negative impact on the economic growth, declining saving rates and increasing social security expenditures.

This paper is organised in the following manner: Section 2 examines the demographic trends in East and Southeast Asia, and Section 3 reviews the existing studies on ways in which demographic changes affect economic growth. Section 4 employs international panel data to attempt a quantitative analysis of the impact of demographic changes on economic growth. Finally, Section 5 concludes the paper.

2. Rapid Demographic Changes in East and Southeast Asia

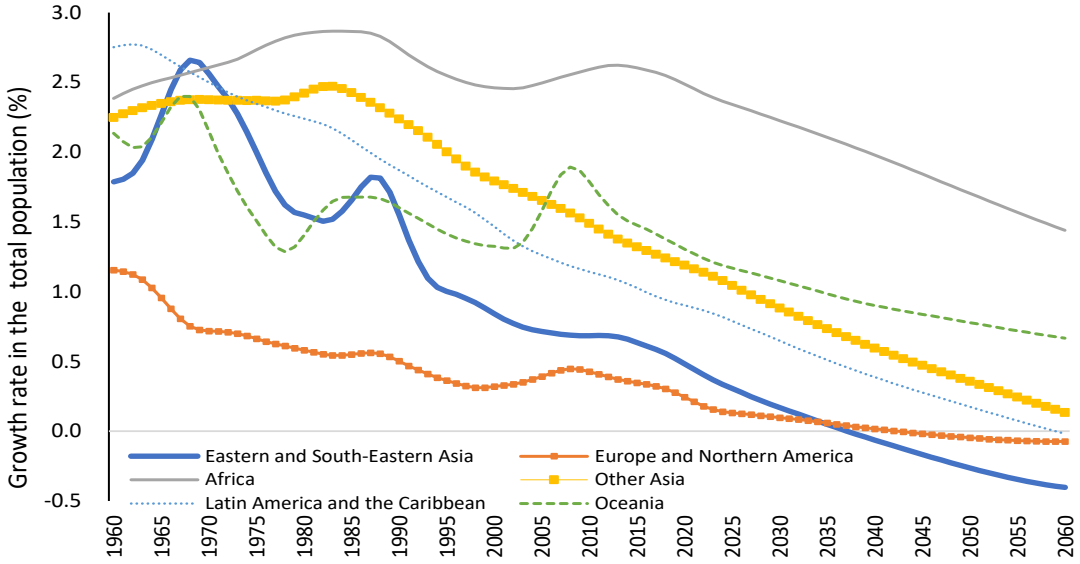
East and Southeast Asia are undergoing drastic demographic changes. According to regional population trends in the UN's World Population Prospects 2019, the population of East and Southeast Asia grew much faster than other regions in the 1960s and 1970s, with the highest growth rate in the late 1960s. However, since then, the growth rate has been declining, and therefore, the total population is expected to decline by 2040, which is earlier than other regions (Figure 1). Except for Japan, other East Asian and Southeast Asian countries recorded 2% excess population growth during the 1960s, after which the growth rate gradually declined. As for Japan, in the 2010s, it became the first country to experience negative population growth.

[1] The analysis in this paper focuses on 10 countries in East Asia and Southeast Asia: Japan, South Korea, China, Taiwan, Hong Kong, Singapore, Thailand, Malaysia, Indonesia and the Philippines.

However, South Korea's population is expected to start declining in the 2020s; Taiwan, Thailand and China's in the 2030s, and Hong Kong and Singapore's in the 2040s[2] (Figure 2). By observing the region wise share of the population, Africa, Latin America and other Asian countries continue to increase, while North American and Europe continue to decline. However, from 1960 to the late 1980s, the share of population in East and Southeast Asia increased, after which it started to decline, and therefore, by 2056–2060, the share is expected to be about 70% of its peak level (Figure 3).

Thus, over the 100-year period starting from 1960, the total population in East and Southeast Asia will undergo a drastic change that is not experienced by any other region in the world- first growing rapidly and then declining earlier than any other region in the world.

Figure 1: Trends in Total Population - Growth rate of total population by region



[2] Although Singapore experienced rapid population growth in the 1990s and 2000s, this was primarily due to an increase in its non-resident population (foreign workers). According to the data from the Singapore Department of Statistics, for example, while the annual growth rate of the resident population was 1.7% in 2008, it was 19.0% for the non-resident population. Singapore's non-resident population (foreign workers) comprises about 30% of its total population.

Figure 2: Trends in Total Population - Growth rate of total population by country

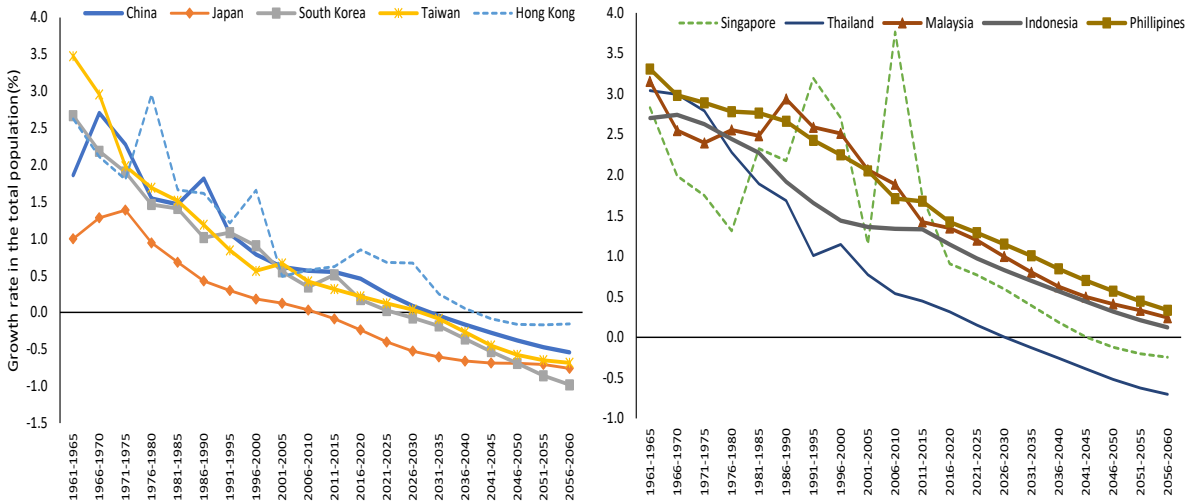
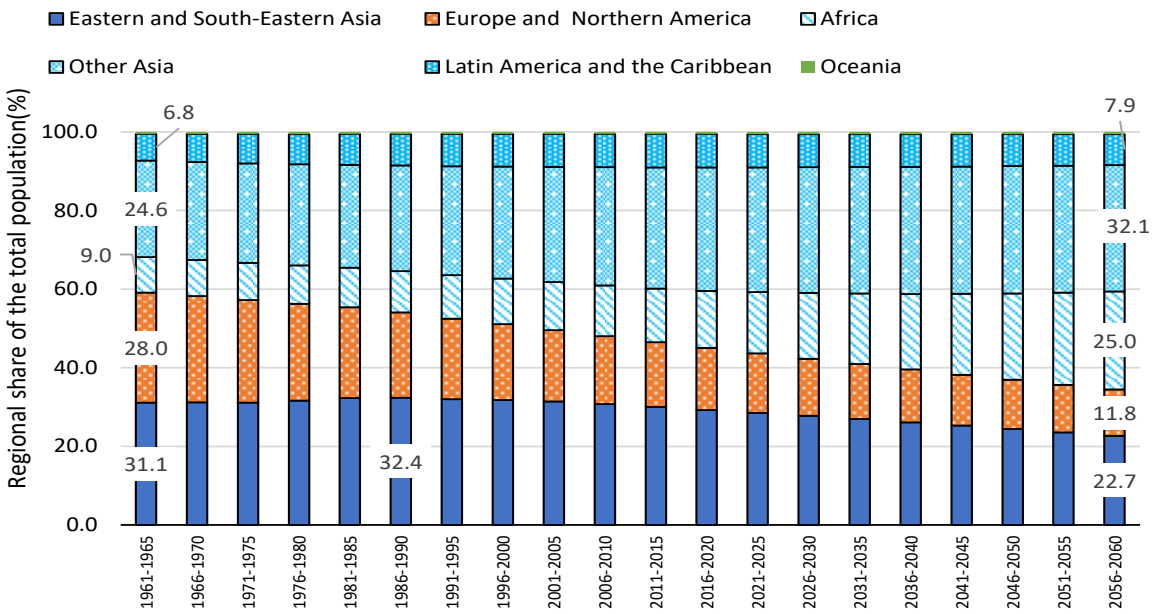


Figure 3: Trends in Total Population - Regional share of total population



Sources: 1. Prepared from the UN's World Population Prospects 2019. 2. Percentages for 2020 and thereafter are medium variant estimated values. 3. Population growth by country and regional share are five-year averages.

2.1 Population growth period: Declining mortality rate supporting population growth

East and Southeast Asia experienced a rapid decline in the mortality rate after World War II (Figure 4). New disease prevention and healthcare technologies developed in advanced nations became widely available in Asia. The effectiveness of such technologies was evidenced by a sharp decline in the infant mortality rate. On comparing the infant mortality rate per 1,000 during 1950–1955 and 1970–1975, it was deduced that the decline was the greatest in South Korea (from 159 to 39). Other countries also experienced sharp declines in infant mortality rate during the same period compared to North America and Europe. The same was true of mortality rates across all age groups, not just infants. In North America and Europe, the crude mortality rate (number of deaths per 1,000 people) declined only 10.7% between 1950–1955 and 1960–1965, while for all East Asian and Southeast Asian countries except China, the crude mortality rate declined by 20% or more, with South Korea at 44.9% (Figure 5).

Simultaneously, values and customs favouring fecundity did not significantly change, and therefore, the decline in the birth rate was rather slow. In terms of crude birth rates (number of births per 1,000 people), in 1960–1965, while the crude birth rate for Japan was 18.2, for East Asian and Southeast Asian countries, it remained high, that is, approximately 40. A comparison of the decline in crude birth rates and crude mortality rates from 1950–1966 to 1960–1965 reveals that the birth rate increased in Indonesia but decreased in other East Asian and Southeast Asian countries. However, in all other East Asian and Southeast Asian countries except Japan, fertility rates declined less than mortality rates (Figure 5). As a result, in all East Asian and Southeast Asian countries except Japan, the decline in mortality rate surpassed the decline in birth rate, leading to a high population growth rate throughout the 1960s.

