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A Study on the Impact of Population Age Structure Change on Economic Growth in China

Zhiwei Liu [1], Yonglei Fang [2] and Lei Ma [3,*]

[1] School of Economics and Management, Zaozhuang University, Zaozhuang 277800, China; 100872@uzz.edu.cn
[2] School of Mathematics and Statistics, Zaozhuang University, Zaozhuang 277160, China; ylfangmath@163.com
[3] School of Opto-Electronic Engineering, Zaozhuang University, Zaozhuang 277160, China
* Correspondence: leima_1017@163.com

Abstract: In the process of changes in total population, structure, and spatial distribution, it is essential to investigate the inner rules of the harmonious correlation between population and development. Thus, this study examines the correlation between demographic variables (e.g., delayed retirement, total fertility rate, and life expectancy) and economic development in China based on the overlapping generations (OLG) model and numerical simulation method. The findings reveal the following: (1) total social output level positively correlates with survival probability; (2) the contribution of the aging labor force (retirement age delay) to the total output is significant and an essential source of sustainable economic growth; (3) aggregate output increases first and then decreases with the increase in individual pension contributions rate, and the correlation between the two is a ∩-shaped curve. The policy implications of this study are that China's economic transformation is a general trend, which should promote the upgrading of the demographic dividend from quantitative type to qualitative type and tap the human capital potential to increase the capital-based demographic dividend and activate the gender dividend.

Keywords: aging; demographic dividend; delayed retirement; sustainable development

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1. Introduction

In the process of their economic development, most developed countries have experienced a "demographic transition", and increasing studies have considered aging as one of the key factors influencing slow economic growth. During the 1978–2019 period, China's economy proliferated, leaping to the world's second-largest economy, with a growth rate of 14.6% at current prices, a 270-fold increase in the GDP, and a 184-fold increase in per-capita GDP. The rapid development of China's economy is attributable to the main contribution of the demographic dividend, namely, a low population dependency ratio, with the working-age population increasing at an average annual rate of 1.8% and the non-working-age population growing at −0.2% [1].

Population aging has become a global phenomenon and is spreading because of the combined effects of declining fertility rates and increasing longevity [2]. As the world's most populous country, China has created a new demographic structure, with a declining working-age population, with 894.38 million people aged 15–59 years accounting for 63.35% of the population, down 6.79% from the same period last year, and a population of 264.02 million people aged ≥60 years accounting for 18.70% [3], which is at the stage of a profoundly aging society.

The potential of a country and its ability to sustain growth, in the long run, is limited by the size of its workforce population, and with the demographic window of opportunity, the quality of China's economic development will undoubtedly be affected to some extent [4]. Thus, this study attempts to examine the correlation between demographic variables (e.g., delayed retirement, total fertility rate, and life expectancy) and economic development in the context of aging, as well as investigate new sources of economic growth in China.

The world is getting older, and the rate of aging is going to lead to increases in health expenditures, increases in pension expenditures, and decreases in education expenditures [5]. Japan's population aging is the furthest advanced in the world. Japan's population aging as a whole adversely affects GNP growth by dampening factor inputs. It also negatively impacts GNP per capita and fiscal variables, especially in the future, mainly due to the decline in the fraction of the population of working age [6]. What is the role of older workers in a population's aging economic growth nexus in developing countries? This question arises when the older population in these countries increases rapidly at the turn of the 21st century, while the labor force participation rate of older people remains low [7]. Challenges such as adequacy of social security, old age pension, rising non-communicable diseases, providing adequate healthcare services, and labor shortage will inevitably strain the economy and public resources of developing countries in the coming decades [8,9].

Most studies concluded that the impact of population aging on economic growth was negative [10–15]. Additional studies demonstrated that per-capita GDP positively correlated with the working-age population and negatively correlated with the proportion of elderly and youth [11–13]. Population aging is frequently associated with a decline in the workforce size, productivity, and savings, and an increment in government spending [16,17]. In contrast, some studies, such as Gasmi et al. [18] and Singh [19], established a positive correlation between population structure change due to an increased workforce share and economic growth, driven by increased savings and investment.

