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Vietnam's Population Projections and Aging Trends from 2010 to 2049

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Abstract

Based on Vietnam's 2009 population census, we use a population prediction model with three schemes (high, medium, and low) to predict the population and structural changes in Vietnam from 2010 to 2049, and we analyze the trend of Vietnam's future aging population. Our results show that (1) Vietnam's population will continue to increase in the next 40 years, but the population growth rate will continue to decline, and the population will exceed 100 million in approximately 2024; (2) Vietnam's demographic structure will change significantly as the fertility level and life expectancy increase; and (3) Vietnam will enter an aging society starting in 2018, while the degree of aging will continue to deepen. The proportion of the population over the age of 60 in Vietnam will exceed 25% of the total population by 2049. In the next 40 years, Vietnam will face the severe challenge of an aging population.

Keywords Vietnam · Aging · Population projections · Total fertility rate · Demographic structure

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Introduction

Backgroud

Vietnam has long been regarded as one of the most dynamic countries in Southeast Asia because of its large working-age population. The population of Vietnam was approximately 91.73 million as of July 2016, ranking 8th in Asia and 3rd in Southeast Asia (National National Bureau of Statistics of China, 2017). In the past 20 years, Vietnam has enjoyed the advantage of a demographic dividend and abundant human resources, which have attracted many foreign companies to invest in Vietnam and build factories, providing a strong impetus for Vietnam's economic development.

Although Vietnam has enjoyed the advantage of a demographic dividend over the past 20 years, the working-age population reached its peak in 2013 and is now beginning to show a downward trend, while the elderly population has been growing. However, Vietnam's "demographic transition" stage has begun to shift towards the aging population stage since 2011. There are two distinctive signs of this shift: (1) People's concept of fertility changes, leading to a decreased fertility rate and size of the young population under the influence of social and economic development, especially the national family planning policy; (2) With the improvement of living standards and improvement of medical and health conditions, the mortality rate will decline, life expectancy will be significantly extended, and the elderly population will continue to grow. Similar to other developing countries in the world, Vietnam is also facing a series of new challenges brought about by the aging issue.

Like China, Vietnam also implemented a family planning policy from 1981 to 2015, which means that each family, whether in an urban or rural area, has a maximum of only two children; minority families in the northern mountains and western and southwestern regions are able to have a maximum of three children. Vietnam's family planning has achieved great success over the past 30 years, but it also accelerated the process of the population aging in Vietnam. According to the Bureau of Population and Family Planning, number of elderly people in Vietnam was 10.1 million (11% of the total population) in 2016, of whom 2 million are over 80 years old. The issue of Vietnam's aging population is only beginning to emerge, the Vietnamese government has begun to face the problem of aging, and the population's aging has gradually become a hot topic of discussion. According to Giang Thanh Long et al. (2011), Ruan (2015), Ming (2016) and other scholars, Vietnam's future population aging will inevitably continue to intensify, and the speed of aging will be faster and faster. The impact of aging is not limited to the increase in the size of the elderly population, the dependency ratio, and the corresponding old-age security issue but will also involve other components of the population structure, which is a difficult problem for the whole society to face. This means that the population's aging will pose a serious policy challenge to Vietnam, which has a low level of social and economic development, because such a population will need to spend significant resources on health care, retirement distribution and social benefits. In other words, Vietnam will face the situation of "not getting rich before getting old" with a very high population that is aging, while per capita income will only reach the level of a low-income country (in 2010, the average per capita was approximately 1170 US dollars/year).

Literature Review

Population aging is one of the most important demographic features in the twenty-first century. Aging of the population affects all aspects of the economy and society including economic growth, the labor market, retirement policy, health, social security, education, socio-cultural activities and family life (Clark et al. 2015; Cloos et al. 2010; Knodel and Pothisiri 2015; Weil et al. 2015). Some literatures focus on the process and characteristics of global aging and have suggested that cultivating a healthy, active aging process must come with intergenerational insight and shared responsibility (Lutz et al. 2008; Makoni 2008; McDaniel 2015; Yenilmez 2015). Some literatures discusses the relationship between aging and economic growth and social development (Clark and Clark 2015; Clark et al. 2015; Hixon 2016). For example, many researchers use macro, meso, and micro processes to identify both the challenges and opportunities of aging in a sociocultural context (Abdulrahim et al. 2012; Karlin et al. 2014; McDaniel 2015; Twigg and Martin 2015). In the study of regional aging, some literatures compare the trends and characteristics of aging in different countries and regions (Cloos et al. 2010; Clark and Clark 2015; Karlin and Weil 2017), some literatures studies aging in different countries such as OECD countries, China and India and so on (Kapteyn 2010; Agarwal et al. 2016; Lu and Liu 2019).

However, research on Vietnam's aging problem is rare, both in foreign studies and in Vietnam. Foreign research includes only the "World Population Prospects" revised and published by the United Nations in 2011, which gives the general trend of population development in Vietnam and the rest of the world, including population aging. Regarding the impact of population aging on society and the economy, it is a common view that the aging of the population has both challenges and opportunities for social and economic development, and the challenge is greater than the opportunity (UNFPA, 2012). From an economic perspective, it will have certain adverse effects on labor productivity, distribution, savings and investment, and industrial restructuring. In Vietnam, research on population aging mainly includes studies by Nguyen (2006), Long et al. (2011), Nguyen and Thanh (2012), and Nguyen and My (2014), who focus on the characteristics of aging and an evaluation of the existing pension system. The most representative research is from Giang Thanh Long et al. (2011), who discussed the current status and characteristics of the aging population in Vietnam and discussed existing problems in Vietnam's pension insurance system, while providing some suggestions. However, the population aging data used in their research are based on the United Nations' Projection (UN, 2011) (only counting the proportion of people over 60 years old as the elderly population and ranking of the old-age coefficient without specific results for urban and rural areas or regarding gender), so his research is only focused on the characteristics of population aging.

