



## POPULATION AGING, MARGINAL PROPENSITY TO CONSUME, AND ECONOMIC GROWTH



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### ABSTRACT

*This paper explores the mechanism of population aging affecting economic growth by influencing marginal propensity to consume. We find that population aging has both a positive and a negative effect on economic growth. We calculate the critical state of the two effects and draw the conclusion that if marginal propensity to consume is greater than the critical value, the decrease of marginal propensity to consume has a more directly impact on consumption and, therefore, that the negative influence of the decreasing consumption dominates the impact on economic growth. Conversely, if the marginal propensity to consume is less than the critical value, capital per capita is affected more and, therefore, the positive influence of the rising capital per capita on economy is dominant.*

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**Keywords:** Population aging, Economic growth, Marginal propensity to consume, Capital per capita, Production function, Critical value.

**JEL Classification:** E21, J11, O11.

Received: 23 April 2016/ Revised: 25 May 2016/ Accepted: 1 June 2016/ Published: 8 June 2016

### Contribution/ Originality

We consider the influence of marginal propensity on economic growth from the perspective of defining the marginal propensity to consume of the whole society and find that population aging has both a positive and a negative effect on economic growth.

### 1. INTRODUCTION

Population aging is a serious and universal social problem, especially in terms of its powerful influences on countries' economic growth. In modern society, many developed countries have become aging societies one after another, such as France, Germany and Italy. In recent years, emerging markets like China also have become aging societies. Population aging has a profound effect on the supply of labor, capital per capita, labor growth rate, saving rate, consumption structure, and every other aspect of an economy, which is the key to a country's economic policy and population policy. Therefore, it is necessary to work out the mechanism(s) by population aging influences economic growth. With the great improvement in living standards and medical treatment conditions over recent decades, the average life expectancy of Chinese has been increasing. It was just 35 in 1949 but increased to 65 in the early 1980s and exceeded 73.5 in 2010, more than double that of just 60 years earlier (Wang, 2010). According to the

standard of the World Health Organization, a country is defined as a longevity country if people's average life expectancy is above 70. In other words, China entered the ranks of the longevity countries before 2000, revealing the current situation of the ever-growing aging population at the same time.

At the same time, the birth rate of China is decreasing constantly. In 1949, the birth rate was 36.00‰, but decreased to 14.03‰ by 2000. Since 2006, the birth rate of China has stayed at about 12‰ (National Bureau of Statistics). Now, China is in serious low-birth-rate condition. On the one hand, it's the consequence of family planning. On the other hand, the increasing expense of raising children and living pressure, the trend towards late marriage, and increasingly strengthened single realization have caused the decrease in birth rate. The total fertility rate of Chinese women decreased to 1.44 in 2000 from 5.81 in 1950 (National Bureau of Statistics). The 2000 figure is far below the replacement fertility threshold (the fertility rate that maintains a constant population), which is 2.1.

All of these reasons make the population aging problem increasingly serious. According to the fifth census in 2000, people aged 0–14 took up 22.90%; people aged 15–29 took up 25.36%; and people over 60 accounted for 10.45%. However in the sixth census in 2010, people aged 0–14 took up 16.61%, a decrease of 6.29% compared to that in 2000; people aged 15–29 took up 24.63%, a decrease of 0.73%; and people over 60 accounted for 13.31%, making an increase of 10.45% (National Bureau of Statistics).

It's obvious that population aging is increasingly severe in China and the demographic dividend is disappearing. Therefore, it is increasingly important to work out how population aging affects economy. This paper tries to work out this mechanism from the perspective of marginal propensity to consume. The rest of this paper consists of three parts: the part II summarizes the literature researching population aging, the part III proposes the mechanism of population aging affecting an economy from the perspective of marginal propensity to consume by constructing a model. Part IV offers conclusions and policy suggestions.

## 2. LITERATURE REVIEW

The effects of population aging on an economy lie in many aspects, and its mechanisms are complex. Many researchers have undertaken in-depth study from different perspectives, mainly focusing on five mechanisms: [Cutler et al. \(1990\)](#) studied labor force supply; [Bloom et al. \(2010\)](#); [Fougere and Merette \(1999\)](#) and [Hviding and Mérette \(1998\)](#) worked on the accumulative effect of human capital; [Backes-Gellner and Veen \(2013\)](#) worked on the effect of labor productivity; [Shimasawa \(2007\)](#); [Wong and Tang \(2013\)](#) and [Peng \(2008\)](#) worked on the effect of the saving rate; [Yuan and Zheng \(2000\)](#) and [Ye et al. \(2012\)](#) worked on the effect of consumption structure. With regard to different mechanisms, researchers often use neo-classical growth theory—that is, the Solow model of economic growth [Solow \(1956\)](#) the life-cycle hypothesis model of [Modigliani \(1986\)](#) and the CEG model of Johnson.