Figure 4: Trends in Mortality Rate - Infant mortality rate

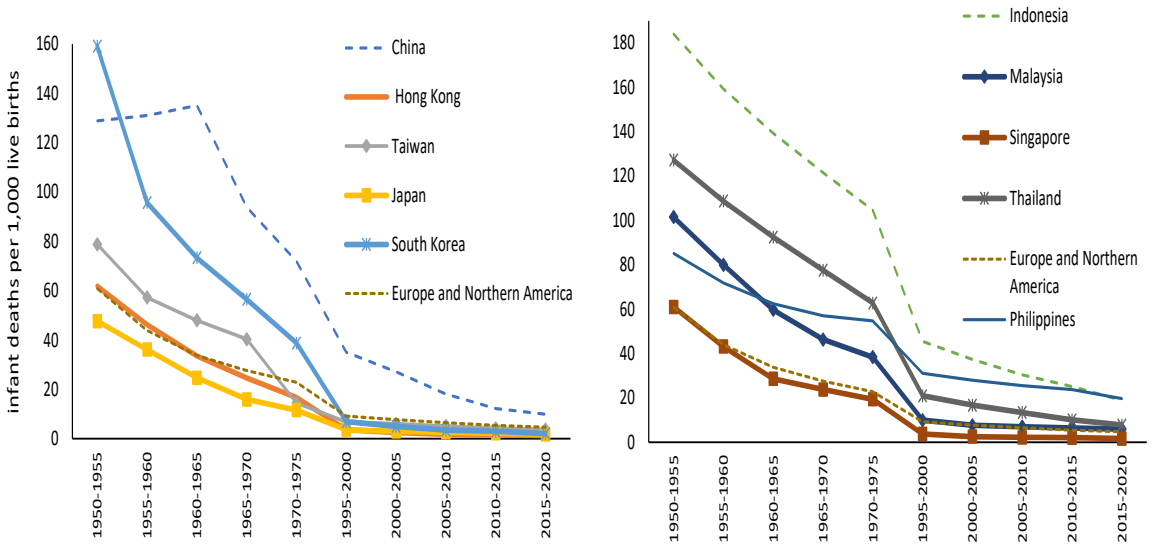
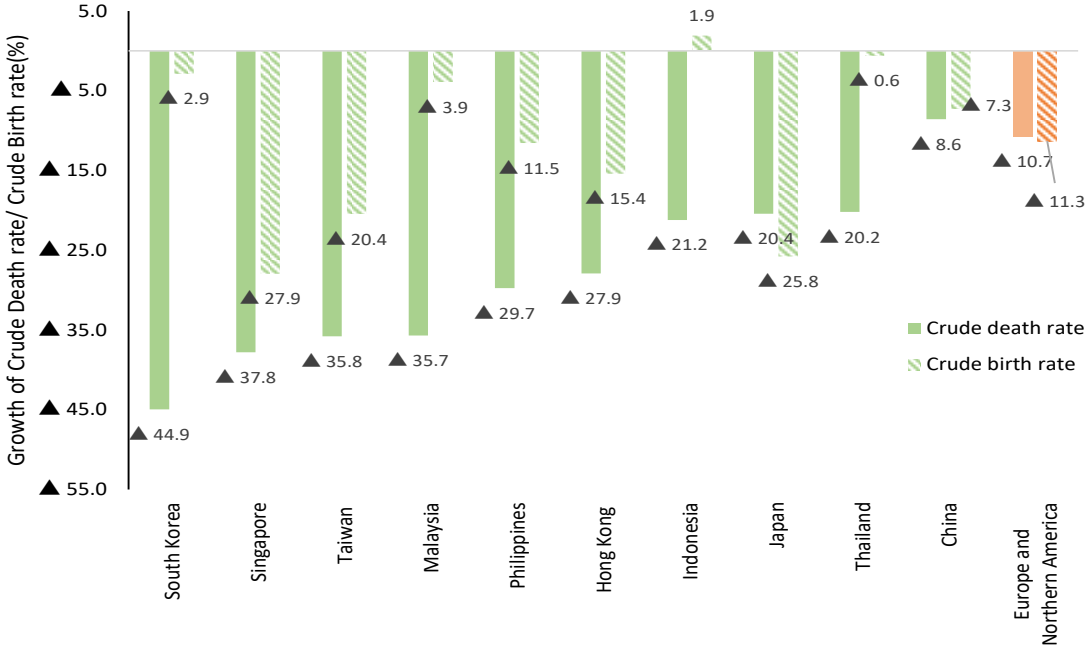


Figure 5: Trends in Mortality Rate - Decline in the crude mortality rate and crude birth rate (1950–55 vs. 1960–65)



Source: Prepared on the basis of the UN's World Population Prospects 2019.

2.2 Declining population growth period: Rapid decline in birth rate

Around 1970, sudden decline in the birth rate contributed to a shift in East and Southeast Asia, that is, from a period of rapid population growth to a period of slowdown in the population growth.

A comparison of the Total Fertility Rate (TFR) by region reveals that East and Southeast Asia recorded a high birth rate during the 1950s and 1960s that exceeded by 5.0. This aspect, along with the drop in the mortality rate, explains the increase in total population. However, unlike other regions, the birth rate in East and Southeast Asia declined rapidly from the 1960s to the 2000s. The TFR declined further below the replacement level[3] in 1995–2000 and even further below those of North America and Europe in 2005–2010, and has hovered around 1.6 since then (Figure 6). Moreover, the UN predicts low birth rates will continue beyond 2020.[4]

The rapid decline in the birth rate was particularly conspicuous in South Korea, Thailand, Hong Kong, Taiwan, Singapore and China where TFRs ranged between 5.0 and 6.0 in 1960–1965 and further declined to the replacement level (or lower) by 1985–1990. The birth rates in Japan, North America and Europe had declined below the replacement level in 1960–1970, and therefore, these became low birth rate societies early, and subsequent decline in their birth rates were more gradual. Contrastingly, these East and Southeast Asian countries experienced a rapid demographic transition, shifting from high birth rate societies to low birth rate societies in only a short time span (Table 1).

Although factors contributing to the rapid decline in birth rates in East and Southeast Asia vary on the basis of country, generally, include changes in gender awareness, increased opportunity costs related to childbirth and childcare for women in association with economic development, and increased educational expenses (Table 2). These factors are increasing the number of people who are single, late-married, or late-birth. Additionally, some East Asian and Southeast Asian governments had taken steps to control the population (e.g. family planning campaigns, promotion of contraception and other measures) (Table 3).[5] These measures are also considered to be one of the factors that caused a rapid decline in the birth rate.

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[3] Replacement level is the level of the TFR at which the population is at equilibrium, that is, neither increasing nor decreasing. The UN sets this value at 2.1%.

[4] This analysis uses medium variant estimates from World Population Prospects 2019. If low variant estimates are employed, the TFRs in East and Southeast Asia would decline to approximately 1.1% in 2030 and beyond.

[5] For example, Saw (2005) states three factors for Singapore's low birth rate, namely, women tending to marry late and a decline in the number of married women, the impact of government- and private-sector population control policies and the legalization of abortion and sterilization procedures.

Figure 6: Total Fertility Rate (TFR) - by region

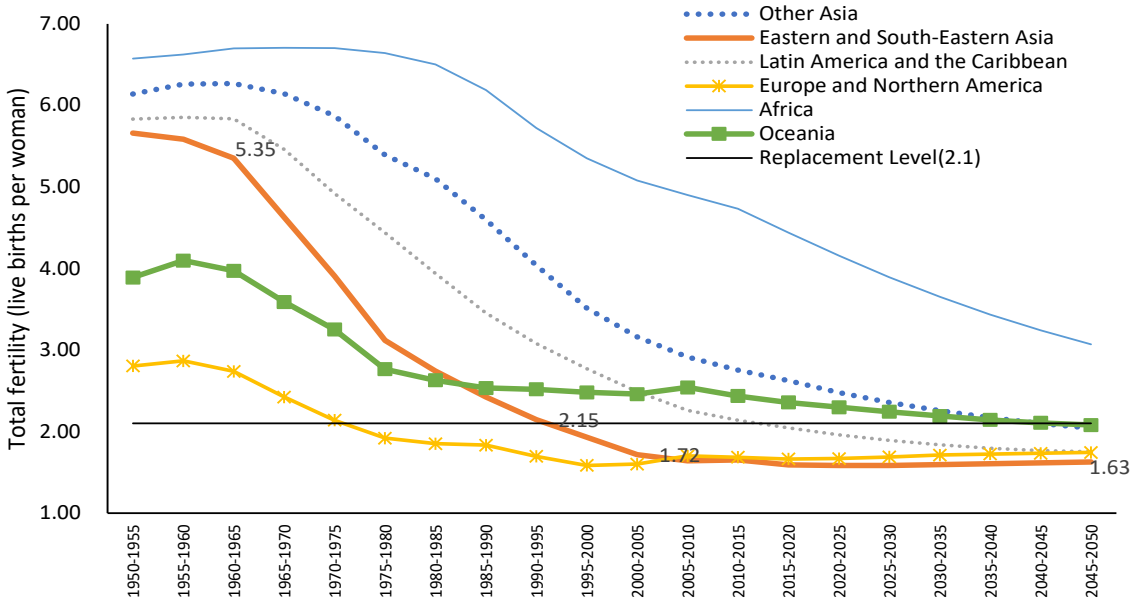


Table 1: Total Fertility Rate (TFR) - by country

	1960-1965	1985-1990	2015-2020	min（1960-2060）		Timing of falling below the replacement level
Hong Kong	5.05	1.36	1.33	0.95	2000-2005	1980-1985
China	6.15	2.73	1.69	1.61	2000-2005	1990-1995
Taiwan	5.41	1.77	1.20	1.05	2005-2010	1985-1990
Singapore	5.12	1.70	1.21	1.21	2015-2020	1975-1980
South Korea	5.60	1.57	1.11	1.08	2020-2025	1985-1990
Thailand	6.13	2.30	1.53	1.53	2030-2035	1990-1995
Malaysia	6.37	3.67	2.01	1.70	2050-2055	2015-2020
Indonesia	5.62	3.40	2.32	1.85	2055-2060	2030-2035
Phillipines	6.98	4.53	2.58	1.89	2055-2060	2040-2045
Japan	2.03	1.65	1.37	1.30	2000-2005	1960-1965
Europe and Northern America	2.74	1.83	1.66	1.58	1995-2000	1975-1980

Sources: 1. Prepared from the UN's World Population Prospects 2019. 2. Medium variant estimates were used.

Table 2: Factors Causing Lower Birth Rates in East and Southeast Asia

	South Korea	Hong Kong	Taiwan	China	Japan
Single rate(%) （Women、age 30-34）	1.4 (1970) 5.3 (1990) 37.5 (2015)	5.6 (1971) 19.8 (1991) 36.8 (2016)	5.7 (1980) 11.1 (1990) 20.5 (2000)	0.6 (1990) 1.4 (2000) 7.3 (2016)	7.2 (1970) 13.9 (1990) 35.7 (2015)
Mean age at marriage (Women)	23.3 (1970) 25.4 (1990) 31.5 (2015)	23.8 (1971) 27.7 (1991) 29.9 (2016)	23.8 (1980) 25.9 (1990) 27.6 (2000)	22.1 (1990) 23.3 (2000) 25.4 (2016)	24.7 (1970) 26.9 (1990) 29.2 (2015)
Average age of delivery （1990-1995、2015-2020）	27.6 32.3	29.6 32.3	27.3 31.7	26.0 27.6	29.1 31.3

	Singapore	Thailand	Indonesia	Malaysia	Philippines
	9.7 (1970) 20.9 (1990) 25.1 (2010)	8.1 (1970) 14.2 (1990) 23.5 (2010)	2.2 (1971) 4.5 (1990) 6.0 (2010)	12.4 (1991) 12.7 (2000) 17.9 (2010)	11.7 (1970) 14.3 (1995) 19.1 (2015)
	24.2 (1970) 27.0 (1990)	22.0 (1970) 23.5 (1990)	19.3 (1971) 21.6 (1990)	24.6 (1991) 25.1 (2000)	22.8 (1970) 21.1 (1990)
	29.6 31.3	27.2 27.3	28.2 28.2	30.0 30.9	29.4 28.9

Source: Prepared from the UN's World Marriage Data 2019 and World Population Prospects 2019.