Based on macro analysis, the perspective is confined to the field of demography and sociology, lacking some micro theoretical and empirical research and lacking comparative scientific expectations of the future development of aging in Vietnam with more research on the old-age security system for the aging issue. It can be seen that Vietnam's current research on the changing trends of aging needs to be deepened. The government and society still have great deficiencies in dealing with aging in the future.

Based on population data published by the Vietnam's National Bureau of Statistics in 2009, this paper first analyzes the current situation of the aging population in Vietnam and then uses the population prediction model to predict the population and structure of Vietnam from 2010 to 2049 to obtain the trend and basic path of the aging population in Vietnam. The

remainder of this paper is organized as follows: The second part introduces the population prediction model, parameter estimation, and scheme design for population prediction; the third part gives the simulation results of population changes and structural changes with the trend of the aging in Vietnam; and the final part offers preliminary conclusions and further discussion.

Model and Method

Population Prediction Model

In this work, we strive to predict the population and age structure of Vietnam from 2010 to 2049. First, according to the tasks and objectives of this work, we use the total fertility rate in urban-rural and specific birth in the model to reflect the changes in the future fertility level of Vietnam. Second, we divide the population according to the urban resident population and rural resident population in the model. Third, the age survival rate of the population is required in the model. According to the Princeton West Model Life Table, we use the life expectancy and age-specific survival rates to obtain a complete life table of urban-rural areas and genders for each forecast year. Finally, this model also considers the impact of factors such as fertility patterns and sex ratio at birth.

Our population prediction model uses the discrete dynamic model of the Leslie matrix (Li et al. 2019). According to the population transfer balance basic equilibrium equation $P(t+1) = AP(t) + G(t)$, we obtain the following prediction matrix model for the urban and rural population by gender and age:

$$\begin{cases} P^{(1)w}(t+1) = S^{(1)w}(t+1) \times P^{(1)w}(t) + E^{(1)w}(t+1) \times P^{(1)w}(t+0.5) - G^{w}(t+1) \\ P^{(1)m}(t+1) = S^{(1)m}(t+1) \times P^{(1)m}(t) + E^{(1)m}(t+1) \times P^{(1)w}(t+0.5) - G^{m}(t+1) \\ P^{(2)w}(t+1) = S^{(2)w}(t+1) \times P^{(2)w}(t) + E^{(2)w}(t+1) \times P^{(2)w}(t+0.5) + G^{w}(t+1) \\ P^{(2)m}(t+1) = S^{(2)m}(t+1) \times P^{(2)m}(t) + E^{(2)m}(t+1) \times P^{(2)w}(t+0.5) + G^{m}(t+1) \end{cases} \tag{1}$$

where $P^{(1)w}(t+1)$ and $P^{(1)m}(t+1)$ respectively represent the age column vectors of rural female and male populations at the end of year $t+1$; $P^{(2)w}(t+1)$ and$P^{(2)m}(t+1)$分 respectively represent the age column vectors of urban female and male populations at the end of year $t+1$; and $P^{(1)w}(t+0.5)$ and $P^{(2)w}(t+0.5)$ satisfy the following relationship[1]:

$$\begin{cases} P^{(1)w}(t+0.5) = T \times P^{(1)w}(t) \\ P^{(2)w}(t+0.5) = T \times P^{(2)w}(t) \end{cases}$$

$$T = \begin{bmatrix} 0.5 & 0 & \cdots & 0 & 0 \\ 0.5 & 0.5 & \cdots & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \cdots & 0.5 & 0 \\ 0 & 0 & \cdots & 0.5 & 0.5 \end{bmatrix} \tag{2}$$

[1] The equation shifts the female population cohort to the middle of the year to consistent with the median cohort population in the age-specific fertility rate.

The equation group (1) consists of four equations, namely, the transfer equations for rural women, rural men, urban women and urban men. Use the first equation as an example to illustrate the meaning of the matrix and the parameters. Definition:

$$S^{(1)w}(t+1) = \begin{bmatrix} 0 & \cdots & 0 & 0 \\ {S^{(1)w}}_0(t+1) & \cdots & 0 & 0 \\ \vdots & \ddots & \vdots & \vdots \\ 0 & \cdots & {S^{(1)w}}_{n-2}(t+1) & 0 \end{bmatrix} \tag{3}$$

$$E^{(1)w}(t+1) = \begin{bmatrix} SRB^{(1)w}(t+1)k^{(1)}(t+1)\left(B1^{(1)}(t+1) + B2^{(1)}(t+1) + B3^{(1)}(t+1)\right) \\ 0 \quad \cdots \quad 0 \quad 0 \\ \vdots \quad \ddots \quad \vdots \quad \vdots \\ 0 \quad \cdots \quad 0 \quad 0 \end{bmatrix} \tag{4}$$

where $S^{(1)w}(t+1)$ represents the survival rate matrix of rural women, which consists of the survival rate of women of different ages ${S^{(1)w}}_x(t+1)$ in year $t+1$, of which $x = 1, \cdots, 100$. The base period of the model is based on age population data from 0 to 100 (we have a population of over the age of 100 as a cohort; since this is not the highest age of the population, we give a separate probability of this cohort population surviving to the next year in the model).