With a shift in the demographic production patterns of society, that is, from high mortality and high fertility to low mortality and low fertility, the demographic age structure transition can be categorized into three stages [20]. The first stage is significantly characterized by the presence of a high childrearing ratio, followed by the second stage with an increasing proportion of the working-age population, resulting in the emergence of a demographic window of opportunity. The final stage is characterized by a rising proportion of the elderly population and a high old-age dependency ratio [21–26]. In the second stage of the age structure transition, as fertility declines and the working-age population increases, the child dependency ratio declines because children born during the high-fertility period enter the working-age group.

The concept of demographic dividend stems from the in-depth exploration of the impact of population structure changes on economic growth. In the population structure transformation, the population usually undergoes an olive-shaped state of the population age structure, which is called the "demographic window of opportunity", that is, the working-age population accounts for a higher proportion of the population and, thus, generates the first demographic dividend on economic growth, and the growth effect is noticeable, thereby pioneering the study of the demographic dividend theory [27–29]. The second dividend stems from improved health, longer life expectancy, and smaller household size, which makes saving easier and more attractive [29,30]. Growth is in general purely exogenous, stemming from savings and consumptions smoothing. If accrued wealth and savings were used for productive investment, it would help attain high economic growth during population aging. To gain dividends during the demographic window of opportunity, appropriate investments in education and health are essential [31,32].

With a population of 1.3 billion, China has become the largest labor market globally, and its universality in the demographic dividend is more convincing for the empirical data in the measurement of economic contribution and sustainable range. The first demographic dividend denotes the contribution of economic growth brought by a higher proportion of working-age individuals and a lower social dependency burden, while the second demographic dividend is the continuation, deepening, and realization path details of the first demographic dividend, which can be summarized into different schools of thought, such as the "savings theory", "capital deepening theory", and the "elderly resource theory" [33]. The "savings theory" and the "capital deepening theory" accentuate the additional contribution of a favorable external policy environment to economic growth, that is, high savings rates and high levels of human capital; the "elder human resource theory" focuses on the use of elder human resources and human capital development to continue reaping economic growth dividends in the context of an aging society [34,35]. Furthermore, additional analysis revealed that the generation mechanism and duration of the two demographic dividends are fundamentally different: the first demographic dividend originates from the phased increase in the labor force scale during the population structure transformation process, which exerts a rapid but short-lived impact on economic growth; the second demographic dividend stems from the behavioral adjustment of the delayed working age and the economic effects produced by the combination and optimization of production factors, which are the source of long-term economic growth [36].

The generation of demographic dividend warrants certain preconditions, namely, a favorable policy environment, including health, education, labor market, and savings, and other supporting measures. If population aging comes with an increase in per-capita wealth, it can easily trigger additional incentives for research and development, thereby increasing the growth rate of the total factor productivity [37–40]. The demographic dividend theory is based on the neoclassical growth theory framework, which examines the correlation between various production factors and economic growth, fitting the quantity, quality, fertility, dependency ratio, and savings rate of labor force into the economic growth model to examine the economic growth source or total factor mix [41].

The value of OLG model lies in its continuous expansion. For example, in the aspect of aging research, the change in life expectancy exerts an impact on economic growth by affecting some intermediate variables (savings, tax rate, etc.), and puts forward policy suggestions on populations, retirement systems, pension systems, etc. The validation results of the overlapping generations (OLG) model show that the national saving rate of Japanese households with a fixed population size was relatively stable between 1960 and 2000 [42,43]. The deductions are primarily based on the assumption that the fertility rate in the model does not affect individuals' utility functions and budget constraints [44,45]. Additional studies demonstrated that by introducing household size and interest rate variables, the population structure effect on economic growth in the 1940s was small, but demographic effects increased as the population aged [46]. The results of a study on economic growth in Spain are similar [47]. In contrast, the OLG model with youth dependence and fixed interest rates led to a different conclusion, with population structure exerting a significant impact on the savings rate in Taiwan [48–50]. Contrarily, China's high savings rate is largely driven by household size [51]. Regardless of the interest rate being fixed or not, which determines different production modes, the above mentioned study results are not comparable, but there is an academic consensus that the introduction of more realistic demographic outcome variables in the OLG model increases the economic–demographic linkage [52], which is commonly used to address issues such as pension systems, aging, economic growth, and immigration policies [13]. This paper is aimed at pointing out the links between population and economic growth. At the same time, from the perspective of promoting economic growth, it gives policy suggestions on China's current fertility and social security systems.