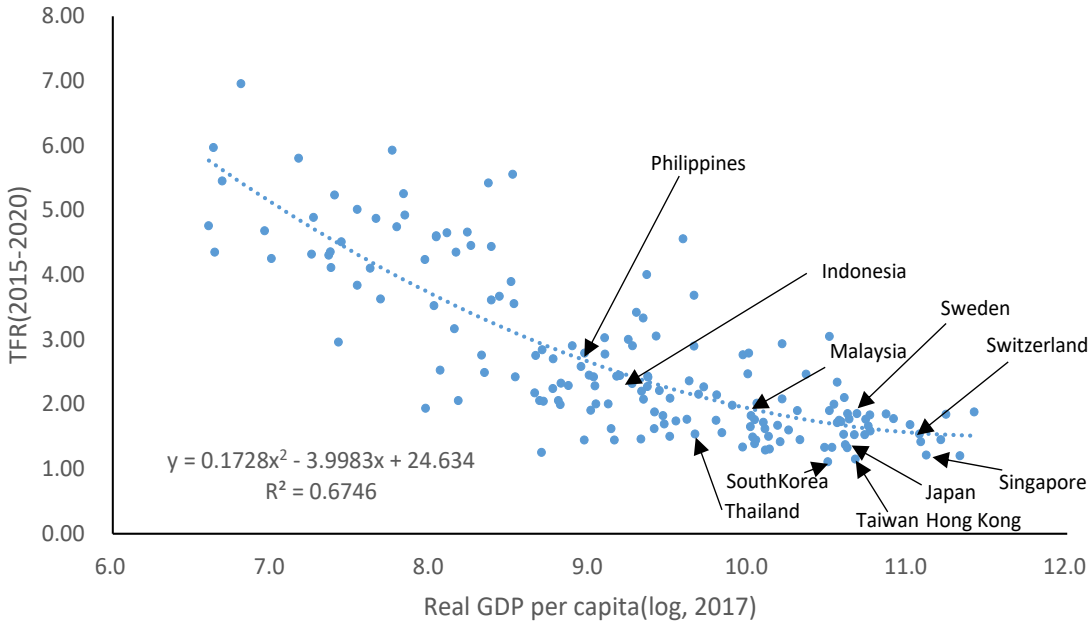
Table 3: Primary Examples of Population Control Policies

South Korea	●The Korean Family Planning Program(1962-1971) ・Free consultation on contraception methods. ・Setting a goal of increasing contraceptive practice rates for married women to 45% and reducing the population growth rate to 2% by 1971.
Taiwan	●Establishment of Family Planning Association(1953), Start of Family Planning Program(1959) ・Implementation of contraceptive promotion activities
China	●"The one-child policy"(1979-2015) ・Limit the great majority of family units in the country to one child each. As a rule, one child is allowed, and the second child and above are licensed by the local government. 〔1〕Encourage late marriage 〔2〕The couple who declared one child had received the "one-child identification" and received incentives and preferential allocation of housing, etc. 〔3〕Penalties such as wage cuts were imposed for excess of births and unplanned birth
Thailand	●Family Planning Promotion Campaign by PDA (1974) ・Under the slogan "Too many children make you poor", conduct a campaign to encourage the use of contraceptives in rural areas.
Singapore	●Establishment of Singapore Family Planning and Population Board, SFPPB(1966) ・"Abortion", "Legalization of contraceptive surgery" (1970) ・Late marriage and two-child policy were encouraged with the aim of achieving a population growth rate of zero, at which time campaigns using slogans such as "Take Your Time to Say" YES "" and "Girl or Boy Two is Enough" were implemented. ・Abolition of paid maternity leave system, strengthening incentives to encourage abortion and fertility treatment, and enforcement of housing regulations (when the number of births is 3 or more)

Source: Prepared on the basis of Kojima and Hiroshima (2019) and Cabinet Office, Japan (2005, 2008).

A clear correlation exists between low birth rates and income levels. Due to the high economic growth in East and Southeast Asia since the 1960s, the per capita income increased, and therefore, by 2017, these countries had achieved the per capita real gross domestic product (GDP) levels that ranged between medium and high in a global comparison. However, the same countries recorded low birth rates (Figure 7). The rapid economic growth in East and Southeast Asia changed lifestyles and attitudes, and hence, remaining single and marrying at a later age led to lower birth rates.

Figure 7: Income Levels and TFR



Source: University of Groningen Penn World Table version 9.1 and UN World Population Prospects 2019.

Increasing the birth rate is thus not an easy task. High income Western countries such as France and Sweden have succeeded in increasing their birth rates. Since the 1990s, France shifted from policies offering family allowances and other economic incentives to policies aimed at facilitating a 'work–life balance' such as by improving its childcare programmes and offering women with various options for having and raising children while working. In Sweden's case, economic assistance and policies aimed at facilitating 'work–life balance', such as childcare facilities and a system of childcare leave were introduced early, and these policies have helped reduce the opportunity costs of childcare for women.

In East and Southeast Asia, while measures to reverse the declining birth rates, such as baby bonuses, tax breaks and better childcare services, have been introduced, no significant results have been achieved, low birth rates are expected to be recorded for the time being.

2.3 East Asian and Southeast Asian countries with the highest life expectancy

In East and Southeast Asia, average life expectancy has increased significantly. Thanks to improved dietary habits, progress in disease prevention and sanitation measures, better healthcare facilities and services, improvements in healthcare and health insurance systems and the spread of hygienic practices. Increasing life expectancy, along with the rapid decline in fertility, have had a major demographic impact on these regions. Average life expectancy for these regions, which was 59.8 years in 1960–1965, increased to 78.7 years in 2015–2020, reflecting an increase of 18.9 years to the average life span over a 50–year period and surpassing Europe, North America and Oceania; thus, East and Southeast Asia recorded the world's highest life expectancy. The UN forecasts that the life expectancy in these regions will increase to 85.2 years by 2055–2060 (Figure 8).

The East and Southeast Asian countries with the highest life expectancy as of 2015–2020 are Hong Kong, at 84.6 years (No. 1 in the world); Japan, at 84.4 years (at No. 2); Singapore, at 83.4 years (at No. 5) and South Korea, at 82.8 years (at No. 11). Average life expectancy in these countries is expected to increase further by 2055–2060, and particularly, for the abovementioned four countries, it is expected to approach 90 years (Figure 9).

Figure 8: Trends in average life expectancy - by region

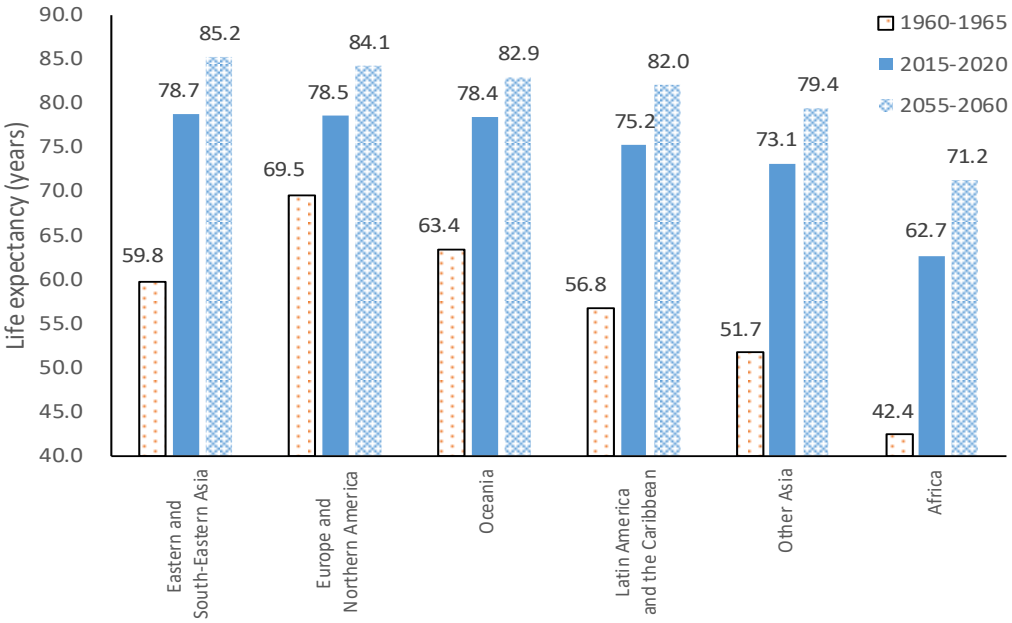
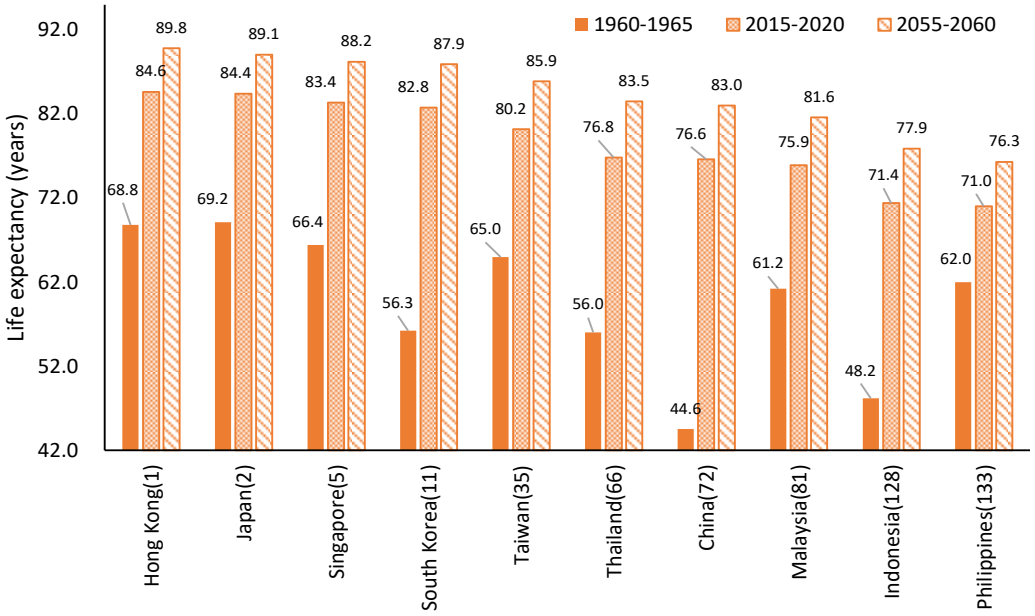


Figure 9: Trends in average life expectancy - by country



Sources: 1. Prepared from the UN's World Population Prospects 2019. 2. Medium variant estimates were used. 3. The world rankings of the countries for 2015–2020 are denoted in parentheses.