$E^{(1)w}(t+1)$ represents the population number matrix of rural baby girls (0 years old). The matrix is 0 except for the first row. Row vector $SRB^{(1)w}(t+1)k^{(1)}(t+1)(B1^{(1)}(t+1) + B2^{(1)}(t+1) + B3^{(1)}(t+1))$ represents the average number of children born to women of different ages. The line vector from the 16th to the 50th element is not 0 (defining the female's reproductive age as 15–49 years old), and the remaining elements are 0. $SRB^{(1)w}(t+1)$ in the row vector, which indicates the survival rate of rural baby girls born in year $t+1$ who survived to $t+1$ at year-end, and $k^{(1)}(t+1)$ indicates the ratio of rural baby girls in year $t+1$ to the total number of rural babies born in the same year; here, $Bi^{(1)}(t+1) = TFR_i^{(1)}(t+1)({b_i^{(1)}}_0, \cdots, {b_i^{(1)}}_{n-2}, {b_i^{(1)}}_{n-1})$, $i = 1, 2, 3$ indicates the average number of i children born to women of childbearing age in rural areas in year $t+1$ (in which $i = 3$ means three children and above), $TFR_i^{(1)}(t+1)$ is the total fertility rate of i children of childbearing-age for rural women in year $t+1$; and $({b_i^{(1)}}_0, \cdots, {b_i^{(1)}}_{n-2}, {b_i^{(1)}}_{n-1})$ is the fertility model of i children of childbearing-age for rural women, that is, the age distribution of i children of childbearing-age for rural women.

The migration population parameters $G^{(1)w}(t+1)$ and $G^{(1)m}(t+1)$ are used in the model. They respectively represent the populations that migrated from rural areas in Vietnam to urban areas by gender and age in year $t+1$.

The above models are implemented by MATLAB programming.

Population Base Period Data and Parameter Estimation

Population Base Period Data

Our population prediction model uses population data by urban-rural area, gender and age groups. Therefore, the base period data we adopted are the population data released by Vietnam's National Bureau of Statistics in 2009.

According to statistics released by Vietnam's National Bureau of Statistics in 2009, the total permanent population in Vietnam is 85.847 million, of which the male population is 42.414 million and the female population is 43.439 million. The urban population is 25.564 million, and the rural population is 60.41 million. The population age structure of Vietnam in 2009 is shown in Fig. 1.

The horizontal axis in Fig. 1 represents the age of different queues, and the vertical axis represents the population size. Figure 1 shows the population size and distribution of the different age cohorts for urban-rural dwellers and gender in Vietnam in 2009. From Fig. 1, it can be seen that both the numbers of males and females in urban and rural areas are roughly the same, and the rural population is far larger than the urban population.

The Pattern of Childbearing in Urban and Rural Areas

Due to the lack of data on age-specific fertility rates in Vietnam, it is very difficult for us to obtain the pattern of childbearing in urban and rural areas in Vietnam. For this reason, we use China's urban-rural childbearing model in 1990 to replace it. This is because first, the total fertility rate of China was 2.1 in 1990, which is similar to the total fertility rate in Vietnam in 2009. Second, Vietnam has been influenced by the Chinese culture circle for a long time and has a similar experience to Chinese culture and customs.

Sex Ratio at Birth

The model needs to use births and sex ratios in urban and rural areas over the years. The historical data of the birth sex ratio came from Vietnam's National Bureau of Statistics. Because of the volatility and growth trend of historical data, we use the average method to show the average value of the sex ratio at birth for urban and rural areas over the years and use the average sex ratio at birth (constant) in the future years.

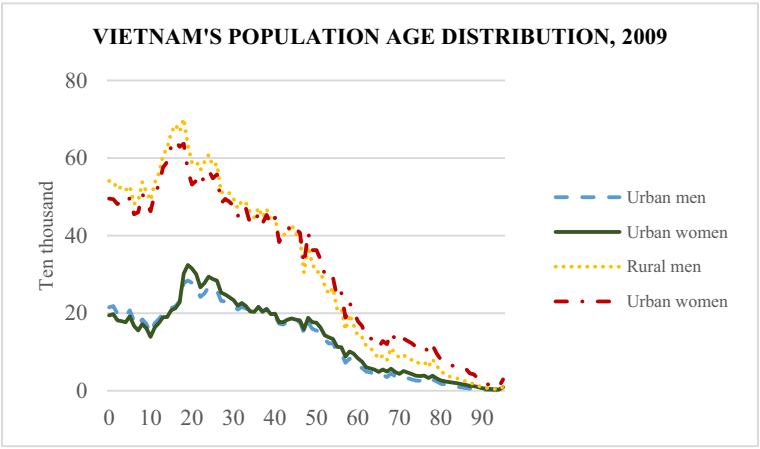


Fig. 1 Vietnam's population age distribution, 2009

Survival Rate

The model needs to provide the survival rates of urban and rural dwellers and gender and age groups over the years. For this reason, we first use the life table of the Princeton West model and combine it with our projected life expectancy for urban and rural dwellers in Vietnam each year, and we create gender-specific life tables for all years; we then obtain the full life table. Then, we obtain the survival rate of the transition to the next age for all age cohorts through the full life table. In the complete life table, we use the age of 95 and above as an age group and calculate the survival rate of this age group separately.

Mobility

The migration rate in the model refers to the ratio of rural population to urban population. Here, we ignore that the population will move into and out of Vietnam in the future. Considering the process of urbanization in Vietnam, we only assume that Vietnam's future population will continue to move from rural to urban areas. To this end, we use the linear extrapolation of Vietnam's urbanization rate over the years to obtain the urbanization rate in 2049, then linearly interpolate the urbanization rate for each year from 2010 to 2049, calculate the annual increment, and obtain the annual migration rate (i.e., the ratio of rural population to urban).

Population Prediction Scheme

The control variable of Vietnam's population prediction model is the fertility level, which is the total fertility rate used for urban and rural and childbearing determinations. Different population predictions will be obtained based on different fertility levels. Here, we consider three possible childbearing fertility levels, which form high, medium, and low prediction schemes.

The specific scheme is designed as follows. First, based on Vietnam's total fertility rate of 2.03 in 2009, the total urban fertility rate was 1.8, and rural areas had a rate of 2.4. Second, we forecast three total fertility rates for Vietnam in 2049, which are divided into high, medium and low, and the results are shown in Table 1. We predict that fertility levels in Vietnam will be lower in the future than they are now. So, we design three scenarios for fertility levels in 2049. Table 1 shows the total fertility rate of urban and rural areas and childbearing under high, medium, and low schemes in 2049.