The pension deficit has been rapidly enlarging for more than a decade, with China as an example. It is astonishingly expected to overpass CNY 150 billion. Compared with European and U.S. retirement ages, which are usually between 65 and 67, China's retirement ages—men at 60 years old and women at 50 years old—are apparently at low levels. In order to avoid the deterioration of the pension crisis, adjusting the retirement age becomes necessary. Since the average life span of the Chinese has extended from 71 to 76 years old in last 10 years, the feasibility of raising the retirement age has also been promoted [53–56].

Major policies developed in response to the aging trend across countries include, though are not limited to, the following measures: (1) increasing the fertility rate, (2) adding young immigrants, (3) promoting productivity by enhancing human capital, and (4) extending the retirement age. Unfortunately, many policy protocols as currently proposed or adopted face substantial challenges [2,57–59].

The present study fills in the research gap by quantifying the role of labor force participation of older people in the aging–growth nexus in developing countries. Compared with the existing literature, the main innovations and work of this study are as follows: (1) An expanded OLG equilibrium model is developed under the existing social pension security system, in which survival probability in old age is introduced. Based on the endogenous fertility rate and the introduction of life expectancy, the impact of population aging, delayed retirement age, survival probability, and pension rate on the total social output in China are further explored. (2) Theoretical models and numerical simulations are conducted to determine whether delayed retirement age would lead to a secondary demographic dividend.

2. Methods

In this paper, we construct and parameterize a general equilibrium two-period OLG model to capture the impact of population aging on a regional economy. The model explains the correlation between demographic variables (e.g., delayed retirement, total fertility rate, and life expectancy) and economic development in China. It includes a public PAYG old-age pension system which pays out pensions to a fourth generation of retirees. The statutory retirement age in our model is 57 and exogenous. The policy of gradually delaying retirement, which has been hotly debated recently, is also a manifestation of the externality of retirement. Therefore, delaying retirement is an important policy tool, and the government has a systemic impact on the economy by adjusting the retirement age. Individuals, however, may face three different retirement ages. Our aim is to find the correlation between demographic variables and economic development in China.

Our main contribution in this paper is to study the impact of aging, fertility survival rate, survival probability, pension rate, time discount rate, consumption time discount factors, and other variables on China's economic growth within one coherent framework, where all these variables are endogenous. Here, we differ from the existing literature.

To study a series of effects of population aging, we parameterized, numerically solved, and simulated our model. In steady-state equilibrium, due to the complexity of the expression of economic growth rate, it is difficult to directly judge the effect of postponing retirement age on China's economic growth through general comparative static analysis. In the part on numerical simulation, we judge its influence through reasonable parameter setting. Before we conduct that, however, we test its empirical validity for reality data from China. The parameter setting and reference value are explained in detail in the fourth section of the paper.

Having established its empirical reliability, we then use the model for policy simulations. Our simulations assess to what extent demographic changes may contribute to employment, growth, and welfare. Our results show that, in the framework of endogenous growth, economic growth rate depends on variables such as probability of survival, later retirement years, and fertility rate. Our model closely links savings with a second demographic dividend through increased life expectancy. Pension reform in this direction encourages young individuals to study and build human capital, which promotes long-run growth. Furthermore, it encourages older workers to postpone retirement. Strengthening the link between one's future old-age pension on the one hand, and one's human capital and labor supply when older on the other, introducing strong financial incentives which may bring about important changes in behavior. Positive effects on employment, the effective retirement age, and growth raise governments' resources, which makes it possible to finance a larger pension burden.

3. Theory Model

3.1. Representative Family Decision Making

Following Irmen's [60] OLG extended model analysis framework, the representative actor's (family) lifetime was simplified into two phases—young and old age—each with a time length endowment set to 1 and homogenized for each phase. In period t, the number of children born (fertility rate) is n_t, and v denotes the proportion of each child's parenting expenses in his wage income. The actor's working time covers both young and old age, where young age provides 1 unit of labor and the wage income is w_t, survival probability is 1, while survival probability of old age is P. Considering the current delayed retirement policy, the length of time that the elderly person continues to work is assumed to be $x(0 < x < 1)$ and the wage income is xw_{t+1}, then, the length of retirement is 1 − x. The utility function of the individual representative actor depends on the two-period consumption and the number of children, expressed in the following form:

$$U = \ln C_t + \beta p \ln C_{t+1} + \varphi \ln n_t \quad 0 < \beta \leq 1, \varphi > 0 \tag{1}$$

where C_t denotes the actor's consumption in young age (period 1); C_{t+1} denotes the actor's consumption in old age (period 2); β denotes the actor's time discount rate; φ represents the child preference rate.