With regard to the effect of population aging on labor force supply, the classical point is that population aging directly causes a decrease of labor force and has a great impact on the labor market. [Cutler et al. \(1990\)](#) are among representatives of this viewpoint. They predicted that the US labor supply would exhibit a downward trend in 2010–2060 and that the increasing average age of labor force would decrease investment demand, negatively affecting economic growth. However, at the same time, if capital stock is considered, the two factors would make high consumption possible, which in turn eases the pressure of population aging on the economy. They also claimed that the decrease of labor supply was not completely decisive, another factor being the international capital flow among countries of different population aging levels, referring to Germany and Japan as examples.

With regard to the effect of population aging on human capital, neo-classical growth theory, namely the [Solow \(1956\)](#) considers human capital as endogenous. [Bloom et al. \(2010\)](#) contended that demographic change had a significant impact on an economy. With the extension of average life expectancy, the savings rate rises, leading to the increase of human capital and causing a positive effect on economic growth. [Fougere and Merette \(1999\)](#) used the

life-cycle hypothesis of [Modigliani \(1986\)](#) to improve [Hviding and Mérette \(1998\)](#) model based on overlapping generations model and introduced endogenous growth theory into the model. The study divided people into three groups: the young, the middle-aged, and the old. Young people spend time learning and invest in human capital; middle-aged people spend time working to accumulate physical capital; and the old do not invest. They assumed that human capital was non-competitive, non-proprietary, and had low contact between generations, and physical capital was competitive, proprietary, and passed between generations through inheritance. In the model, they got accumulated human capital within learning time  $t$  and accumulated effective labor supply within work time  $1-t$  of 15 generations. The latter depended on contemporary age structure and human capital. Then they elicited the total outputs corresponding to material capital and effective labor through the Cobb–Douglas function. They finally considered the effects from two aspects—individuals, who maximize their utility in constraint of consumption and heritage, and government, which seeks optimum outcomes considering the expenditures such as tax revenue, annuities, and social welfare. After surveying the data of seven OECD countries, they compared it with [Hviding and Mérette \(1998\)](#) original model and concluded that population aging could alleviate the decline of the rate of capital return, the savings rate, and economic growth and contribute to economic growth in the long term through the improved model. Their paper also indicated that although population aging decreased the accumulation of physical capital and workforce, it promoted investment in human capital, which in the long term would increase effective labor. Meanwhile, the impact of population aging on expenditure such as education and health care made the results uncertain. In addition, some scholars believe that population aging incentivizes technical progress and motivates long-term economic growth.

With regard to the effect of population aging on the labor productivity, some scholars deem that the elderly's influence on the young should not be neglected and that older people's experiences are also important factors. For example, [Backes-Gellner and Veen \(2013\)](#) reported that diversity of labor force would affect companies' productivity and offered two hypotheses: firstly, the balance point of cost and benefit of diversity would determine the effect of diversity of labor on companies; secondly, the type of company mission played the role of arbiter. They drew the conclusion that the diversity of age had positive effect on a company if and only if it is engaged in creative tasks rather than regular tasks.

With regard to the effect of population aging on the saving rate, scholars generally believe that with population aging increasing, the increasing dependency burden for young people and tax revenue will decrease the social saving rate, thereby affecting the accumulation of capital and slowing economic growth. Besides, the increasing number of old people will increase the burden of government, not only through expenses on social security and welfare, but also increased transfer payments, which misappropriates public expenditure and harms the economy. However, based on the classical theory, [Shimasawa \(2007\)](#) adopted the endogenous growth OLG model to study the change of Japanese domestic policy. They stated that the exogenous OLG model underestimated the influence of policies changes such as public pension's abolition and financial reconstruction. They also claimed that these policies would increase the savings rate and the accumulation of human capital, thereby promoting economic development. In a recent study, [Wong and Tang \(2013\)](#) argued that population aging not only increased dependency burden and decreased saving rate, but also lengthened people's lifespan, which would in turn increase the savings. By studying the data of 22 OECD countries, they drew the conclusion that whether the saving rate of a society would increase depended on the speed of the two factors influencing the saving rate. [Peng \(2008\)](#) hypothesized that in the rapid development stage of population aging, China's saving rate would decrease to 33% in 2020 from 36% in 2010, and that it would decrease further to 20% in 2050 and even 12% by 2100 in the accelerated development stage.

With regard to the effect of population aging on the consumption structure, it involves both the analysis of consumer psychology of the old and consideration of the population age structure (the proportion of the population at

each age level). Because quantitative analysis is hard to achieve, scholars have not attained consistent conclusions. With the increase of population aging, the consumption of old people plays an increasingly important role in the consumer market, which inevitably causes a change of consumption structure. Towards this subject, Scholars have done a lot of research from macroscopic and microcosmic perspectives. Meanwhile, due to the intimate connection between savings and consumption, the above-mentioned research of foreign scholars on the saving rate can be regarded as research on consumption in a way.

However, one's consumption has a tight relationship with the development of social economy and cultural custom. Thus, the results of foreign scholars' research cannot be directly applied to China; that is to say, the domestic scholars need to "adjust measures to local conditions" when considering the problem. Under the background of the increasingly serious population aging in China, domestic scholars have also done a lot of research on this problem. According to the statistics on household consumption and the definition of marginal propensity to consume, some data of marginal propensity to consume of urban residents in China are shown in Table 1.