Finally, we use the total fertility rate of urban and rural areas in Vietnam in 2009 as the starting point to obtain the total urban-rural fertility rate for the years from 2009 to 2049 through a linear interpolation. We then split the total fertility rate of urban and rural to obtain the subtotal fertility rate in the coming years.

The specific resolution method is as follows: First, fix the total fertility rate of the first child as 0.9, and then, subtract 0.9 from the total urban-rural total fertility rate over the calendar year (e.g., 1.6–0.9 = 0.7). Divide the remaining values by 80%:20%,[2] where 80% corresponds to (0.7 × 0.8 = 0.56) data for the total fertility

[2] The determination of the ratio of 80:20% refers to the actual data of the 2009 Vietnam census. Considering that the continued decline in the future fertility level includes a decline in the second birth fertility rate and the reduction of the three and above birth fertility rate, we keep the ratio unchanged.

Table 1 Total fertility rate of urban-rural areas and childbearing under high, medium, and low schemes in 2049

Schemes	$TFR^{(1)}$	$TFR1^{(1)}$	$TFR2^{(1)}$	$TFR3^{(1)}$	$TFR^{(2)}$	$TFR1^{(2)}$	$TFR2^{(2)}$	$TFR3^{(2)}$
High	2.0	0.9	0.88	0.22	1.8	0.9	0.72	0.18
Medium	1.8	0.9	0.72	0.18	1.6	0.9	0.56	0.14
Low	1.6	0.9	0.56	0.14	1.4	0.9	0.4	0.10

Explanation: The above are the total fertility rates in 2049, where $TFR^{(1)}$ indicates the total rural fertility rate, $TFR^{(2)}$ indicates the total urban fertility rate, and the other figures are the corresponding childbearing TFR

rate of two children and 20% (0.7 × 0.2 = 0.14) corresponds to the total fertility rate of three or more children.

Analysis of Population Forecast Results

The Size and Change of Vietnam's Population

Based on our population prediction model, we can provide the change of Vietnamese population and institutions by using the base data and the estimated model parameters. Figure 2 (a) and (b) respectively show changes in the total population and population growth rates of Vietnam from 2010 to 2049 under three schemes.

As seen in Fig. 2(a), the total population of Vietnam has been on the rise in the future under all three schemes. According to the results of the medium scheme, by 2024, Vietnam's total population will exceed 100 million, reaching 107 million people, and Vietnam's total population will reach 113.7 million people by 2049. The total

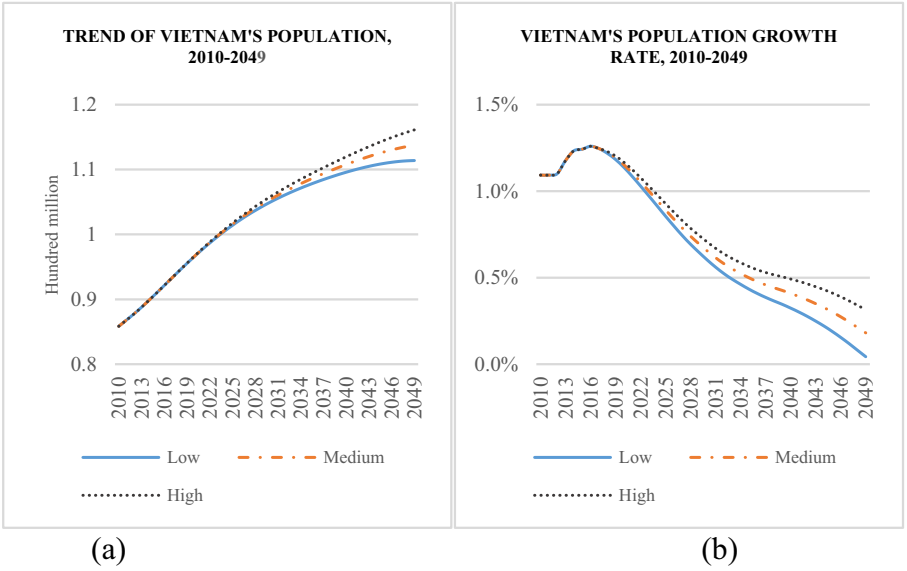


Fig. 2 Vietnam's population and growth rate, 2010–2049

population under the low scheme is 111.4 million people by 2049, and the total population under the high scheme is 116 million people. With the continuous decrease in the total fertility rate, although the total population of Vietnam has been growing, the growth rate has shown a tendency of rising first and then decreasing, as shown in Fig. 2(b). During the period of 2010–2049, the population growth rate will reach its peak in approximately 2016, which is 1.26%, and the population growth rate will continue to decrease from 2016; the population growth rate under the medium scheme will be reduced to approximately 0.2% by 2049.

From Fig. 3, there are two differences between us and the World Population Prospects 2019 (UN, 2019). On the one hand, our population projection is higher than that of the World Population Prospects 2019 (medium variant). At the same time, the range of total population change under the three scenarios predicted by us is smaller than that predicted by World Population Prospects 2019. For example, in 2049, the total population of Vietnam predicted by us under the three scenarios is 117, 114 and 111million respectively, while that of World Population Prospects 2019 is 118, 109 and 101 million respectively. On the other hand, even in the low scenario, we predict that Vietnam's total population will continue to rise until 20,149, while the low scenario of World Population Prospects 2019 indicates that Vietnam's total population will begin to decline in 2037.

Figure 4 shows the changes in subpopulations in Vietnam during 2010–2049 under the medium scheme.

From Fig. 4, it can be seen that the size of the urban population in Vietnam has been rising rapidly with the continuous growth of the total population. The urban population will reach 60.579 million people by 2049. At the same time, the rural population increased slightly before 2023 and reached its peak by 2023, followed by a downward trend. The rural population dropped to 53.188 million people by 2049. At this time, the proportion of urban population in the total population is 53.2%.