2.4 East and Southeast Asia are ageing very rapidly

Lower birth rates and higher average life expectancy have spurred population ageing in East and Southeast Asia. The percentage of elderly people (the ratio of people aged 65 years and older to the total population) has been rapidly increasing since the beginning of the 2010s. Comparing the percentage of elderly people by region (Figure 10), East and Southeast Asia surpassed Oceania in 2006 and is expected to surpass Europe and North America in 2031, and this percentage will continue to increase thereafter. In 2060, the elderly population ratio is expected to be 38.9%, thereby making East and Southeast Asia the world's most aged regions.

The breakdown on the basis of country in these regions (Figure 11) reveals that Japan has the regions' highest elderly population ratio as of 2019. South Korea's population is expected to age rapidly, surpassing Japan's 37.7% in 2050 to reach 38.1%, exhibiting the world's highest elderly population ratio. By 2060, the elderly population ratios for Hong Kong, Taiwan and Singapore will also be around 40%.

Figure 10: Elderly population ratio - by region

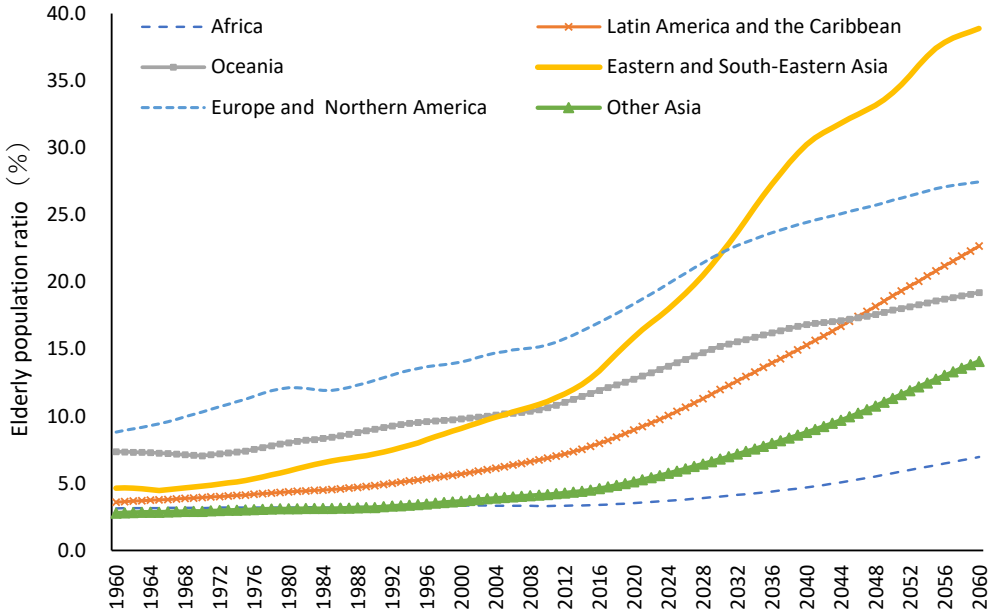
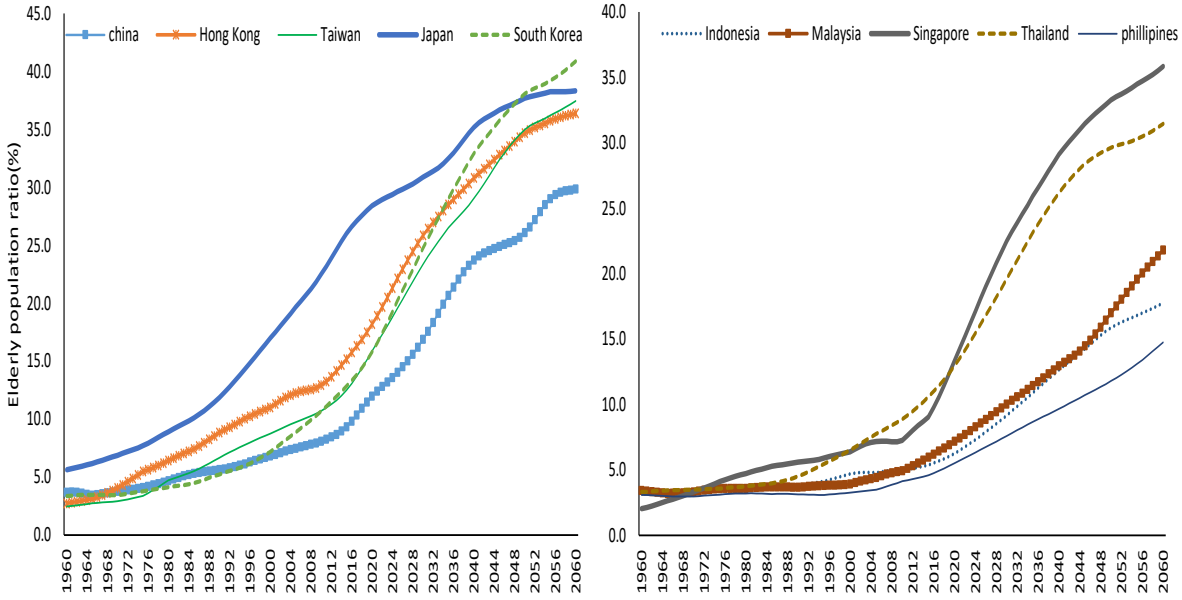


Figure 11: Elderly population ratio - by country



Sources: 1. Prepared from the UN's World Population Prospects 2019. 2. Mid-point estimates were used.

2.5 Characteristics of population ageing in East and Southeast Asia

Let us discuss some of the characteristics of population ageing in East and Southeast Asia. The most widely acknowledged characteristic is that population ageing in this region has been much faster than in the other parts of the world. As of 2019, seven of the world's countries[6] have become 'super-aged societies'[7], with Japan (28%, No. 1) being the only one from East and Southeast Asian regions. Nevertheless, all the East and Southeast Asian countries, except Malaysia, Indonesia and the Philippines, are expected to become 'super-aged societies' by 2036 (Table 4), while Malaysia, Indonesia and the Philippines are expected to become 'super-aged' in 2059, 2074 and 2080, respectively.

East and Southeast Asia is expected to transit from being an 'ageing society' to 'aged society' in 23 years (which is less than half the time taken by Europe and North America) and from being an 'aged society' to a 'super-aged society' in about 25 years. South Korea, Singapore and Thailand are ageing rapidly, with South Korea and Singapore transiting from

[6] The seven countries that had become super-aged societies as of 2019 were Japan (28.0%), Italy (23.0%), Portugal (22.4%), Finland (22.1%), Greece (21.9%), Germany (21.6%) and Bulgaria (21.3%).

[7] The UN defines 'an aging society' as one with an elderly population ratio exceeding 7%, 'an aged society' as one with an elderly population ratio exceeding 14% and 'a super-aged society' as one with an elderly population ratio exceeding 21%.

being ‘ageing societies’ to ‘aged societies’ in just 18 years and Thailand in only 20 years. South Korea and Singapore will shift from being ‘aged societies’ to ‘super-aged societies’ in only 8 years, while Thailand will take only 10 years (Figure 12).

With respect to the second characteristic, the order of demographic change is such that Japan goes first, then the other East Asian and Southeast Asia countries follow. Komine (2007) termed the demographic trend occurring in East and Southeast Asia a ‘Flying Geese Model’,[8] that is, the sequence of events in Japan (declining birth rate → shift to being an aged society → decline in the working-age population → decline in the total population) will be followed by other East and Southeast Asian countries. In fact, as we can see in Figure 13, the East Asian countries will immediately follow Japan’s sequence of events, and the Southeast Asian countries are expected to go through the same sequence of events thereafter.

The third characteristic is the large absolute size of East and Southeast Asia’s elderly population. In 2060, it will be about 576 million, suggesting that 1 out of 3 of the world’s elderly will live in these regions (Figure 14) because of the high ratio of elderly people in Japan from the beginning and the ongoing ageing in China, which is the most populous country.

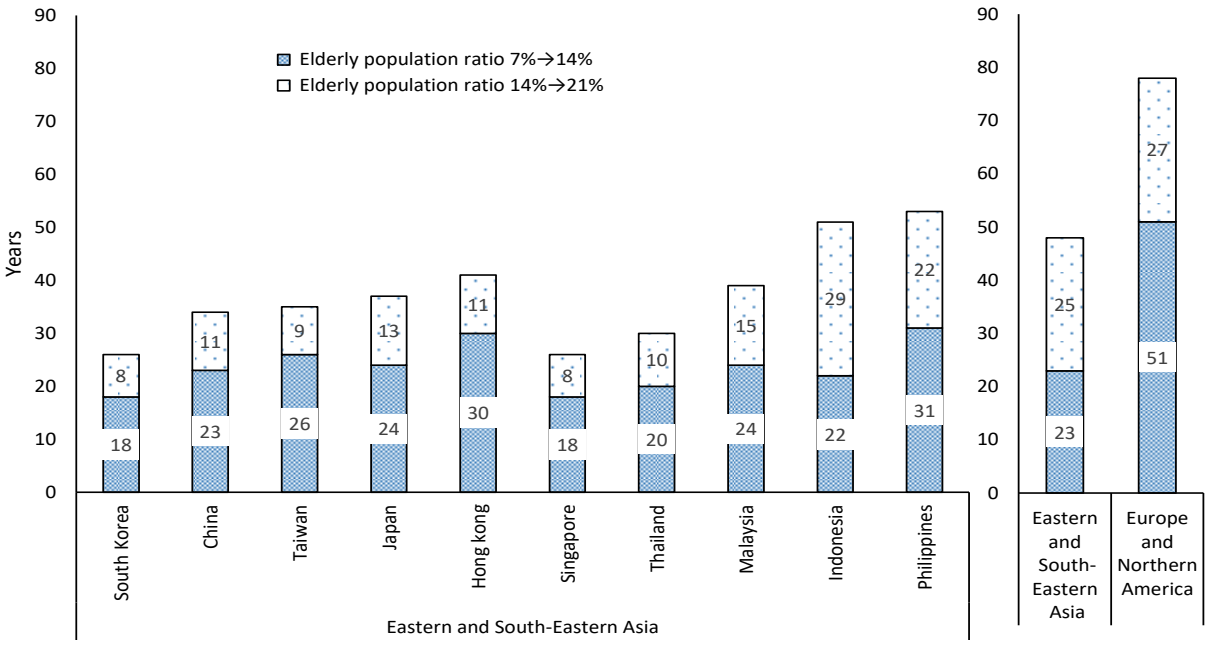
Furthermore, the population comprising very old people (75 years and above) is greater in these regions than in other regions. As of 2020, these regions have 33.0% of the world’s very old people, and this percentage is expected to reach 38.7% by 2050. Thus, East and Southeast Asia, which have higher life expectancies, will see a significant increase in their very old population due to longevity. This cohort of the very old requires more social security benefits for medical and long-term care, thereby imposing an enormous financial burden.

[8] ‘Flying Geese Model’ is a term that was originally used to denote changes in Asia’s industrial structure. It shows how the process of adding value to the industrial structure has progressed, starting with Japan and spreading to the NIEs to ASEAN and then to China. Komine (2007) suggests that the ‘flying geese model’ can apply not only to changes in the industrial structure but also to changes in the demographic structure, starting with Japan and spreading to the other countries one after the other.