**Table-1.** Marginal Propensity to Consume of Urban Residents in China

Year	2002	2003	2004	2005	2006	2007
Marginal propensity to consume of urban residents	0.85	0.63	0.71	0.71	0.60	0.64

**Source:** cited from article: the change of marginal propensity to consume of China urban and suburb residents and policies. [Gu et al. \(2009\)](#)

Data show that the marginal propensity to consume of Chinese urban residents declined constantly over the 20-year period, which suggests that marginal propensity to consume is negatively related with the level of population aging in China. Aiming at the big drop of marginal propensity to consume of urban residents in China, [Yuan and Zheng \(2000\)](#) built an iterative model that could characterize the basic features of the Chinese old-age insurance system. Through numerical simulation, they found that population aging generally stimulated people to increase their savings. They also thought that China's current savings rate is not optimal and it could probably undergo a Pareto improvement if people could reduce the savings rate. [Ye et al. \(2012\)](#) loosened the assumption of the rational economic man and expressed the consumer culture differences between the east and west with "self-control" cognitive biases and the corresponding model parameter setting under the framework of the hyperbolic discounting model in behavioral economics. This further illustrated the formation of the two kinds of consumption deviation containing overconsumption (Europe and America) and underconsumption (East Asian countries). They adopted panel data of 48 countries and regions from 1978 to 2007 and concluded that income was significantly negatively related to consumption rate, which accorded with the Keynesian Consumption Function and also provided new ideas for expanding domestic demand.

To sum up, scholars have analyzed and expounded how population aging affects economic development from different perspectives; however, their researches are not comprehensive and systematic enough, and cannot reflect the interaction of multiple factors well. More importantly, few scholars consider the influence of marginal propensity on economic growth from the perspective of defining the marginal propensity to consume of the whole society, thus quantitatively studying this mechanism. At the same time, the particularities of consumption preference, savings behavior, and asset disposal decisions of elderly Chinese mean that foreign research cannot be applied to China reliably.

Therefore, based on previous study results and the condition of achieving steady-state economy in Solow Model, our paper uses the Keynesian Consumption Function to discuss the mechanism of population aging affecting economic growth from a new perspective (marginal propensity to consume): population aging affects consumption

and capital per capita, thus influencing economic growth. We conclude that population aging has both a positive effect and a negative effect on economic growth. By introducing the Cobb–Douglas production function, we expound the relationship between capital and marginal propensity to consume, thence working out the critical state of marginal propensity to consume.

### 3. FRAMEWORK AND NUMERICAL SIMULATION

#### A. Logic of this Article

Aging rate has an impact on the depreciation rate, the growth rate of labor, marginal propensity to consume, the savings rate, the rate of technological advance, and other factors. We assume that the depreciation rate, the growth rate of labor, and the rate of technological advance are constant and focus on exploring the effects of marginal propensity to consume on economic growth. We divide income per capita into two parts: current consumption and future consumption (i.e., current savings). Savings are positively related to capital per capita; that is, population aging acts on social consumption and capital per capita by influencing the marginal propensity to consume, consequently affecting economic growth. Nevertheless, the influence of marginal propensity to consume on consumption is the opposite to that on capital per capita: when consumption increases, capital per capita decreases, and when consumption decreases, capital per capita rises in a way. They interact mutually and influence the economy jointly. The logic that we describe is shown in FIG.1.

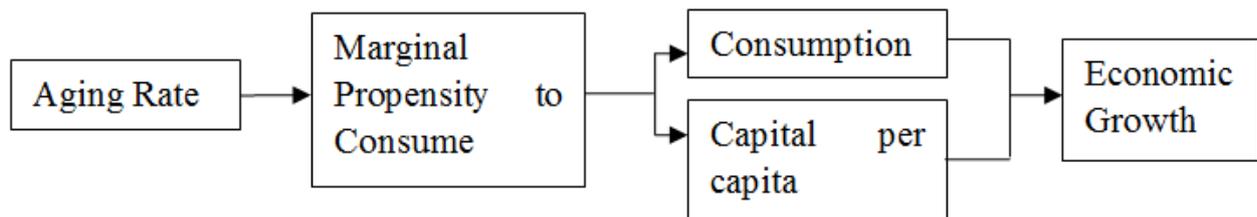


Fig-1. Logic of This Article

Source: tabulated by authors.

Based on the Solow model, the condition of achieving steady-state economy is:

$$sy = (l + \delta)k \tag{1}$$

Here,  $s$  refers to the marginal propensity to save of a country,  $0 < s < 1$ ;  $y$  refers to income per capita;  $l$  refers to the growth rate of labor;  $\delta$  refers to the depreciation rate; and  $k$  refers to capital per capita.