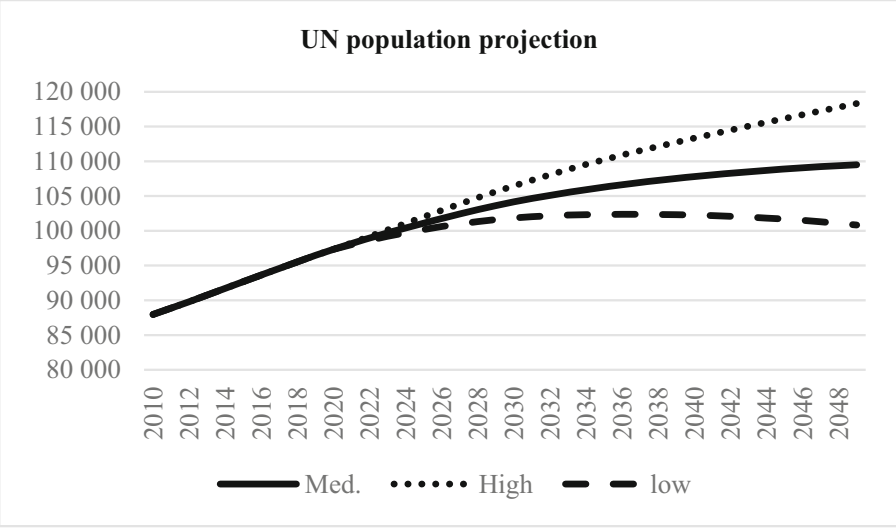


Fig. 3 Vietnam's total population projection of World Population Prospects 2019. Data source: http://creativecommons.org/licenses/by/3.0/igo/

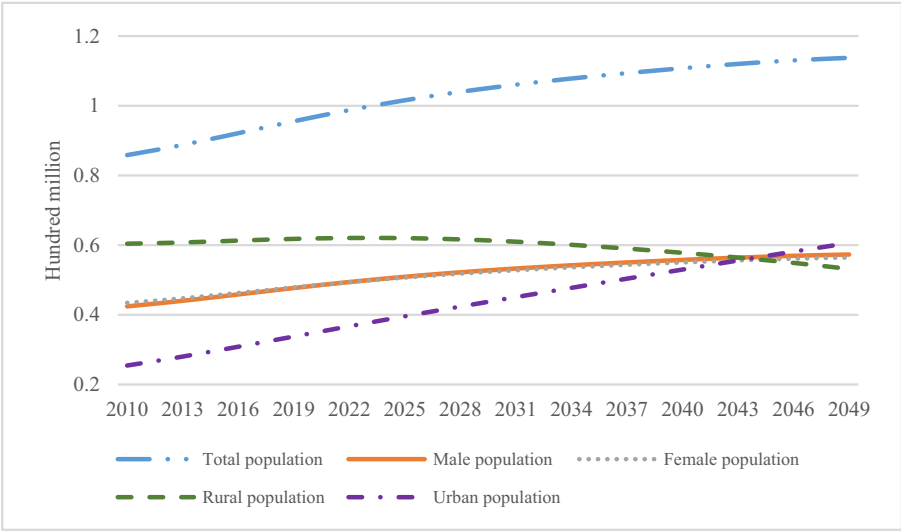


Fig. 4 Vietnam's sub-population, 2010–2049

Demographic Structure and Changes in Vietnam

Although Vietnam's population will continue to increase in the future, Vietnam's demographic structure will change significantly. Figure 4 shows the population pyramids of Vietnam in 2019, 2029, 2039 and 2049. From these graphs, we can see the trend of the population structure in Vietnam.

As seen in Fig. 5, Vietnam's population structure will turn from a typical pyramid shape to a similar columnar structure in the next 40 years. This also indicates a significant change in Vietnam's population structure. Table 2 shows the average age, median age and child-dependency ratio of Vietnam's population in 2010–2049 under the medium scheme.

As seen in Table 2, the average age of Vietnam's population will increase from 30.23 to 40.69 from 2010 to 20,149, with an average annual increase of 0.26. The median age will increase from 27.91 to 40.47, with an average annual increase of 0.31, and the child-dependency ratio will decrease from 0.366 to 0.291, indicating a decline in the birth population relative to the labor population.

At the same time, the number and structure of Vietnam's labor population have also changed significantly. Figure 5 shows the number, structure, and trends of Vietnam's labor population from 2009 to 2049 under the medium scheme.

As seen in Fig. 6, the working-age population in Vietnam continues to grow from 2010 to 2040, but it will begin to decline after 2040. The size of the working-age population will reach the highest value at 68.3 million by 2040, then drop rapidly to 56.40 million by 2049. The trend of changes in the size of the labor population is different from the actual proportion. In addition to the slight increase in the proportion of the labor population during the period 2010–2015, the ratio of the labor population to the total population in Vietnam from 2016 to 2049 shows a downward trend. From Fig. 5(b), it can be seen that the ratio of the labor population in Vietnam to the total