Table 4: Countries that are 'Aged Societies' and 'Super-Aged Societies'

	An aged society Elderly population ratio Over 14%		A super-aged society Elderly population ratio Over 21%			
2019年	Hong Kong	17.5%	Japan			28.0%
	Taiwan	15.1%				
	South Korea	15.1%				
2036年	–	–	Japan	33.0%	Singapore	26.6%
			South Korea	29.8%	Thailand	23.8%
			Hong Kong	29.0%	China	21.4%
			Taiwan	27.0%	–	–
2080年	–	–	South Korea	41.3%	Singapore	35.2%
			Japan	37.9%	Thailand	35.0%
			Taiwan	35.6%	Malaysia	26.5%
			Hong Kong	32.3%	Indonesia	22.7%
			China	30.6%	Philippines	21.1%

Figure 12. Years Required for Ageing to Progress



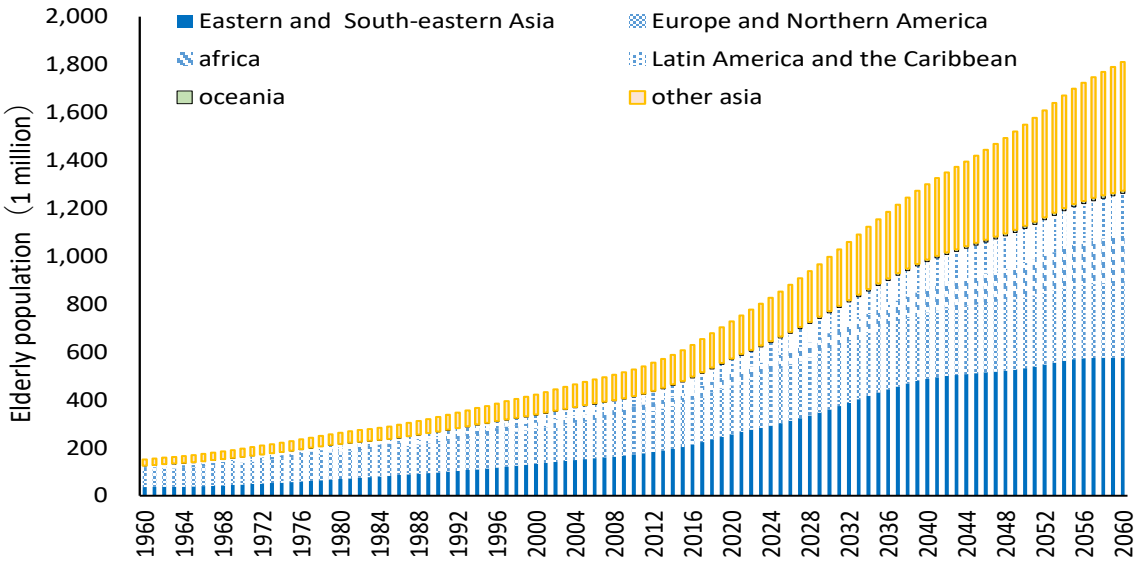
Sources: 1. Prepared from the UN's World Population Prospects 2019. 2. Medium variant estimates were used. 3. When the UN began its data collection for this aspect, Europe's and North America's elderly population ratios had already reached 7% in 1950. However, for convenience, I have considered it to be above 7% in 1950. Thus, it can be inferred that Europe and North America took at least 51 years for their elderly population ratios to transit from exceeding 7% to exceeding 14%.

Figure 13: Order of Demographic Changes in East and Southeast Asian Countries

period (years)	Timing when TFR falls below 2.1	Time to reach an aged society	Timing when the working-age population begins to decline	Timing of total population begins to decline
1960-1965	Japan			
1965-1970				
1970-1975				
1975-1980	Singapore			
1980-1985	Hong Kong			
1985-1990	Korea, Taiwan			
1990-1995	China, Thailand			
1995-2000		Japan	Japan	
2000-2005				
2005-2010				
2010-2015				Japan
2015-2020	Malaysia	Hong Kong, Korea, Taiwan	HongKong, Taiwan, China	
2020-2025			Korea, Singapore, Thailand	
2025-2030		Singapore, Thailand,China		Korea
2030-2035	Indonesia			Taiwan,Thailand
2035-2040				China
2040-2045	Philippines			Hong Kong
2045-2050		Malaysia,Indonesia		Singapore
2050-2055			Malaysia	
2055-2060				
2060－		Philippines	Indonesia, Philippines	Indonesia, Malaysia, Philippines

Sources: 1. Prepared from Komine (2007) and the UN's World Population Prospects 2019. 2. Rates of population growth are five-year averages. Labour force population means working-age population (between 15 and 64 years).

Figure 14: Size of the Elderly Population



Source: Prepared from the UN's World Population Prospects 2019.

3. Impact of Changing Demographics on Economic Growth

As discussed in Section 2, East and Southeast Asia will be undergoing major changes in their demographic structures due to their sharply declining birth rates and higher life expectancies within the 100-year, commencing from 1960; however, how will these rapid demographic changes affect their economic growth?

The relationship between population and economic growth was first discussed by Malthus (1798) in *An Essay on the Principle of Population,* and has been a debatable topic ever since. Malthus (1798) wrote, 'The power of population is indefinitely greater than the power in the earth to produce subsistence for man. Population, when unchecked, increases in a geometrical ratio. Subsistence increases only in an arithmetical ratio. A slight acquaintance with numbers will reveal the immensity of the first power in comparison of the second (Chapter1 p.14)'. He argued that population growth would lead to a shortage of daily necessities, thus deteriorating living standards. To deal with the negative effects of population growth, he advocated for moral restraints such as the postponement of marriage. In fact, as we have already mentioned, some East and Southeast Asian nations began implementing population control policies back in the 1950s and 1960s, which comport with Malthus' theory.

Mason (1997) first presented a prototype of the 'demographic dividend'[9] in *Population and the Asian Economic Miracle*. He contended that an increase in the ratio of the income-earning population will lead to an increase in the income level and that a rapid increase in the working-age population due to a lower birth rate will generate a 'demographic dividend'. He also highlighted that Asia has benefited from this demographic dividend due to its government-sponsored family planning and applauded its economic growth resulting from these population control policies.

And the UN Population Fund (1998) noted in its 'State of the World Population' that declining birth rates in emerging countries will cause a 'workforce bulge' that could lay the foundation for increased investments, labour productivity and rapid economic growth.

Empirical research on the demographic dividend and economic growth has been performed since the late 1990s. Bloom and Williamson (1998) investigated the rapid economic growth during the so-called East Asian Miracle that took place between the 1960s and the 1990s, examined how factors such as population growth and growth in the working-age population in East Asia, in general, affected economic growth and concluded that roughly one-third of the growth in GDP per capita was attributable to the demographic dividend and that demographic trends had increased labour and capital inputs, thus facilitating economic growth.[10] Bloom and Williamson (1998) disaggregated the effects of demographic change on economic growth into the change in the population growth rate and the change in labour force growth rate and conducted an empirical analysis on Asian countries. Their analytical model is called as the Harvard Model. Undertaking a similar approach, Kelley and Schmidt (2005) found that from 1960 to 1990, demographic changes accounted for 44% of the per capita income.

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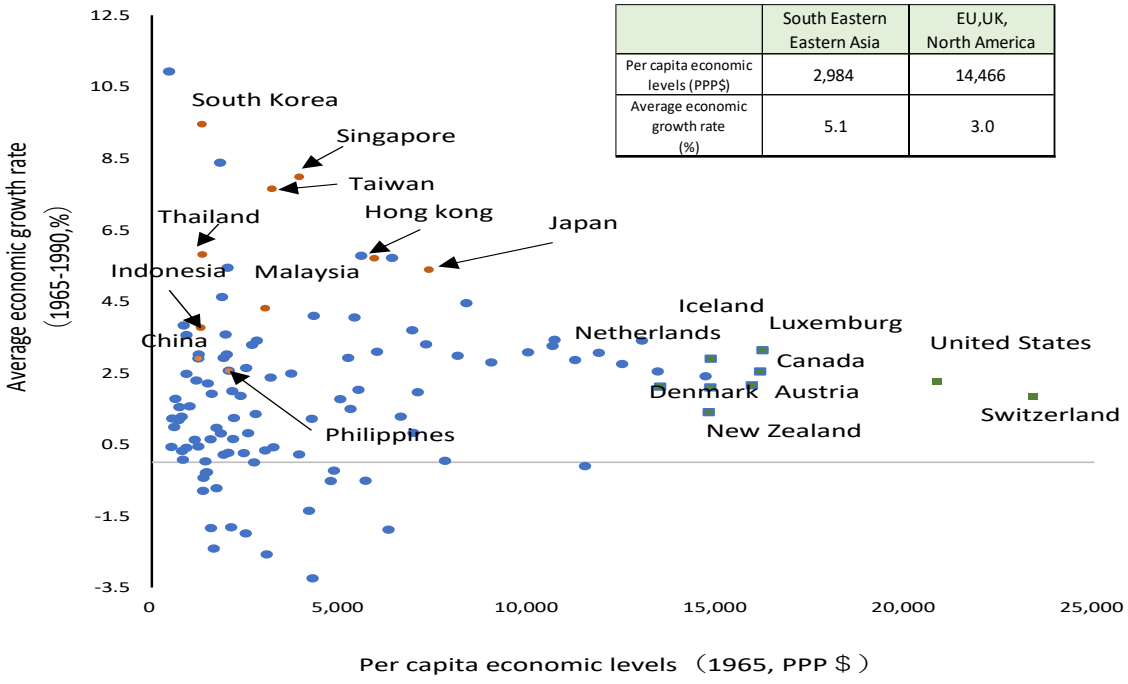
[9] The 'demographic dividend' refers to a population structure where the working-age population increases faster than the dependent population (the population under 15 years and above 65 years).

[10] The term 'demographic dividend', after it was used in the studies of Bloom and Williamson (1998), has become widely known. Bloom et al. (2003) indicates that Southeast Asian countries were able to enjoy a demographic dividend because they could build the social, economic and political systems that made it possible. If only the growth rate of working-age population and the ratio of dependent population are considered, larger relative increases can be observed in more than one country in the Middle East, in Africa and in other parts of Asia than among the Southeast Asian countries. On the contrary, economic growth in those countries was not necessarily higher than in Southeast Asian regions. For example, the increased rate of working-age population in Jordan between 1965 and 1990 was 203%; however, its average growth rate per capita for the same period was a mere 0.2%. This means that the economic growth cannot be explained only by population factors, and other factors such as trade expansion, high savings rate, expansion/improvement of human resources and economic policies also contribute towards economic growth; thus, the relevant countries achieved high growth rates through positive spiral effect by benefiting from multiple factors during the abovementioned period.

Indeed, East and Southeast Asia enjoyed an era of demographic dividend during the 1960s–1990s, achieving a remarkable economic growth known as the 'Asian Economic Miracle'. On observing the correlation between per capita income levels in 1965 (real GDP, dollar PPP basis, 2011 base year) and the average real GDP growth rate during 1965–1990, we see that European and North American countries initially enjoyed high per capita income and were more affluent than East and Southeast Asia. However, East and Southeast Asia have since then grown faster, with South Korea growing at a rate of more than 10%, and Japan, Taiwan, Hong Kong and Singapore growing between 6% and 8% (Figure 15).[11] During this period, the dependency ratio[12] in these countries was declining faster than in Europe and North America, indicating that these countries were benefiting from the demographic dividend (Figure 16).