A person's income ( $y$ ) is spent on two aspects: current consumption ( $c$ ) and future consumption ( $c'$ ). Future consumption is deposited temporarily in the bank, becoming savings ( $sy$ ). This process is expressed as :

$$y = c + sy$$

Then, we introduce the Keynesian Consumption Function:

$$C = \bar{C} + MPC \cdot Y_D \tag{2}$$

Here,  $\bar{C}$  refers to autonomous consumption—namely, consumption when income is zero, which can be understood as the most basic consumption demand,  $\bar{C} > 0$ .  $MPC$  refers to marginal propensity to consume,  $0 < MPC < 1$ ;  $Y_D$  refers to disposable income:

$$Y_D = Y + TR - TA \quad (3)$$

Here,  $TR$  refers to transfer payments, and  $TA$  refers to total taxes.

If both sides of equation (2) are divided by  $L$  at the same time, we can expand it to individuals and get:

$$c = \bar{c} + MPC \cdot y_D. \quad (4)$$

Here  $C$  refers to current consumption;  $\bar{c}$  refers to individual autonomous consumption—namely, consumption that does not increase with the increase of income;  $y_D$  refers to personal disposable income.

Assuming that personal disposable income is  $x$  times personal income, it can be expressed as:

$$y_D = xy \quad (5)$$

Combining the three formulas (1), (4), and (5), we can get:

$$(1 - x \cdot MPC)y - \bar{c} = (l + \delta)k. \quad (6)$$

Here,  $y$  refers to income per capita. Consequently, we have that  $y = \frac{Y}{L}$ , where

$Y$  refers to gross output,  $L$  refers to labor, and  $k$  refers to capital per capita. Consequently, we have  $k = \frac{K}{L}$ .

Substituting them into formula (6), we can get:

$$Y = \frac{\bar{L}c + (l + \delta)K}{1 - xMPC}. \quad (7)$$

Here,  $K$  is not a constant and has relationship with  $MPC$ . A person's income is decomposed into two parts, consumption and savings. When social marginal propensity to consume declines, consumption will decrease, while savings will increase. Because the savings and capital per capita are positively related, we can infer that marginal propensity to consume and capital per capita are negatively related. With social marginal propensity to consume declining,  $K$  will rise, so  $K$  is a function of marginal propensity to consume, which can be expressed as:

$$Y = \frac{\bar{L}c + (l + \delta)K(MPC)}{1 - xMPC}. \quad (8)$$

Making  $MPC = \alpha$ , the F.O.C is:

$$\frac{\partial Y}{\partial \alpha} = \frac{(l + \delta) \frac{\partial K}{\partial \alpha} (1 - x\alpha) + 0.9[\bar{c}L + (l + \delta)K(\alpha)]}{(1 - x\alpha)^2}. \quad (9)$$

To get  $\partial K / \partial \alpha$  and  $K(\alpha)$ , we introduce the Cobb–Douglas production function from the perspective of aggregate supply:  $Y = AK^\theta L^{1-\theta}$ .

With both sides divided by  $L$ , we get :

$$y = Ak^\theta. \quad (10)$$

Combining formulas (6) and (10), we get :

$$Ak^\theta(1-x\alpha) - \bar{c} = (l + \delta)k$$

We make a simple treatment, ignoring the constant  $\bar{c}$ , and we get  $Ak^\theta(1-x\alpha) = (l + \delta)k$ . Namely,

$$k = \sqrt[1-\theta]{\frac{A(1-x\alpha)}{l + \delta}}$$

Then, we can get:

$$K = \sqrt[1-\theta]{\frac{A(1-x\alpha)}{l + \delta}} L \tag{11}$$

Combining formulas (9) and (11), we can get:

$$\frac{\partial Y}{\partial \alpha} = \frac{xL[\bar{c} + \frac{\theta}{\theta-1}(1+\delta)^{1-\theta}\sqrt[1-\theta]{\frac{A(1-x\alpha)}{l + \delta}}]}{(1-x\alpha)^2} \tag{12}$$

Therefore, the relationship between the economic aggregate ( $Y$ ) and the marginal propensity to consume ( $\alpha$ ) cannot be determined; that is,  $\alpha$  could have a positive impact or a negative impact on the economy.

Making  $\partial Y / \partial \alpha = 0$ , we can get :

$$\alpha' = \frac{A - (l + \delta)^\theta [(\frac{1-\theta}{\theta})\bar{C}]^{1-\theta}}{xA} \tag{13}$$

Table-2.Critical marginal propensity to consume

$x=0.1$	$\alpha' = \{10A - 10(l + \delta)^\theta [(\frac{1-\theta}{\theta})\bar{C}]^{1-\theta}\} / A$
$x=0.2$	$\alpha' = \{5A - 5(l + \delta)^\theta [(\frac{1-\theta}{\theta})\bar{C}]^{1-\theta}\} / A$
$x=0.3$	$\alpha' = \{10A - 10(l + \delta)^\theta [(\frac{1-\theta}{\theta})\bar{C}]^{1-\theta}\} / 3A$
$x=0.4$	$\alpha' = \{5A - 5(l + \delta)^\theta [(\frac{1-\theta}{\theta})\bar{C}]^{1-\theta}\} / 2A$
$x=0.5$	$\alpha' = \{2A - 2(l + \delta)^\theta [(\frac{1-\theta}{\theta})\bar{C}]^{1-\theta}\} / A$
$x=0.6$	$\alpha' = \{5A - 5(l + \delta)^\theta [(\frac{1-\theta}{\theta})\bar{C}]^{1-\theta}\} / 3A$
$x=0.7$	$\alpha' = \{10A - 10(l + \delta)^\theta [(\frac{1-\theta}{\theta})\bar{C}]^{1-\theta}\} / 7A$
$x=0.8$	$\alpha' = \{5A - 5(l + \delta)^\theta [(\frac{1-\theta}{\theta})\bar{C}]^{1-\theta}\} / 4A$
$x=0.9$	$\alpha' = \{10A - 10(l + \delta)^\theta [(\frac{1-\theta}{\theta})\bar{C}]^{1-\theta}\} / 9A$