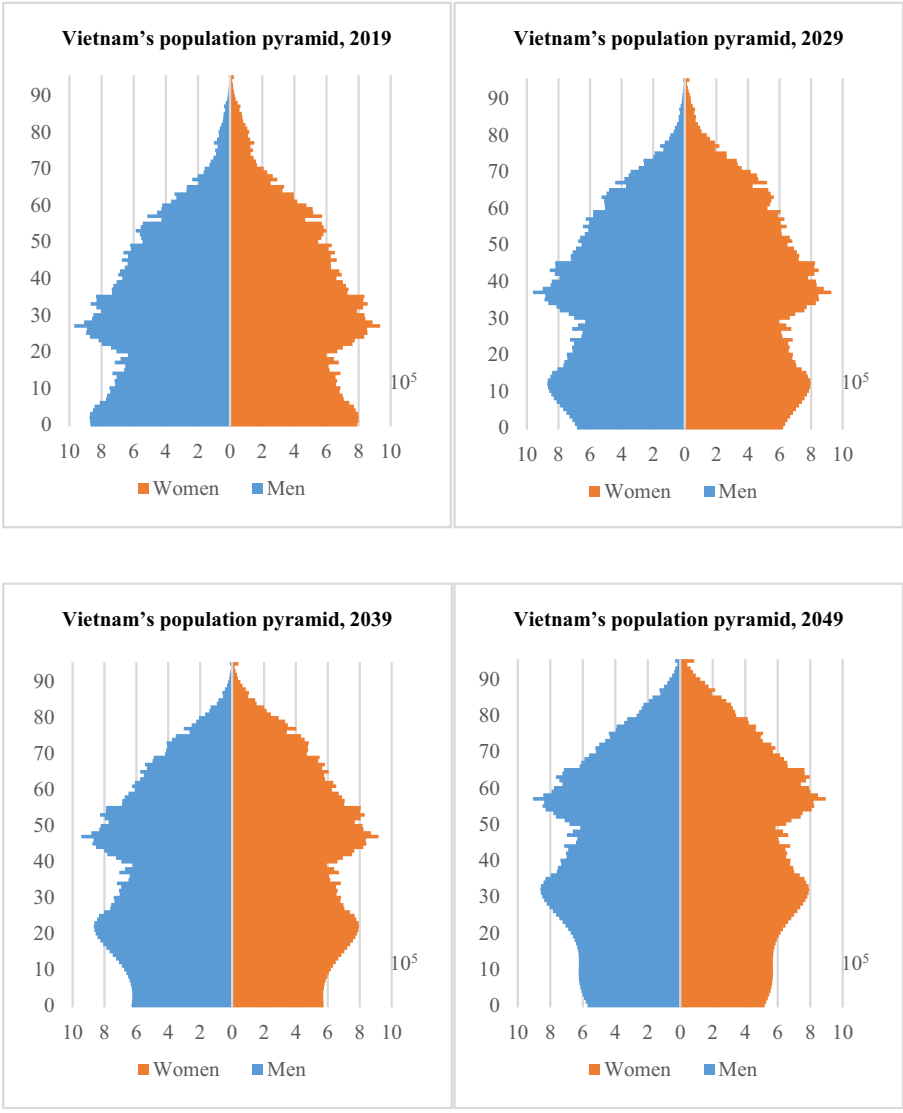


Fig. 5 Vietnam's population pyramid in 2009, 2019, 2029, 2039 and 2049

population was 66.93% in 2010 and then fell to 57.96% by 2049. This indicates that the social-dependency ratio of Vietnam will continue to increase in the next 40 years.

Trend of Aging in Vietnam

Key Aging Indicators in Vietnam

The main indicator for measuring population aging is the old-age coefficient, which is the ratio of the elderly population to the total population. International regulations usually use the proportion of the population over 60 years old in the total population or

Table 2 Average age, median age and child-dependency ratio of Vietnam's population, 2010–2049

	2010	2019	2029	2039	2049
Average age	30.23	32.16	35.05	38.25	40.69
Median age	27.91	31.1	35.33	38.69	40.47
Child-dependency ratio	0.366	0.365	0.354	0.292	0.291

the proportion of the population over 65 years old in the total population to measure the degree of population aging. Figure 6 shows the changing trend of the old-age coefficient of Vietnam from 2010 to 2049 under the high, medium and low schemes, respectively.

As seen in Fig. 6 (a), the proportion of Vietnam's residents over the age of 60 in the total population shows a trend of steady and rapid growth at the beginning. The proportion of the population over the age of 60 in Vietnam under the medium scheme accounted for only 8.69% of the total population in 2010. This proportion will increase to 25.05% by 2049. As seen in Fig. 6 (a), there is no significant difference in the old-age coefficient between the three schemes before 2018, and there is a certain difference after 2019. By 2049, the old-age coefficient of three schemes will be 24.54% (high), 25.05% (medium) and 25.58% (low), respectively.

In Fig. 6 (b), it can be seen that the proportion of population over the age of 65 in Vietnam remained relatively stable or even slightly decreased in the first few years and began to grow rapidly after 2015. The proportion of the population over the age of 65 when compared to the total population was 6.4% in 2010, and this proportion will increase to 18.42% by 2049. Comparing the three schemes, there was no significant difference in the old-age coefficient before 2019. Differences began to appear after that

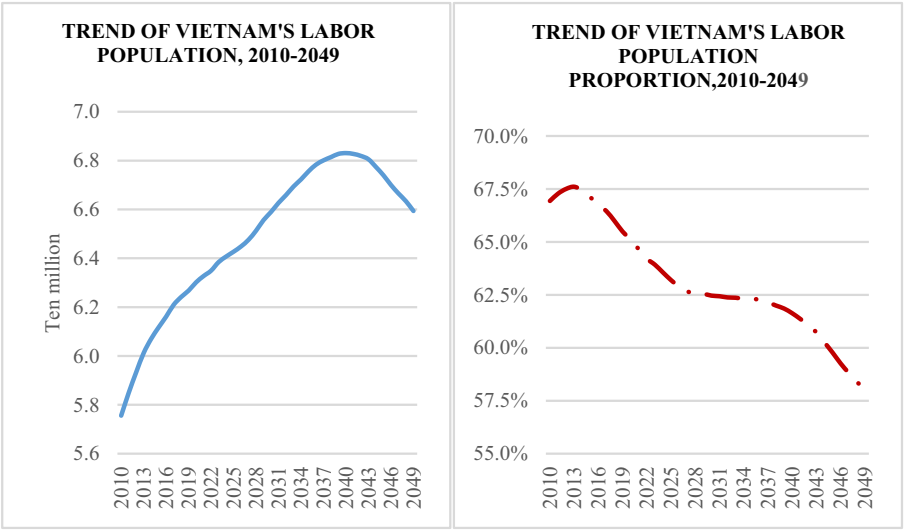


Fig. 6 Changes in the number and proportion of Vietnam's labor population, 2010–2049

time. By 2049, the old-age coefficients under the three schemes were 17.98% (high), 18.35% (medium) and 18.74% (low).