The actor's payroll tax rate and pension contribution rate are τ in his/her young age and based on the previous setting that the survival probability in old age is p; it is clear that the probability of the actor receiving the inheritance as heir at this stage is $1 - p$, which is shared equally among all children in the next generation. Thus, the actor's budget constraint equation is as follows:

$$s.t \quad C_t = (1-\tau)w_t - s_t - vn_t w_t - \frac{(1-p)s_{t-1}R_t}{n_{t-1}} \tag{2}$$

$$C_{t+1} = s_t R_{t+1} + (1-x)\phi_{t+1} + (1-\tau)xw_{t+1} \tag{3}$$

where R_t denotes the return on assets in period t; ϕ_{t+1} denotes the pension income per unit of time, and the total pension income of the actor after retirement is $(1-x)\phi_{t+1}$. We constructed the Lagrange equation to solve for optimal consumption and saving, and obtained the following functional expression:

$$C_t = \frac{1}{1+\varphi+\beta p}\left[(1-\tau)w_t + \frac{(1-p)s_{t-1}R_t}{n_{t-1}} + \frac{(1-x)\phi_{t+1} + x(1-\tau)w_t}{R_{t+1}}\right] \tag{4}$$

$$S_t = \frac{\beta p}{1+\varphi+\beta p}\left[(1-\tau)w_t + \frac{(1-p)s_{t-1}R_t}{n_{t-1}}\right] - \frac{(1+\varphi)}{(1+\varphi+\beta p)}\frac{(1-x)\phi_{t+1} + x(1-\tau)w_{t+1}}{R_{t+1}} \tag{5}$$

3.2. Enterprise Behavior

In a perfectly competitive market environment, the enterprise's production function takes the Cobb–Douglas form: $Y_t = A_t K_t{}^{\partial} L_t{}^{1-\partial}$, where $0 < \partial < 1$, A_t denotes the total factor productivity, the base period is 1, ∂ is the capital-output elasticity, $y_t = \frac{Y_t}{L_t}$ represents per-capita labor output in period t, Y_t represents the total output in period t, $L_t = N_t + xpN_{t-1}$ denotes the total labor force input in period t, including adult labor force N_t and older labor force with delayed retirement xpN_{t-1}, and $k_t = \frac{K_t}{L_t}$ denotes per-capita capital. For simplicity, assume that capital is fully depreciated in the current period and the rate of return on capital is equal to the marginal output. The expressions for the rate of return on capital and the wage rate under the conditions of optimal vendor profit are as follows:

$$R_t = \partial k_t^{\partial-1} \quad w_t = (1-\partial)k_t^{\partial} \tag{6}$$

3.3. Government Action

Assuming that the government budget is balanced, that is all social security payroll taxes collected in both periods are used to pay retirement pensions for the elderly, the budget balance expression is as follows:

$$\tau N_{t+1}w_{t+1} + \tau xpN_t w_t = pN_t(1-x)\phi_{t+1} \tag{7}$$

where the left side of the equation denotes the social security pension income, which originates from the social security payroll tax paid by young people in the first period and the social security wages paid by the elderly during their working years after the delayed retirement in the second period, while the right side of the equation is the pension expenditure. After rectifying Equation (7), we obtain the following:

$$\tau w_{t+1}(n_t + xp) = p(1-x)\phi_{t+1} \tag{8}$$

3.4. Market Equilibrium

Considering the capital depreciation situation, the enterprise production capital in period t + 1 stems from private savings in period t. Thus, in capital market equilibrium, we have $K_{t+1} = N_t s_t$, and the per-capita capital is $k_{t+1} = \frac{s_t}{(n_t+xp)}$. According to Equations (4)–(8), the dynamic evolution equation of per-capita capital can be solved, and the expression is as follows:

$$k_{t+1} = \frac{\partial\beta p(1-\partial)(1-\tau)}{\partial(1+\beta p+\varphi)(px+n_t)+(1+\partial)(1+\varphi)(px+\tau n_t)}k_t^{\partial} \tag{9}$$

where k* denotes the value of per-capita capital at convergence and $k^* = k_{t+1} = k_t$, we can obtain:

$$k^* = \left\{\frac{\partial\beta p(1-\partial)(1-\tau)}{\partial(1+\beta p+\varphi)(px+n^*)+(1-\partial)(1+\varphi)(px+\tau n^*)}\right\}^{\frac{1}{1-\partial}} \tag{10}$$

According to the previous analysis, the series of expressions for the average per-capita output, the equilibrium interest rate, the average wage, and the total output at the point of convergence are:

$$\begin{array}{cc} y^* = Ak^{*\partial} & R^* = \partial Ak^{*\partial-1} \\ w^* = (1-\partial)Ak^{*\partial} & Y^* = y^*N^*(n^*+xp) \end{array} \tag{11}$$

$$Y^* = A\left\{\frac{\partial\beta p(1-\partial)(1-\tau)}{\partial(1+\beta p+\varphi)(px+n^*)+(1-\partial)(1+\varphi)(px+\tau n^*)}\right\}^{\frac{\partial}{1-\partial}}N^*(n^*+xp) \tag{12}$$

Additional derivation from Equations (11) and (12) leads to the expression for the economic growth rate (g):

$$1+g = \frac{Y_{t+1}}{Y_t} = \frac{y_{t+1}[(1-vn_{t+1})n_t+x]L_t}{y_t[(1-vn_t)n_{t-1}+x]L_{t-1}} = \frac{y_{t+1}[(1-vn_{t+1})n_t+x]}{y_t[(1-vn_t)n_{t-1}+x]}n_{t-1} \tag{13}$$

According to Equation (13), when the economy is in equilibrium, per-capita output and population growth rates are equal at different periods of convergence so that the economic growth rate equates to the population fertility rate.

4. Parameter Calibration

This study calibrates the crucial parameters of the model according to China's reality, focusing on how China's "expected demographic dividend" and "demographic quality dividend" evolve with the deepening of aging and the adjustment of fertility policies and how they affect China's economic growth. The increase in the household saving rate promoted by aging in the "expected demographic dividend" based on the "life cycle wealth effect" is used as a "mesomeric effect" of economic growth to validate the growth effect of the "expected demographic dividend". The increase in survival rate because of the "demographic quality dividend" is also used as a "mesomeric effect" to validate the growth effect of the "demographic expectation dividend". The increase in the survival rate because of the "demographic quality dividend" is also used as a "mediating effect" to establish the growth effect of the "demographic quality dividend". In this study, the equilibrium equations derived from the theoretical model are numerically simulated by parameter calibration.

(1) Capital output elasticity: The capital output elasticity of the production function model is usually between 0.3 and 0.6, and the capital output elasticity of developed countries is normally 0.3. China's domestic capital output elasticity is mostly concentrated between 0.4 and 0.5, and there exists a long-term decreasing trend of output elasticity with increasing capital abundance [61]. Based on the robustness considerations, we selected three scenarios with α = 0.3, 0.4, and 0.6 for the evaluation.

(2) Total factor productivity and total labor force: The values of A and N* only affect the absolute magnitude and do not affect the fundamental mechanistic conclusions [62,63], so they can be taken as arbitrary positive values. To ensure that the equilibrium economic output values are not too low, values of 1 and 10 were taken here, respectively.

(3) Individual pension insurance contribution rate. Pension insurance will attain national coordination in the future and combine with the "comprehensive plan to decrease social insurance rates" released by China in April 2019, which clearly mentions that "if the pension insurance unit contribution ratio of all provinces, autonomous regions, municipalities and Xinjiang Production and Construction Corps (hereinafter referred to as provinces) is higher than 16%, it can be reduced to 16%. Currently, if it is less than 16%, the transitional methods shall be study and proposed." Therefore, we selected τ = 0.16.