Figure 15: Per Capita Economic Levels (1965) and Subsequent Average Growth Rates (1965–1990)

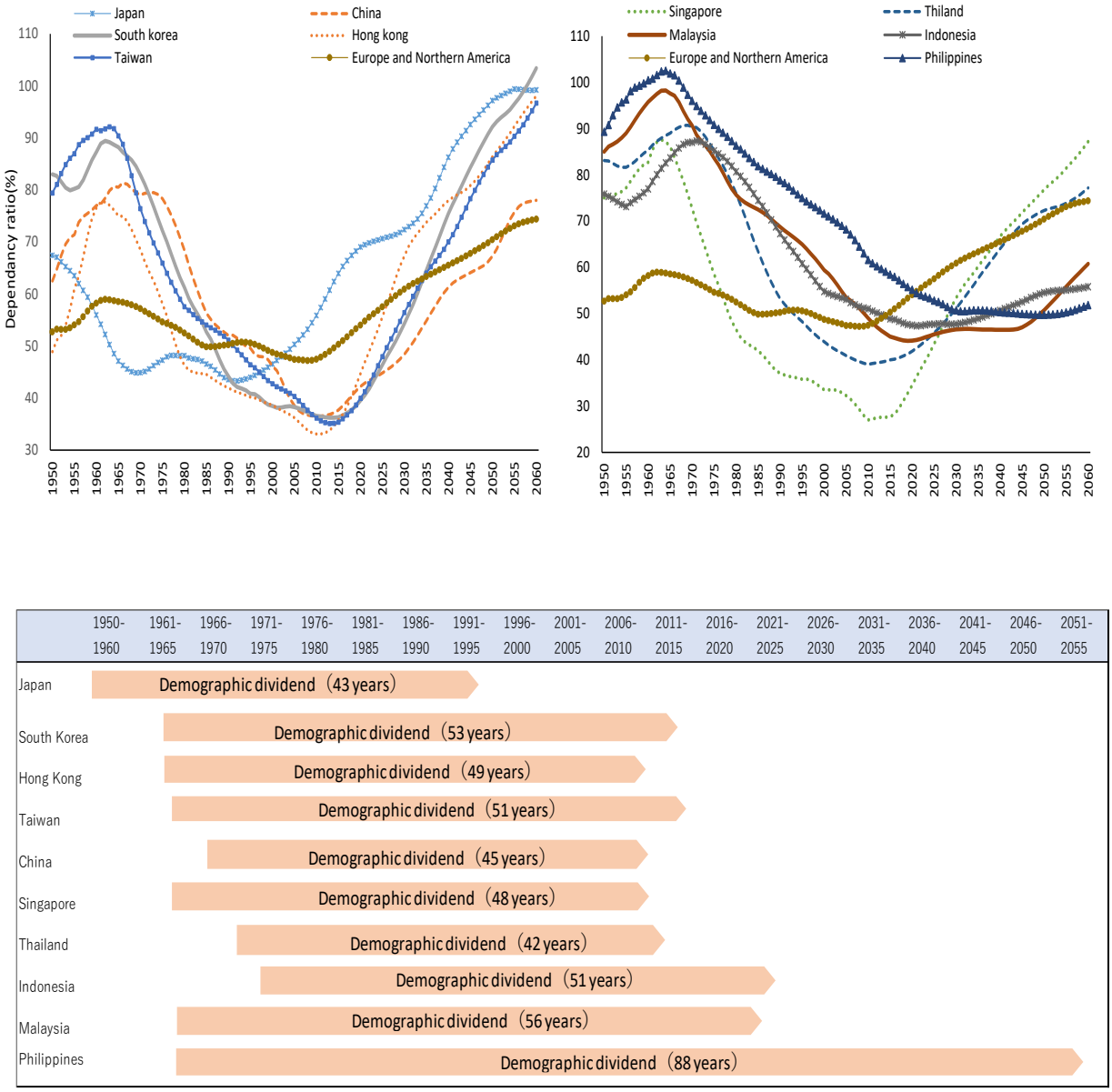


Source: Prepared from University of Groningen Penn World Table version 9.1. In all, 113 countries were surveyed.

[11] The eight countries, namely, South Korea, Taiwan, Hong Kong, Singapore, Japan, Indonesia, Malaysia and Thailand were regarded as by the World Band (Mason, Andrew. (1997) as HPAEs (high-performing Asian economies) of the Asian Economic Miracle.

[12] The Dependency ratio is an index showing how much the working-age population (15-64 years old) supports the younger population (under 15 years old) and the aged population (65 years old or older).

Figure 16: Change in Dependency Ratio



Source: Prepared from the UN's World Population Prospects 2019.

At the same time, as we can see in Figure 16, for many East and Southeast Asian countries, this demographic dividend lasted from the 1960s to the 2000s, and as of 2019, with the exception of the Philippines and Indonesia, several countries are already in the process of transiting from experiencing a 'demographic bonus' to a 'demographic onus'. Since the 2000s, more research has been conducted on how the shift to experiencing a

demographic onus[13] is affecting economic growth, because the focus is now on demographic onus than demographic dividend. This transition to experiencing a demographic onus was precipitated by the increase in the ratio of the elderly people in the population, and for the rapidly ageing East and Southeast Asia countries, understanding how changing demographics are affecting economic growth is critical.

IMF (2004) conducted panel estimates for the 1960–2000 period; it found that an increase in the ratio of the working-age population was positively correlated with savings rate, investment rate, the current account balance and the growth rate of per capital GDP, while an increase in the ratio of the elderly population was negatively correlated with savings rate, investment rate and the current account balance.

Bloom et al. (2010) used the Harvard Model developed by Bloom and Williamson (1998) to study Africa and Latin America. They particularly employed data from 1960 to 2005 to investigate how economic growth was affected by changes in the ration of the dependent population, that is, the youth and elderly age groups and found that an increase in the ratio of the elderly population has a negative effect on the short-term economic growth, while an increase in the ratio of the youth population has a major negative impact on both short-term and long-term economic growth.

We can offset the negative impact on economic growth of a declining working-age population and rising elderly population ratio by promoting the hiring of women and the elderly whose skills were not being used even if they wanted to work/contribute and accepting more foreign workers. Bloom and Finley (2009) argue that Asian countries were able to absorb the ever-increasing working-age population because they maintained a certain 'flexibility towards change' (as evidenced by their strong work ethic and commitment to progress), and the authors conclude that this ability to adopt a sufficiently flexible response towards change probably mitigates the negative impact of the declining working-age population ratio.

Additionally, some argue that economic growth can be sustained by supplementing the labour force with robots and artificial intelligence. For example, in an empirical analysis using the Organisation for Economic Co-operation and Development panel data for 1990–2015, Acemoglu and Restrepo (2017) found that a population decline will not have a negative

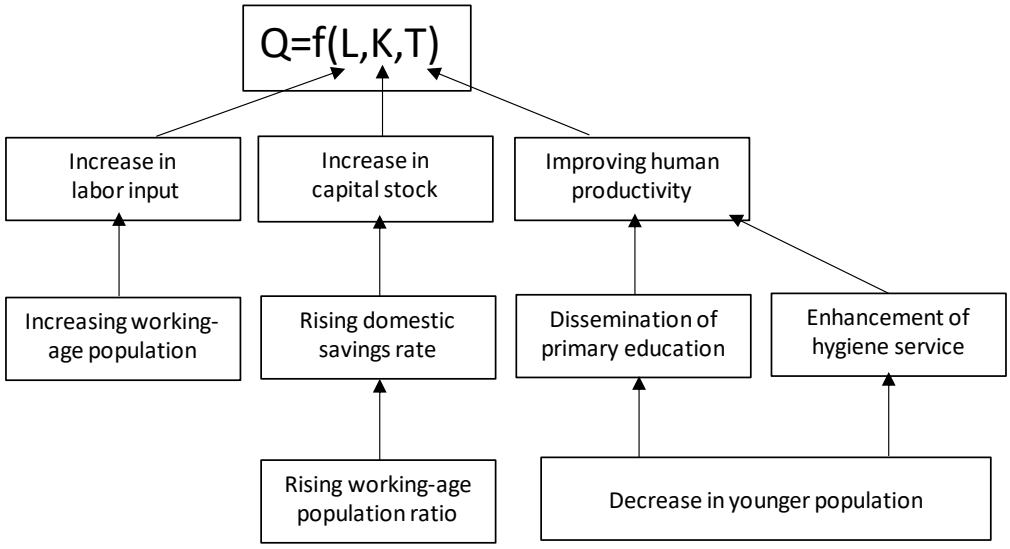
[13] A phase where the dependency ratio increases (the ratio of the working-age population to the total population declines). During the 'demographic onus' period, working-age population declines and the burden on the working people increases, and therefore, the economy will be burdened.

impact on the economic growth if labour is replaced with technology and the decline in the labour force is offset by robots.

Empirical studies of how demographic structures influence economic growth are also frequently used in analysis based on the growth accounting approach. In the growth accounting analysis, which disaggregates economic growth into three factors, namely, capital, labour and technological progress, the change in the production that cannot be accounted by capital and labour is regarded as Total Factor Productivity (TFP), which constitutes technological innovation, the streamlining of production and other such factors.

According to growth accounting, the determinants of a country's economic growth[14] are labour, capital and TFP. Population increases/decreases and changes in the population structure affect economic growth through these three channels. This model, shown in Figure 17, enables us to get a clear picture of how demographic changes affect the labour input, the capital input and TFP.

Figure 17: Growth accounting analysis approach



Source: Prepared by the author based on Oizumi (2012).

[14] In the Harvard Model, per capita income is considered as the metric of economic growth (the explained variable), whereas in the studies based on the growth accounting approach, GDP or gross regional domestic product is the metric of economic growth.

According to the growth accounting analysis approach, ageing will negatively impact economic growth due to a decline in the labour force, less capital stock and lower TFP.

However, some recent studies regard the ongoing ageing process as a good opportunity to enhance economic growth. Yoshikawa and Hatta (2017) propose a new type of economic growth model that they regard as 'agenomics'[15] that will sustain economic growth through innovative goods and services such as robots that provide long-term nursing care and systems or regulations that support the use of these goods and services for the specific requirements of the ageing society.

The Asian Development Bank discusses the 'longevity dividend'[16] in its 2018 report, 'Tapping Technology to Maximize the Longevity Dividend in Asia', contending that a society in which the elderly can stay healthy and live for a longer time can reduce its medical and long-term care costs and eliminate labour shortages. Thus, using technology is essential to maximise the profits from this longevity dividend. Moreover, the report states that the issues experienced by labour markets in ageing societies can be resolved with technology, and it highlights the importance of technology in maintaining health and lengthening life spans, transforming work and workplace and establishing a supportive environment that enables many types of workers, including the elderly, to have jobs.

As we have seen, research on how demographic changes affect economic growth dates back to Malthus and has taken many different approaches. Section 4 of this paper uses the Harvard Model to conduct a quantitative analysis of how changing demographics affect economic growth. Quantitative verification methodologies typically use either the growth accounting model or the Harvard Model. The former, however, focusses on capital stock and requires more time series data, and verifying the impact of changing demographics on the TFP growth rate as shown by the Solow residual is difficult. As for the Harvard Model, we are able to easily acquire recent time series data by employing the University of Groningen's Penn World Table version 9.1, and as more samples are available, we are able to base analyse on the most recent ageing trends. The Penn World Table allows international time series

[15] Agenomics is a term that is coined by combining 'age' and 'economics'.