Comparing Fig. 6(a) and (b), we can see that the proportion of the population over the age of 60 in Vietnam will exceed 10% by 2018, which means that Vietnam will officially enter the aging stage beginning in 2018 Fig. 7.

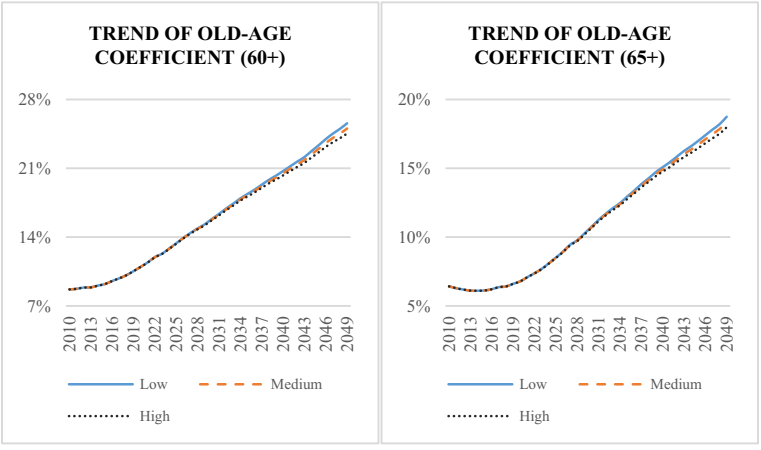
The aging index of the population shows the aging population structure from another angle. The aging index is the ratio of the number of people aged 60 and over to the population aged 14 and below. This indicator reflects the structural characteristics of the socially dependent population. Figure 8 shows the trend of the aging index in Vietnam in 2010–2049.

As seen in Fig. 8, the aging index of Vietnam from 2010 to 2049 displays an upward trend. Under the medium scheme, the aging index in 2010 was 0.36, which increased to 1.48 by 2049. This means that among Vietnam's population in 2010, each teenager under 14 years old corresponds to 0.36 over 60-year-old elderly people, and by 2049, each teenager under 14 years old corresponds to 1.48 over 60-year-old elderly people. Comparing the high, low and medium schemes can give an indication of the aging index. The aging index under the three schemes in Vietnam was 0.36 by 2010. By 2049, the aging index will be 1.36 (high), 1.48 (medium), and 1.62 (low) Table 3.

Figure 9 shows the trend of the net increment of the elderly population in Vietnam from 2010 to 2049.

It can be seen from Fig. 8 that the net increase in the elderly population in Vietnam from 2010 to 2049 is the same as that of the aging coefficient and aging index. Influenced by the age structure of the population, the annual increase in the elderly population fluctuates significantly every year but has been growing rapidly. For example, the net increase in the elderly population in Vietnam was only 19,000 in 2010. The net increase in the elderly population rose to 634,000 by 2049.

Figure 10 shows the changing trend of the newly increased proportion of Vietnam's elderly population. The newly increased proportion of the elderly population refers to the proportion of the elderly population with a net increase each year.



(a) (b)

Fig. 7 Trend of the proportion of the population of ages 60 and 65 in Vietnam under three schemes, 2010–2049

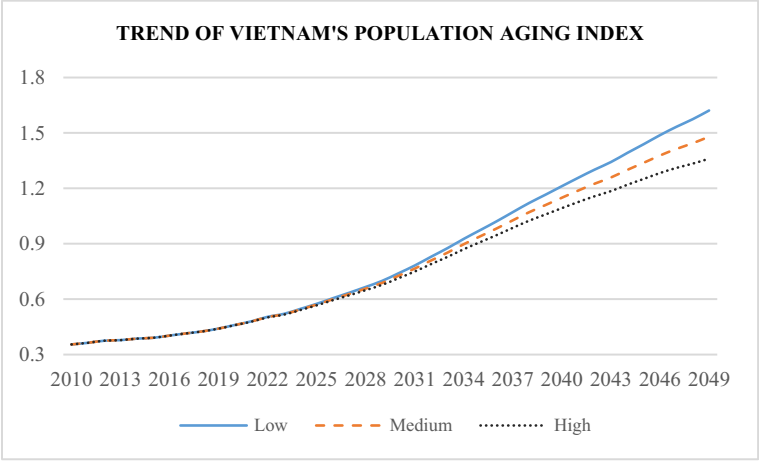


Fig. 8 Trend of Vietnam's population aging index, 2010–2049

From Fig. 10, it can be seen that the proportion of newly increased elderly population has shown a trend of rising first and then decreasing, whether in rural or in urban areas. Influenced by the newly increasing population fluctuations in the elderly population, the proportion of the newly increased elderly population in Vietnam is also very unstable. However, it can be seen clearly in Fig. 9 that the proportion of the new elderly population in the urban areas is much higher than that in the rural areas, which means that the urban aging issue is much more serious than that of the rural areas.

In short, Vietnam will enter an aging society in approximately 2018. Meanwhile, the aging of Vietnam will be characterized by accelerated development in the future.