(4) Fertility rate: According to the UN Population Division, China's fertility rate was 1.55 in 2010–2015, and the total fertility rate in 2020 was 1.3 per the seventh census of China. Considering the full implementation of the current 2 and 3 children national policy [64], we assumed a baseline fertility rate of η = 1.55.

(5) Delayed retirement years: The duration of each period was 35 years, and the current retirement age was set to 55 years (the current retirement age in China is 60 years for men, 50 years for women, and 55 years for female cadres; the actual average retirement age in China was about 57 years in 2015). In this study, the retirement age for young people was set at 22 years, the duration of each period was 35 years, and the retirement age was 57 years. Based on the current retirement policy, three scenarios are discussed—normal retirement, 5-year delayed retirement, and 10-year delayed retirement—which correspond to x = 0, 1/7, and 2/7, respectively.

(6) Time-discounting factor for consumption: In the traditional utility discounting models, the discount factor is generally assumed to be extrinsically given and is simply assumed not to change over time. This discount factor expresses the degree of people's patience with the future, and a constant discount factor implies that people's patience with the future remains constant. The time discount factor of individual consumption depends on the individual's subjective discount rate, which was set to 0.78 in this study, following Wang [65].

(7) Survival probability: Considering that the life expectancy of the population is increasing over time, the average life expectancy of the Chinese population is 77 years in 2021 based on the seventh national census of China. Assuming that the working age is 22 years, the survival probability is $p = \frac{57-22}{35} = 0.57$.

(8) Time discount rate: The existing literature mostly takes the value of 0.98. In this study, we followed the existing idea as each period was set to 35 years, then, $\beta = (0.98)^{35} = 0.49$. Table 1 shows the baseline values of each parameter.

Table 1. Parameters meaning and benchmark values.

Parameter	Definition	Value
α	Output elasticity of capital in the product production function	0.3, 0.4, 0.6
A	Total factor productivity	1
τ	Payment ratio of individual pension insurance	0.16
n	Total fertility rate	1.55
x	Delayed retirement years	0, 1/7, 2/7
ψ	Time discount factor of consumption	0.78
P	Survival probability in the elderly	0.57
β	Time discount rate	0.49

5. Numerical Simulation

5.1. Aging and Economic Growth

According to Equations (11) and (12), the derivative of p, x shows that the sign of $\partial Y^*/\partial p, \partial Y^*/\partial x$ remains uncertain, depending on parameters such as τ and β and needs to be interpreted using the results of numerical simulations, which leads to the following hypotheses:

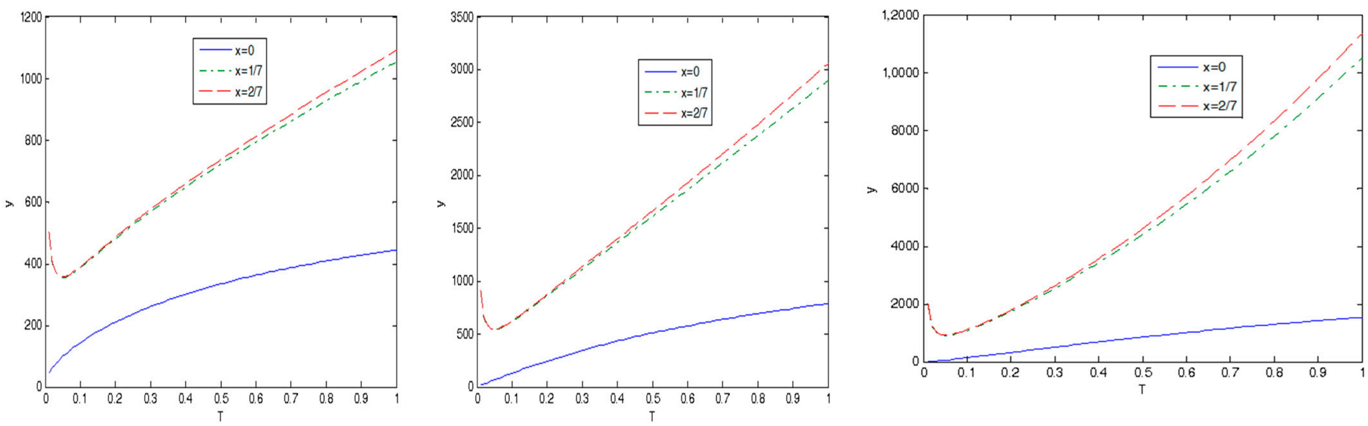
Hypothesis 1 (H1). *The total social output positively correlates with the survival probability (P); that is, a higher survival probability also implies a longer life expectancy (t), which generates a "wealth effect" and then stimulates economic growth.*