Source: tabulated by authors.

Here,  $x$  is a constant representing the proportion of disposable income in the total income, which can be an arbitrary number between 0 and 1. We take  $x = 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9$  for example, and list the formulas of critical marginal propensity to consume in Table 2.

Here, we assume that all people are divided into two groups: old people and young people. The aging rate is  $n$  (i.e., the proportion of old people is  $n$ ). The marginal propensity to consume of old people is  $\eta_1$ , and the marginal propensity to consume of young people is  $\eta_2$ . We consider the social marginal propensity to consume ( $MPC^*$ ) as a weighted average of the two groups:

$$MPC^* = \alpha^* = \eta_1 n + \eta_2 (1 - n) = \eta_2 + (\eta_1 - \eta_2) n \quad (14)$$

From formula (14), we can see that the social marginal propensity to consume is associated with the aging rate ( $n$ ). With the increasing of the aging rate, whether the marginal propensity to consume of a society rises or falls depends on the size of  $\eta_1$  and  $\eta_2$ . If the marginal propensity to consume of old people is greater than that of young people, social marginal propensity to consume and population aging are positively related; otherwise, they are negatively related.

There is a critical value of marginal propensity to consume, which is influenced by total factor productivity ( $A$ ), the growth rate of labor ( $l$ ) and the depreciation rate ( $\delta$ ), the output elasticity of capital ( $\theta$ ), and autonomous consumption ( $\bar{C}$ ). Take the situation where social marginal propensity to consume and population aging are negatively related: when the degree of population aging of a society increases (that is,  $\alpha$  changes from  $\alpha_1$  which is bigger than  $\alpha'$  to  $\alpha_2$  which is smaller than  $\alpha'$ ), the negative impact of population aging on economic changes to a positive impact. The reason is that in the process of  $\alpha_1$  changing to  $\alpha'$ , the change of aging rate is relatively minor, which can be seen as a short-term process, so the short-term decline of marginal propensity to consume directly leads to the decline of the consumption and therefore the negative effect is dominant. However, in the progress of  $\alpha$  changing from  $\alpha'$  to  $\alpha_2$ , the aging rate changes considerably, which can be seen as a long-term process, so the decline of marginal propensity to consume has affected capital per capita and, therefore, the positive effect of the rising capital per capita on economy is dominant. On this basis, we can derive the following four conclusions:

Conclusion 1: When the aging rate of a society and the social marginal propensity to consume are negatively related—that is, the marginal propensity to consume of old people is less than that of young people, and the marginal propensity to consume in the first period (i.e., at the beginning of economy operation) is greater than the critical value of social marginal propensity to consume,  $\alpha > \alpha'$ —then with aging rate increasing, the total economic output will decrease at first and then increase.

Proof: the marginal propensity to consume of old people is less than that of young people, so with population aging,  $\alpha$  decreases. When  $\alpha > \alpha'$ , we can get  $\frac{\partial Y}{\partial \alpha} > 0$ , so  $Y$  decreases when  $\alpha$  decreases. When  $\alpha$  reduces to the critical value, we can get  $\alpha < \alpha'$ ,  $\frac{\delta Y}{\delta \alpha} < 0$ , so  $Y$  increases when  $\alpha$  decreases.

Conclusion 2: When the aging rate of a society and the social marginal propensity to consume are negatively related—that is, the marginal propensity to consume of old people is less than that of young people, and the marginal propensity to consume in the first period (i.e., at the beginning of economy operation) is less than the critical value of social marginal propensity to consume,  $\alpha < \alpha'$ —then with aging rate increasing, the total economic output will always increase.

Proof: the marginal propensity to consume of old people is less than that of young people, so with population aging,  $\alpha$  decreases. When  $\alpha < \alpha'$ , we can get  $\frac{\partial Y}{\partial \alpha} < 0$ , so  $Y$  increases when  $\alpha$  decreases.

Conclusion 3: When the aging rate of a society and the social marginal propensity to consume are positively related—that is, the marginal propensity to consume of old people is greater than that of young people, and the marginal propensity to consume in the first period (i.e., at the beginning of economy operation) is less than the critical value of social marginal propensity to consume,  $\alpha < \alpha'$ —then with aging rate increasing, the total economic output will increase at first and then decrease.