Sensitivity Analysis of Major Aging Indicators

In this section, we conduct sensitivity analysis of aging indicators. First, considering that rural workers in Vietnam often work well into their lives as long as they can work. Secondly, for the urban working population, by appropriately extending the retirement

Table 3 The trend of Vietnam's old-age coefficient, aging index and old-age dependency ratio in 2010–2049

		2010	2019	2029	2039	2049
Old-age coefficient	Low	0.087	0.105	0.153	0.202	0.256
	Medium	0.087	0.105	0.1525	0.2	0.25
	High	0.087	0.105	0.152	0.199	0.245
Aging index	Low	0.355	0.441	0.699	1.166	1.621
	Medium	0.355	0.4408	0.688	1.110	1.480
	High	0.355	0.4405	0.677	1.059	1.361
Old-age dependency ratio	Low	0.355	0.5255	0.592	0.603	0.705
	Medium	0.355	0.5257	0.598	0.616	0.723
	High	0.355	0.526	0.604	0.629	0.741

Old-age dependency ratio defines as the ratio of population aged 60+ per 100 population 15–59

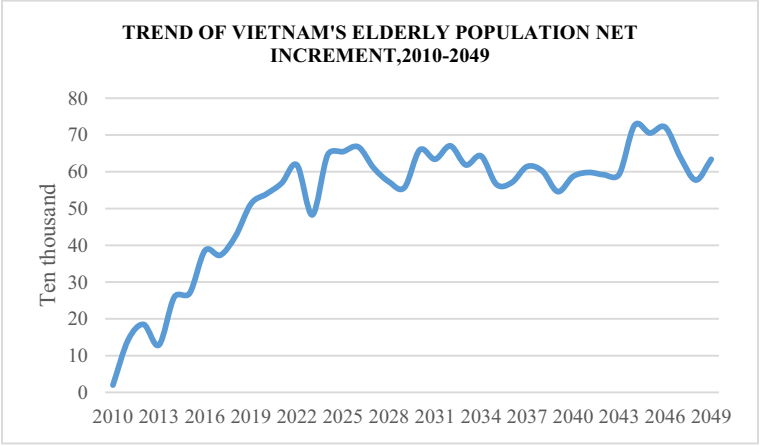


Fig. 9 Trend of Vietnam's elderly population net increment, 2010–2049

age, the labor supply can also be increased and the old-age dependency ratio can be reduced. Therefore, we take 65+ and 70+ as the old population standards respectively to calculate the situation of key aging indicators in 2049. Table 4 presents important results.

We use 60+ as the benchmark for the elderly population, and compare key aging indicators when 65+ and 70+ are defined as the elderly population respectively. From Table 4, in the medium scenario, the aged coefficient is 0.184 and 0.121 in 2049 respectively, which is 26.4% and 51.6% lower than the benchmark. The aging index is 1.09 and 0.715, respectively, down 26.4% and 51.7% from the benchmark. The old-age dependency ratio is 0.448 and 0.251, respectively, down 38% and 65.3% from the benchmark. Therefore, raising the age standard of the elderly can effectively improve the aging degree of society.

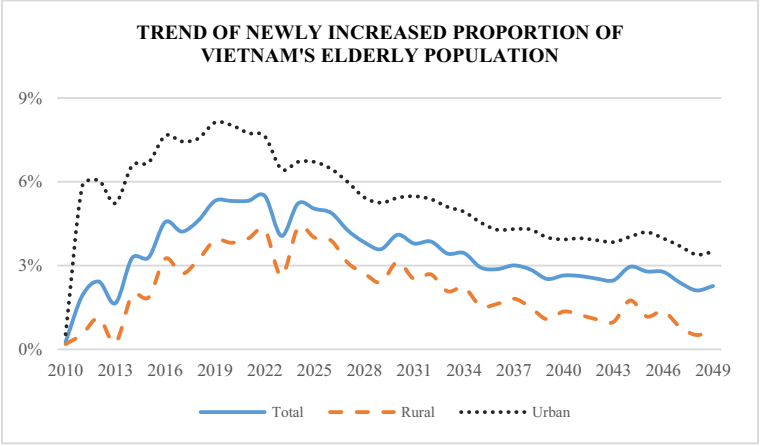


Fig. 10 Trends of the newly increased of elderly population in urban-rural areas in Vietnam, 2010–2049

Table 4 Vietnam's aging indicators in 2049 at the age of 60, 65 and 70 respectively

		60	65	70
Old-age coefficient	Low	0.256	0.180	0.119
	Medium	0.250	0.184	0.121
	High	0.245	0.187	0.123
Aging index	Low	1.621	1.19	0.714
	Medium	1.480	1.09	0.715
	High	1.361	1.00	0.720
Old-age dependency ratio	Low	0.705	0.437	0.250
	Medium	0.723	0.448	0.251
	High	0.741	0.454	0.257

Conclusion

This paper uses the population forecast model to predict the population and age structures of Vietnam from 2010 to 2049. The forecast results indicate the following: (1) The future population of Vietnam will always increase, but the growth rate will be slower and slower. The total population will exceed 100 million in 2024, and the total population will reach 113.7 million by 2049. (2) There will be significant changes in the population structure of Vietnam. The average age and median age of the population will continue to increase. The size of the labor population will increase first and then decline, and the ratio of social dependency will continue to increase. (3) Vietnam will enter an aging society in 2018, and its aging level will continue to deepen. By 2049, the old-age coefficient in Vietnam will exceed 25%; one in four people will be over 60 years old. In view of low social and economic development and low urbanization level with severe urban-rural differences, Vietnam is facing a very severe aging challenge in the future. Dealing with this challenge is a major task for Vietnam to address and thus achieve sustainable social and economic development in the future.

For this purpose, we propose the following proposals.

(1) To raise the awareness level of decision-makers and the society as a whole about the aging population. In fact, if policy makers and all members of society are not aware of the extend of Vietnam's aging population, many of the problems of aging will not be solved.
(2) The government should formulate development strategies to cope with the aging population and constantly improve the social security level of the elderly. For example, the government should reform the retirement system, improve the pension system, and strengthen medical and health services for the elderly.
(3) The government should learn from the experience of developed countries, establish a multi-form system for the elderly, focusing on home-based and community-based care.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval This article does not contain any studies with human participants or animals performed by any of the authors.

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