Hypothesis 2 (H2). *Total social output inversely correlates with life expectancy (p), that is, a decrease in survival probability or life expectancy exerts a "burden effect" that inhibits economic growth.*

Hypothesis 3 (H3). *The total social output is positively related to labor force aging (x), that is, social aging will produce positive effects, and then stimulate economic growth.*

Hypothesis 4 (H4). *The total social output and the aging of the labor force (x), that is, the aging of society, will produce negative effects and then inhibit economic growth.*

Figure 1 shows the correlation between per-capita output and average life expectancy in equilibrium state for different capital output elasticities (α = 0.3, 0.4, and 0.6) with constant values of total fertility, subjective discount factor, and other parameters. The analysis reveals that:



(**a**) (**b**) (**c**)

Figure 1. The correlation between life expectancy and total output when α = 0.3, 0.4, and 0.6.

(1) In Figure 1a, the total output level positively correlates with survival probability (P); the higher the survival probability (P), the higher the total output. In addition, the

second demographic dividend can be harvested, thereby validating Hypothesis 1. This result can be clarified from the savings theory perspective, in which a larger survival probability (P) over the whole life cycle implies a longer life expectancy (T increases) and more leisure time after retirement, needing an increase in the personal savings rate in the first period, a proactive design of retirement life, and an increase in retirement security, which results in an increase in the total capital and total output. Thus, the root cause of the secondary demographic dividend is the savings effect. Moreover, an extended life expectancy implies the reduction in the probability of inheritance and the personal initial assets of young people, which exerts a negative impact on personal savings, per-capita capital, and per-capita output, and dissolves the secondary demographic dividend effect to some extent, thereby validating Hypothesis 2.

(2) Figure 1b shows that the contribution of delayed retirement (aging of the labor force) to the total output is significant and a crucial source of the secondary demographic dividend. The retirement age delay determines the formation of the secondary demographic dividend through its endogenous effect on fertility and individual retirement pension income, with a double effect [66]. On the one hand, based on the latest retirement policy, the increase in the value of x is bound to intensify the aging trend of the labor force; keeping the values of the relevant parameters of the model unchanged, the working period of representative individuals increases, the leisure years of retirement are correspondingly reduced, and considering individual income and consumption equilibrium, the consumption among young ages increases, savings decreases, and consumption in the retirement stage correspondingly declines, and the per-capita capital and per-capita output of the production function display a decreasing trend. On the other hand, delayed retirement increases the labor supply, resulting in an increase in the aggregate output. Thus, the net effect of delayed retirement on aggregate output depends on the strength of both; when the decline in output due to rational saving behavior created by the delayed retirement policy exceeds the increase in output because of the increase in labor supply, the level of aggregate output decreases and, conversely, the level of aggregate output increases. Hence, Hypotheses 3 and 4 are confirmed.

(3) In Figure 1c, under the current retirement policy (x = 0), there exists a critical point in the range of α, especially when α = 0.5–0.6, and the level of aggregate output increases and then decreases as the value of T(P) increases; the correlation between the two demonstrates a inverted U shape curve. To analyze the reason, the output elasticity of capital positively correlates with the level of industrialization [67]; however, when it exceeds 0.5, the negative effect of capital output starts appearing because of the significant increase in exterior liabilities. In other words, when the capital output elasticity coefficient is before the cutoff value, the contribution of labor output is significant, and the high wage level inevitably increases individual savings and social savings, which, in turn, leads to the increase in per-capita capital and per-capita output. With the arrival of the critical value, labor output is significantly more sensitive, heterogeneous, and diversified than physical capital, which can better attain long-term, sustainable economic growth.

5.2. Fertility, Labor Force Aging, and Economic Growth

According to Equations (11) and (12), the three-dimensional relationship between labor force aging and economic growth is simulated by dynamically simulating total population fertility, using the parameter setting values in Table 1. When different values of α were attempted, the overall trend was highly consistent. Figures 2–4 are representative results for α, taking the value of 0.6.