Proof: the marginal propensity to consume of old people is greater than that of young people, so with population aging,  $\alpha$  increases. When  $\alpha < \alpha'$ , we can get  $\frac{\partial Y}{\partial \alpha} < 0$ , so  $Y$  decreases when  $\alpha$  increases. When  $\alpha$  increases to the critical value, we can get  $\alpha > \alpha'$ ,  $\frac{\delta Y}{\delta \alpha} > 0$ , so  $Y$  increases when  $\alpha$  increases.

Conclusion 4: When the aging rate of a society and the social marginal propensity to consume are positively related—that is, the marginal propensity to consume of old people is greater than that of young people, and the marginal propensity to consume in the first period (i.e., at the beginning of economy operation) is greater than the critical value of social marginal propensity to consume,  $\alpha > \alpha'$ —then with aging rate increasing, the total economic output will always increase.

Proof: the marginal propensity to consume of old people is greater than that of young people, so with population aging,  $\alpha$  increases. When  $\alpha > \alpha'$ , we can get  $\frac{\partial Y}{\partial \alpha} > 0$ , so  $Y$  increases when  $\alpha$  increases.

## B. Numerical Simulation

Now, we numerically simulate the change of the economy. We assume  $t$  represents time and  $t = 1$  represents the first period.  $L_1 = 100$ ,  $l = 0.02$ ,  $\delta = 0.08$ ,  $MPC_1 = 0.58$ ,  $A = 100$ , and individual autonomous consumption is 10. The initial value of  $n$  is different, but  $n$  is growing at the same speed of 1%. We assume that  $x = 0.9$ ; that is, disposable income is 0.9 times of the total income.

Assuming that the output elasticity of capital is 0.5, by combining formulas (1) and (10), we can get  $k_1 = 477.79^2$ .

Next, we assign  $\eta_1$  and  $\eta_2$  with different values to observe how the total economic output changes.