[16] Longevity dividend is also mentioned in the World Economic Forum's report (Pang Sze-Yunn et al., 2020); this report states that as ageing of population progresses 'longevity dividend', a dividend in demographic statistics, has emerged and that 'longevity allowance' may lead to productivity improvement and increase the gross national income over the long life spans.

comparisons on how changing demographics (caused by rapid ageing) can impact economic growth. Section 4 thus attempts an empirical analysis based on the Harvard Model.

4. Implementation of the Quantitative Analysis

4.1 Analytical Framework

This section uses the most recent internationally comparable and longitudinal data from sources such as the University of Groningen's Penn World Table (version 9.1) and conducts a panel data analysis on the impact of demographic changes due to rapid population ageing in recent years on economic growth.

A convergence hypothesis derived from the Solow model[17] is assumed. Regions where incomes are low will grow faster than regions where incomes are high, and therefore, in the long term, the former will try to catch up or converge with the latter. The convergence hypothesis is expressed through Equation (1):

$$\Delta\left(\frac{Y_{i,t}}{L_{i,t}}\right) = c\left[\ln\left(\frac{Y_{i,t}}{L_{i,t}}\right)^{*} - \ln\left(\frac{Y_{i,0}}{L_{i,0}}\right)\right] \qquad (1)$$

where Y = income, L = labour, i = country, region, t = time, c = constant, $\frac{Y}{L}$ = labour productivity.

According to Equation (1), the growth rate of labour productivity for country *i* at time *t* is determined by the difference between the labour productivity under steady conditions and the initial labour productivity. The greater is this difference, the higher the growth rate of productivity, and therefore, the regions with low initial productivity will be able to catch up with higher-productivity regions in the long term. Now, we employ conditional conversion and assume that steady state productivity is dependent on variables $Z_{i,\,t}$, which denote the characteristics of a country or region, and that the steady state productivity is not consistent, but varies on the basis of region and its characteristics. This aspect is represented by Equation (2):

$$\ln\left(\frac{Y_{i,t}}{L_{i,t}}\right)^{*} = a + bZ_{i,t} \qquad (2)$$

From equations (1) and (2), the following equation is derived:

[17] The conversion hypothesis suggests that all economies possess both absolute convergence, indicating that the convergence hypothesis occurs without any conditions, and conditional convergence, indicating that convergence theory occurs only under certain conditions. In analysing the data from various countries throughout the world, Barro (1997) and Barro and Sala-i-Martin (1995) found that although absolute convergence was not observed, the economies of the world tended to converge when factors such as educational levels, the proportion of government spending to income and the degree of democracy were excluded.

$$\Delta\left(\frac{Y_{i,t}}{L_{i,t}}\right) = a^{'} + b^{'} Z_{i,t} - c \ln\left(\frac{Y_{i,0}}{L_{i,0}}\right) \quad (3)$$

where $a^{'} = ac$ and $b^{'} = bc$ hold. Barro (1997) considered factors such as educational level, the ratio of government spending to income and the degree of democracy as variables that represent the characteristics of countries and regions. In this paper, years of education is adopted as a variable.

Next, the Harvard Model expresses labour productivity using the following identical equation:

$$\frac{Y_{i,t}}{L_{i,t}} \equiv \left(\frac{Y_{i,t}}{P_{i,t}}\right)\left(\frac{P_{i,t}}{L_{i,t}}\right) \quad (4)$$

where P: population,$\frac{Y}{P}$: per capita income and $\frac{P}{L}$: reciprocal of the labour force participation rate.

Considering the logarithm of both sides of Equation (4) and differentiating by time period, equation (5) is derived.

$$\Delta\frac{Y_{i,t}}{P_{i,t}} \equiv \Delta\frac{Y_{i,t}}{L_{i,t}} + \Delta L_{i,t} - \Delta P_{i,t} \quad (5)$$

Assuming that Equation (3) represents the growth rate of labour productivity and substituting Equation (5) with Equation (3), the following equation is obtained.

$$\Delta\frac{Y_{i,t}}{P_{i,t}} = a^{'} + b^{'} Z_{i,t} - c \ln\left(\frac{Y_{i,0}}{L_{i,0}}\right) + \Delta L_{i,t} - \Delta P_{i,t}$$

Disaggregating $\ln\frac{Y_{i,0}}{L_{i,0}}$ into $\ln\left(\frac{Y_{i,0}}{P_{i,0}}\right) - \ln\left(\frac{L_{i,0}}{P_{i,0}}\right)$ and substituting it into the above equation give us Equation (6):

$$\Delta\frac{Y_{i,t}}{P_{i,t}} = a^{'} + b^{'} Z_{i,t} - c^{'} \ln\left(\frac{Y_{i,0}}{P_{i,0}}\right) + d^{'} \ln\left(\frac{L_{i,0}}{P_{i,0}}\right) + \Delta L_{i,t} - \Delta P_{i,t} \quad (6)$$

where $c^{'} = d^{'}$.

Equation (6) shows that the growth rate of the labour force has a positive effect on the growth rate of the per capita income; however, the growth rate of the population has a negative effect on the growth rate of the per capita income. Additionally, the economy grows when the labour force is growing faster than the population.

In this analysis, population variables are used to explain economic growth, and for the major explanatory variables (exogenous variables) for ageing metrics, the elderly

population ratio or the elderly dependency ratio (ratio of elderly population to working-age population) and average life expectancy are used, along with the population growth rate and the growth rate of the labour force. In addition, the youth dependency ratio (ratio of youth population to working-age population) and the youth population ratio[18] are used as a population variable.

The empirical analysis uses a fixed effects model in which the real per capita economic growth rate is the dependent variable for the period from 1990 to 2017[19]. To make comprehensive international comparisons, the data from the University of Groningen's 'Penn World Table version 9.1',[20] the UN's 'World Population Prospects 2019' and Barro-Lee's 'Educational Attainment Database' are used.

The three following types of analysis are performed: (1) a panel data analysis once every 5 years during the 1990–2017 period (a total of six periods), (2) a panel data analysis once every 10 years each during the 1990–2017 period (a total of three periods) and (3) a trial calculation of the impact on economic growth using data from the UN population forecasts and data used (2) analysis. Analyses 1 and 2 examine the short-term and long-term effects, respectively, of ageing on the economic growth. Analysis 3 attempts to identify the impact on the future in a simplified manner. For the per capita real economic growth rate, the population growth rate and the labour force growth rate, the real GDP per capita in the initial year of each period and the labour participation rate in the initial year of each period are used, and these are expressed as base values (logarithms). For the other variables, the means for the relevant periods are used. The basic information of the data used is shown in Reference 1.

4.2 Results and Discussion

Tables 5 and 6 show the results of our empirical analysis.

(1) Panel data analysis for every five years during the period 1990–1999 (a total of six periods)

In all the models used, per capita real GDP in each period's initial year is statistically significant and negative in relation the per capita real economic growth rate, which is a

[18] Percentage of population aged 0-14 to total population.
[19] The F-test and the Hausmann test were also confirmed, and the fixed-effect model was adopted.
[20] Although the data in 'Penn World Table version 9.1' date back to 1960, for most Eastern European countries, data on real GDP, for instance, are not available until 1990. Because this reduces the sample size of the chronological data starting in 1960, data from 1990 until the most recent figures are used for the analysis.

dependent variable, implying that conditional convergence holds. The results were significant at the 1% level. Further, the growth rate of the labour force was statistically significant and positive in relation to economic growth. The coefficients of population growth rate were all negative and conformed with the Harvard Model, but were not statistically significant.

Among the population variables, the coefficients for the elderly dependency ratio and the elderly population ratio, which show the extent of ageing, were both negative in the models that used these variables. Although this comports with Bloom et al. (2010), these results were not statistically significant.

With respect to average life expectancy, these variables were all positive in relation to economic growth in all models, and the results were significant at the 1% level. As for the youth population ratio and the youth dependency ratio, the results revealed a negative impact on economic growth and were statistically significant at the 10% level. This result is consistent with the result of Bloom et al. (2010), which argues that the increase in the proportion of youth population has a negative impact on economic growth in the short term.

(2) Panel data analysis for every ten years during the period 1990–1999 (a total of three periods)

As in (1), in each model used, the per capita real GDP in each period's initial year had a negative correlation (statistically significant at the 1% level) with the dependent variable of per capita real economic growth. Similarly, the labour force's growth rate was also positive in relation to the dependent variables, confirming a statistically significant positive correlation with economic growth in the short and long terms. The coefficients of the population growth rates corresponded with the Harvard Model wherein these coefficients were all negative. However, the results were not statistically significant.

In all models, years of education has a positive impact on the dependent variables. In (1), the coefficient for years of education was positive for all models, but the levels were statistically significant only in Models 1, 2 and 3. It therefore seems that an increase in years of education has a positive impact on economic growth in the long term.

Further, with respect to population variables, in the models that used the elderly dependency ratio and the elderly population ratio to indicate the extent of ageing, the coefficients were negative and statistically significant at the 5% level. Although the study by Bloom et al. (2010) was unable to confirm that the elderly population ratio has a negative

impact in the long term, this analysis revealed a negative impact. Additionally, as in (1), the coefficients for average life expectancy were positive and statistically significant at 1% level in all models. The youth population ratio and youth dependency ratio were negative and significant at the 1% level in all models that adopted the variable.

Therefore, the results of (1) and (2) above are summarized as follows. The results show that an increase in the youth population ratio/ the youth dependency ratio has a negative impact on the economic growth in the short and long terms, and an increased elderly population ratio/ the elderly dependency ratio has a negative impact on the economic growth in the long term. As for increased life expectancy, the results show that it has a positive impact on economic growth in both the short and long terms.

Furthermore, an increase in the growth rate of the labour force has a positive effect on the economic growth in the short and long terms and that more years of education has a positive and statistically significant effect on the economic growth in the long term.

In an aged society, the higher proportion of elderly people will negatively impact economic growth in the long term, but the decline in the youth population ratio will spur economic growth. Increased life expectancy, increased labour force (including participation by the elderly and other people who want to work) and the strengthening of human capital through more years of education will offset the negative impact caused by the increased elderly population, and this aspect has the potential to support economic growth.

Table 5: Panel Data Analysis for Every Five Years during the Period 1990–1999 (a total of six periods)

	model1	model2	model3	model4
Real GDP per capita in each period's initial year(log)	-6.043 *** (-8.783)	-6.047 *** (-8.774)	-6.240 *** (-9.010)	-6.241 *** (-8.971)
Labor participation rate in each period's initial year(log)	-4.850 ** (-2.196)	-4.888 ** (-2.194)	-6.131 *** (-2.682)	-5.876 ** (-2.553)
Labor force growth rate	0.493 *** (3.748)	0.494 *** (3.748)	0.480 *** (3.651)	0.476 *** (3.617)
Population growth rate	-0.046 (-0.204)	-0.046 (-0.206)	-0.010 (-0.045)	-0.015 (-0.067)
Years of education	0.940 * (1.740)	0.956 * (1.729)	0.971 * (1.803)	0.788 (1.413)
Life expectancy	0.273 *** (3.694)	0.271 *** (3.625)	0.265 *** (3.593)	0.296 *** (3.928)
Elderly population ratio				-0.084 (-0.4702)
Youth population ratio				-0.166 * (-1.866)
Elderly dependency ratio		-0.014 (-0.139)		
Youth dependency ratio			-0.059 ** (-2.107)	
Year dummy	Yes	Yes	Yes	Yes
const	51.430 *** (4.697)	51.877 *** (4.542)	61.2491 *** (5.159)	59.5362 *** (4.763)
R^2	0.284	0.284	0.289	0.288
Number of observations	804	804	804	804

*** means significant at 1% level, ** means significant at 5% level, and * means significant at 10% level.
( ) Is t value.

Source: Author's calculation

Table 6: Panel Data Analysis for Every Ten Years for the Period 1990–1999 (a total of three periods)

	model 1'	model 2'	model 3'	model 4'
Real GDP per capita in each period's initial year(log)	-7.867 *** (-12.42)	-7.781 *** (-12.38)	-8.067 *** (-13.03)	-8.128 *** (-13.03)
Labor participation rate in each period's initial year(log)	-0.298 (-0.119)	-1.496 (-0.5916)	-4.077 (-1.546)	-4.684 (-1.764)
Labor force growth rate	0.544 *** (3.299)	0.588 *** (3.572)	0.529 *** (3.291)	0.562 *** (3.469)
Population growth rate	-0.196 (-0.660)	-0.300 (-1.008)	-0.107 (-0.370)	-0.231 (-0.786)
Years of education	1.059 ** (2.145)	1.270 ** (2.549)	1.016 ** (2.111)	1.097 ** (2.227)
Life expectancy	0.204 *** (2.872)	0.172 ** (2.395)	0.199 *** (2.868)	0.198 *** (2.804)
Elderly population ratio				-0.324 ** (-1.980)
Youth population ratio				-0.307 *** (-3.740)
Elderly dependency ratio		-0.221 ** (-2.280)		
Youth dependency ratio			-0.121 *** (-3.697)	
Year dummy	Yes	Yes	Yes	Yes
const	57.608 *** (5.261)	66.067 *** (5.760)	79.326 *** (6.515)	87.924 *** (6.750)
R^2	0.548	0.558	0.573	0.578
Number of observations	363	363	363	363

*** means significant at 1% level, ** means significant at 5% level, and * means significant at 10% level.
( ) Is t value.

Source: Authors' calculation

(3) Trial calculation of the impact on the economic growth using UN population forecast data

Here, a simple trial calculation based on Model 4' in (2) is attempted, using data from the UN population forecast to ascertain the impact of changing demographics (ageing) in East and Southeast Asia on their future economic growth.[21]

Forecast data from 2020 is available from the UN's World Population Prospects 2019 for the population growth rate, the elderly population ratio, the youth population ratio and life expectancy. For each data item, the average for each ten-year period from 2020 to 2059 is calculated, and the change in each period is multiplied by the coefficient of Model 4' to obtain a trial calculation of how changes in these explanatory variables would affect the per capita economic growth rate.

The results of the trial calculations are given in Table 7.[22] For each period, the per capita economic growth rate increased due to the decline in the population growth rate, longer life expectancy and the decline in the youth population ratio, but due to the negative impact of the increase in the elderly population ratio, the economic growth rate is expected to decline by approximately -0.5% to -1.0% points from the previous period from 2020 to 2059.

Table 7: Impact of Various Demographic Metrics on Economic Growth

	2020-2029	2030-2039	2040-2049	2050-2059
Population growth rate(% point)	0.1	0.1	0.1	0.0
Life expectancy(years)	0.3	0.3	0.3	0.3
Elderly population ratio(% point)	-1.7	-1.8	-1.5	-1.0
Youth population ratio(% point)	0.6	0.4	0.4	0.2
Real economic growth rate per capita(% point)	-0.7	-1.0	-0.7	-0.5

Source: Authors' calculation

[21] This trial calculation is a simplified estimation of the impact that changes in demographic structure will have on the economic growth on the basis of certain assumptions such as no change in years of education, initial economic standards and the initial labour participation rate. The estimates should thus be interpreted with some latitude.

[22] See Reference 2 for basic data on each metric.

As the increase in the elderly population would suppress economic growth, I also performed a trial calculation of how much the labour force growth rate would have to increase to offset this. Using the coefficients from Model 4′ and the changes in economic growth rates for each of the periods in Table 7, it was found that, based on period averages, a 1.0%–1.7 % points increase in the growth rate of the labour force could offset the abovementioned negative factor caused by the demographic changes (Table 8).

Table 8: Labour Force Growth Rate Required to Boost Economic Growth (period averages, change from prior period)

	2020-2029	2030-2039	2040-2049	2050-2059
Labour force growth rate(%point)	1.2	1.7	1.3	1.0

Source: Authors' calculation

Is it realistically possible to increase the labour force growth rate by 1.0% to 1.7 % points, as proposed by this trial calculation? The historical period-over-period growth rates (in terms of period averages) in East and Southeast Asia during the 1970–2017 period reveal that an increase of more than 1.5% points in each period indicate that it may be possible to offset the negative impact of changing demographics to a certain degree (Table 9). As the elderly population ratio is expected to continue growing, economic growth could be attainable if the labour force is increased by employing more women and elderly people and accepting foreign workers, or supplementing the labour force with robots.

Table 9: Historical Growth Rates in the Labour Force (period averages, change from prior periods)

	1970-1979	1980-1989	1990-1999	2000-2009	2010-2017
Labour force growth rate(%point)	3.5	2.9	1.8	1.6	1.5

Source: Prepared from the UN's World Population Prospects 2019.

5. Conclusion

East and Southeast Asian countries have undergone major demographic changes in a short time, and their populations are expected to age very rapidly due to declining birth rates and increased life expectancy. These regions' total population should begin to decline by 2040, earlier than other regions, and therefore, by 2060, these countries will become 'super-aged societies' wherein approximately 40% of the population is elderly. In the past, East and Southeast Asian countries achieved very high economic growth and were known as 'Asian Economic Miracles' because they benefited from the demographic dividend; however, now, they are transiting to a new era of experiencing 'demographic onus' and need to think about sustaining their economic growth.

This paper used the latest international panel data to perform a quantitative analysis regarding how demographic changes impact economic growth. These findings suggest that in an aged society, the higher proportion of elderly people will have a negative impact on the economic growth in the long term. However, increased life expectancy and a decline in the youth population ratio will support economic growth, and strengthening human capital by promoting labour force participation and extending the years of education could offset the negative effect of more elderly people in the population and thus boost the economic growth.

Furthermore, a trial calculation using the UN's forecast data confirmed that the higher ratio of elderly people in East and Southeast Asia will suppress the economic growth from 2020 on, and therefore, securing labour is a critical factor in supporting the growth of these economies. It is found that even now this can offset the negative impact of ageing to a certain degree. However, there is ample room for economic growth if more labour can be secured.

In addition to expanding employment of women and foreign workers, it is thus important to build a society where healthy elderly people are willing and able to work for a long time, as the transition to a 'super-aged society' is already in progress. To bring about such a society, technology is required, and it will enable people to live long healthy lives and will promote the building of a supportive environment for workers of all kinds, including the elderly. For example, automation and artificial intelligence (AI) will not only supplement the labour force directly but will extend the elderly people's career spans by promoting preventive care and various health initiatives to extend healthy life expectancy. Productivity growth can also be revived by enhancing contributions to human resources through upgrading elderly people's job skills and providing them with new tools that are tailored for

their jobs.

Most people tend to perceive ageing in a negative light, but a long life span and securing a long career life span will ensure extracting the optimum level of longevity dividend. It is important that East and Southeast Asian regions, which are on the cusp of becoming super-aged societies, maximise the benefits of this longevity dividend by committing themselves to having the ‘flexibility to change’ as pointed out by Bloom, Finley (2009), and having a strong commitment towards their work ethic and progress, aspects that have supported their remarkable economic growth in the past.

Appendix 1: Data used

Data	Source
Real GDP growth rate per capita(PPP$, 2011)	
Real GDP per capita in each period's initial year(PPP$, log)	Penn World Table version9.1, World Population Prospects 2019
Labour participation rate in each period's initial year(log)	
Labour force growth rate(%)	Penn World Table version9.1
Population growth rate(%)	World Population Prospects 2019
Avg. Years of Secondary Schooling(years)	Barro R. & J.W. Lee v. 2.2, June 2018
Life expectancy(years)	
Elderly population ratio(%)	
Youth population ratio(%)	World Population Prospects 2019
Elderly dependency ratio(%)	
Youth dependency ratio(%)	

Appendix 2: Basic statistics of each five-year period from 1990 to 1999 (a total of six periods)

Data	Avg.	Median	Max	Min	S.D.
Real GDP growth rate per capita(PPP$, 2011)	2.68	2.64	22.86	-25.00	0.17
Real GDP per capita in each period's initial year(PPP$, log)	8.96	9.05	11.68	6.20	0.04
Labour participation rate in each period's initial year(log)	3.66	3.70	4.40	2.28	0.01
Labour force growth rate(%)	1.97	2.05	25.07	-6.72	0.08
Population growth rate(%)	1.49	1.37	17.06	-4.50	0.05
Avg. Years of Secondary Schooling(years)	2.67	2.50	6.87	0.08	0.05
Life expectancy(years)	69.37	77.63	84.43	21.79	0.35
Elderly population ratio(%)	7.89	5.38	26.57	0.77	0.20
Youth population ratio(%)	29.96	29.52	51.20	12.38	0.39
Elderly dependency ratio(%)	12.27	8.55	43.92	0.92	0.28
Youth dependency ratio(%)	51.32	46.65	111.10	15.18	0.84

Appendix 3: Basic statistics of each ten-year period from 1990 to 1999 (a total of three periods)

Data	Avg.	Median	Max	Min	S.D.
Real GDP growth rate per capita(PPP$, 2011)	2.79	2.74	16.28	-15.86	0.19
Real GDP per capita in each period's initial year(PPP$, log)	8.90	9.03	11.68	6.21	0.06
Labour participation rate in each period's initial year(log)	3.67	3.71	4.31	2.29	0.25
Labour force growth rate(%)	2.00	2.01	16.25	-3.63	0.10
Population growth rate(%)	1.48	1.42	11.40	-1.50	0.07
Avg. Years of Secondary Schooling(years)	2.71	2.53	6.84	0.09	0.08
Life expectancy(years)	68.99	71.68	83.27	33.16	0.52
Elderly population ratio(%)	7.90	5.57	24.90	0.92	0.29
Youth population ratio(%)	29.97	29.41	50.17	13.07	0.58
Elderly dependency ratio(%)	12.29	8.74	40.25	1.08	0.42
Youth dependency ratio(%)	50.73	45.71	106.13	15.40	1.27

Appendix 4: Data used (period averages)

	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059
Population growth rate(%)	0.8	0.5	0.2	-0.1	-0.2
Life expectancy(years)	78.1	79.8	81.3	82.7	84.0
Elderly population ratio(%)	10.7	16.0	21.4	25.9	29.1
Youth population ratio(%)	19.0	17.0	15.6	14.3	13.7

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