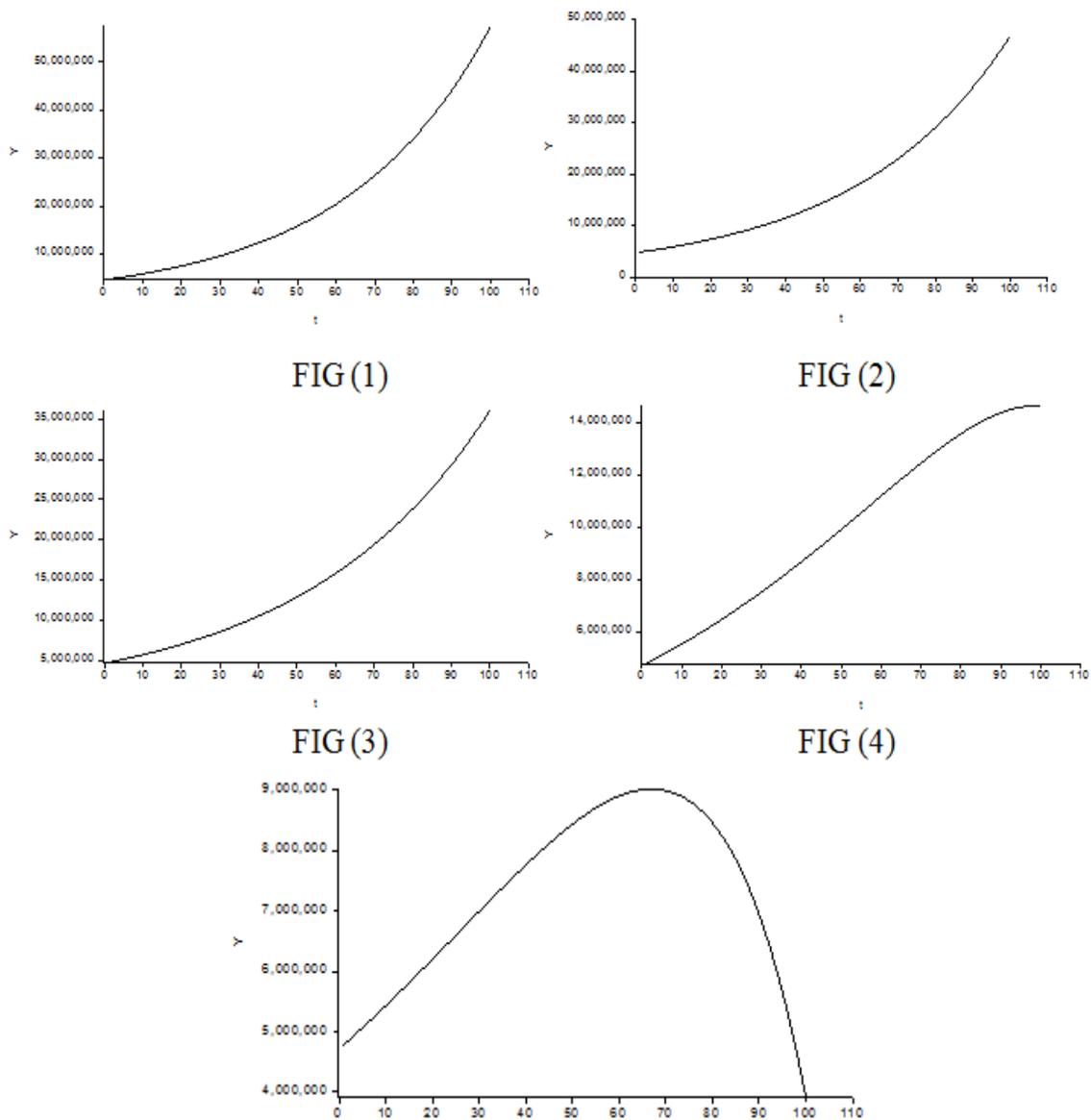


Fig-2. Numerical Simulation ( I )

Source: tabulated by authors.

In FIG (2-1),  $\eta_1$  and  $\eta_2$  are 0.2 and 0.8 respectively. Since then,  $\eta_1$  progressively increases by 0.1 and  $\eta_2$  progressively decreases by 0.1, forming FIG (2-2) and FIG (2-3). In FIG (2-4),  $\eta_1$  and  $\eta_2$  are 0.6 and 0.4 respectively. Then,  $\eta_1$  progressively increase by 0.1 and  $\eta_2$  progressively decreases by 0.1, forming FIG (2-5). From FIG (2-1) to FIG (2-5),  $\eta_1$  are 0.2, 0.3, 0.4, 0.6, and 0.7, respectively, and  $\eta_2$  are 0.8, 0.7, 0.6, 0.4, and 0.3, respectively.

From FIG (2-1) to FIG (2-3), the marginal propensity to consume of old people is less than that of young people; that is, the aging rate and the marginal propensity to consume are negatively related, and the marginal propensity to consume in the first period (i.e. at the beginning of economy operation) is less than the critical value, so with aging rate increasing, the total economic output increases, which proves conclusion 2. From FIG (2-4) to FIG (2-5), the marginal propensity to consume of old people is greater than that of young people. FIG (2-4) demonstrates conclusion 4, while FIG (2-5) proves conclusion 3.

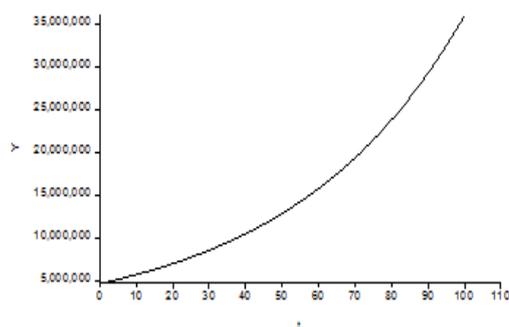


FIG (1)

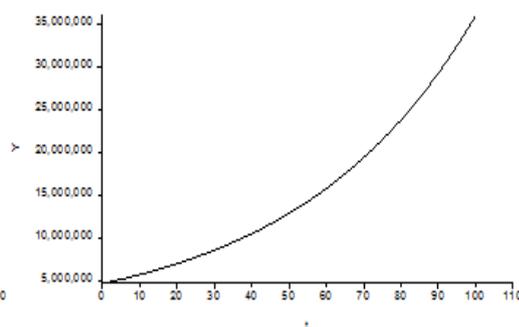


FIG (2)

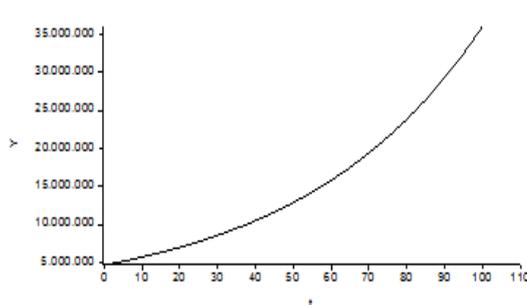


FIG (3)

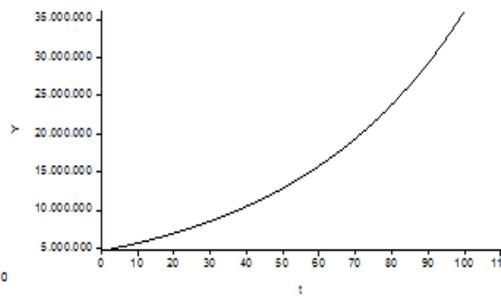


FIG (4)

Fig-3. Numerical Simulations (II)

Source: tabulated by authors.

From FIG (3-1) to FIG (3-4),  $\eta_1$  are 0.2, 0.3, 0.4, and 0.5, respectively, and  $\eta_2$  is always 0.6; that is, the marginal propensity to consume progressively increases by 0.1 and the marginal propensity to consume of young people is fixed. In these cases, the total economic output is always increasing and the increment is the same, which is the result of the difference of the proportion of old people in the first period. From FIG (3-1) to FIG (3-4), the proportion of old people in the first period increases. Therefore, despite that the marginal propensity to consume of old people increases, it is still always lower than that of young people, and the proportion of the old is increasing, so the results are the same. To be sure, in these experiments, the influence of population aging on economic growth is negative, because the increase of the marginal propensity to consume makes up for the growth of the proportion of old people.

#### 4. CONCLUSION AND POLICY SUGGESTION

From the model above, we can elicit different influences on economic growth caused by population aging under four kinds of status. There are two direct contributory factors to economic change caused by population aging: the overall consumption level and capital per capita. The decrease of marginal propensity to consume decreases the overall social consumption level, which has a negative impact on an economy while increasing capital per capita, which has a positive impact on economy. That is to say, the change of social marginal propensity to consume has both a positive and a negative effect on economy. Which effect dominates depends on the quantitative relations among marginal propensity to consume, total factor productivity, the growth rate of labor, the depreciation rate, the output elasticity of capital, and autonomous consumption. According to the analysis of the model, the economic growth of China belongs to one of the two following cases.

The first case is that the aging rate of Chinese society and the social marginal propensity to consume are negatively related—that is, the marginal propensity to consume of old people is less than that of young people, and

the marginal propensity to consume in the first period (i.e. at the beginning of economy operation) is less than the critical value of social marginal propensity to consume. In this case, with aging rate increasing, the total economic output will always increase. The second case is that the aging rate of a society and the social marginal propensity to consume are negatively related—that is, the marginal propensity to consume of old people is less than that of young people, and the marginal propensity to consume in the first period (i.e. at the beginning of economy operation) is greater than the critical value of social marginal propensity to consume. In this case, with aging rate increasing, the total economic output will decrease at first and then increase. The mechanism of population aging affecting an economy is a complicated process. In terms of the second case, when the marginal propensity to consume is greater than the critical value, it will decrease and converge on the critical value with population aging deepening. Such a process can be regarded as a short-time operation, in which the decrease of marginal propensity to consume has a more direct impact on consumption and, therefore, the negative influence of the decreasing consumption dominates the trend of economy. When the marginal propensity to consume becomes less than the critical value, such a process can be regarded as a long-time operation, in which capital per capita is affected more and, therefore, the positive influence of the rising capital per capita on economy is dominant.

Confronted by different cases, policies should be executed considering the above dynamic. The main distinction of the two cases above is whether marginal propensity to consume is greater than the critical value or not at the beginning of economy operation. In the first case, the marginal propensity to consume in the first period is less than the critical value. This means marginal propensity to consume is low at the beginning. With population aging deepening, capital per capita is affected more and, therefore, the negative influence of consumption on the economy dominates. Thus, the total economic output will increase when the conditions such as the growth rate of labor and total factor productivity remain unchanged. Our goal of economic growth can be achieved without changing the parameters, so we just need to accelerate the development of the aging industries, promote the elderly's consumption growth, and increase their purchasing power and purchasing intention. In the second case, the marginal propensity to consume in the first period is greater than the critical value of social marginal propensity to consume and, thus, the economy will decrease at first. To avoid the decrease of the total economic output, we need to increase the critical value and transform the operation of economy into that of the first case. The critical value is related to total factor productivity, the growth rate of labor, the depreciation rate, the output elasticity of capital, disposable income, and autonomous consumption. The depreciation rate is hard to change macroscopically; the constant growth rate of labor is the hypothesis of the model, and increasing the critical value by decreasing disposable income will not be accepted, so there remain three methods. In terms of consumption, we can decrease autonomous consumption. Autonomous consumption refers to the consumption having no relations with income, which mainly depends on the preference of consumer, price level, social custom, and so on. Controlling the price of food and other necessities of life and advocating reasonable consumption can alleviate the excessive growth of autonomous consumption in our country.

In terms of capital, we can increase the output elasticity of capital. When the output elasticity of capital increases, the economy is affected less by the decrease of the labor. There are three ways to increase the output elasticity of capital (i.e., the rate of capital utilization). First, encourage enterprises to develop production, increase asset turnover, and improve operation ability. Second, perfect the investment and financing system to strengthen regulation of financial markets and improve the utilization of the social capital. Third, perfect regional policies and regional factor mobility, enhancing capital flows. In terms of technology, we can increase the total factor productivity. There is no doubt that technological progress is crucial to economic development. Therefore, we should increase scientific research input, strengthen the protection of intellectual property, and actively apply scientific and technological achievements to production to increase productivity.

To be brief, different countries and regions have different marginal propensity to consume and age structure. Economic development, social security, legal system, national psychological characteristics, and even customs will affect the marginal propensity to consume, in which case the habits of the elderly group are more distinct and complex. The best solution is formulating corresponding policies based on current situations and empirical study, and converting population aging into the motivation of economic development to capacity.

Funding: This study received no specific financial support.

Competing Interests: The authors declare that they have no competing interests.

Contributors/Acknowledgement: All authors contributed equally to the conception and design of the study. This paper has been finished under the guidance of Doctor Zhang Su, the professor in Central University of Finance and Economics, focusing on macroeconomics, labor economics and development economics. Without Professor Zhang's diligence and patience, we could not have finished this paper. We therefore are particularly grateful for Professor Zhang's guidance.

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