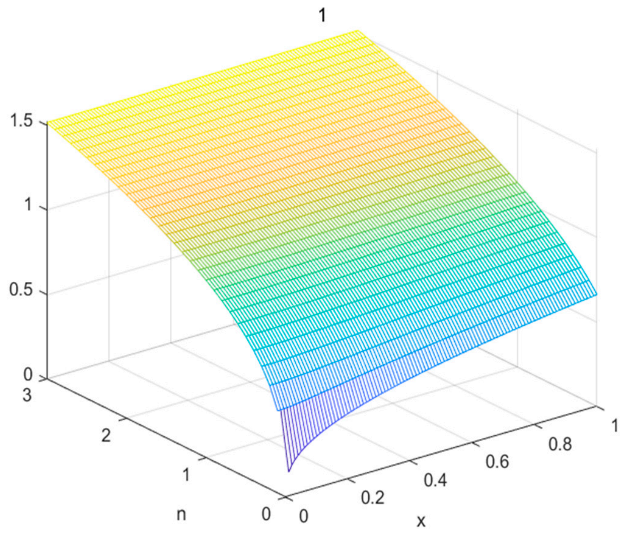


Figure 2. Fertility, labor force aging, and economic growth in three dimensions.

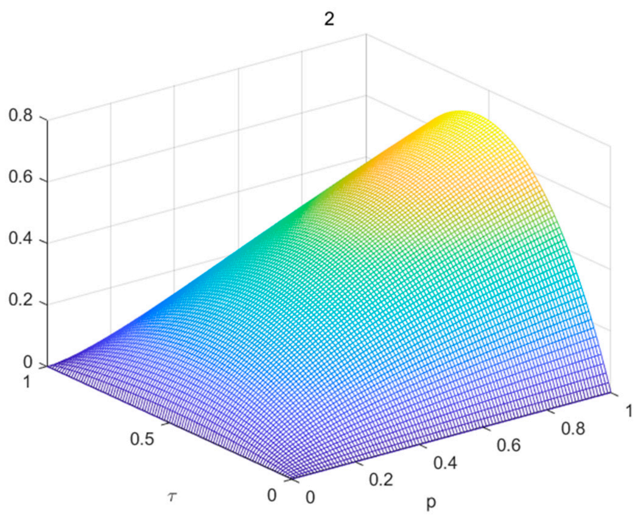


Figure 3. Survival rate, pension rate, and economic growth in three dimensions.

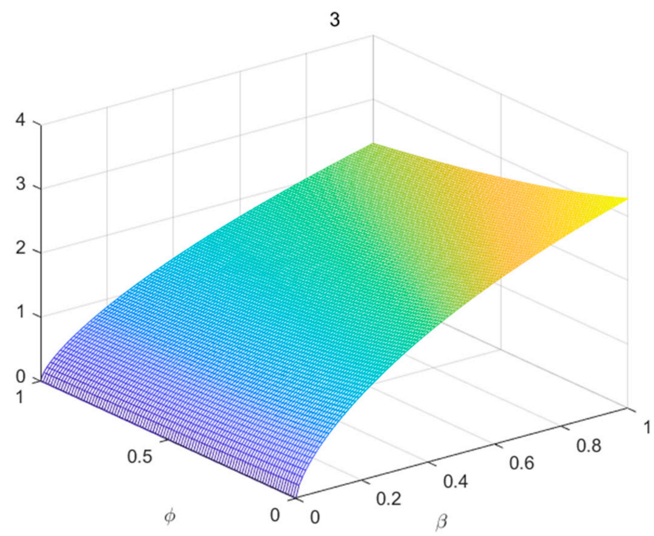


Figure 4. Time discount rate, time discount factor of consumption, and economic growth in three dimensions.

Figure 2 shows that the total social output positively correlates with both total fertility and delayed retirement, and the sensitivity of the fertility rate is higher than the impact of delayed retirement. Regarding fertility, an increase in fertility tends to exert two distinct effects because of the substitution correlation between quantity and quality of fertility [68]. On the one hand, it decreases the opportunity cost of childbearing for the actor, and under the impact of quantitative and qualitative substitution mechanisms, the average educational input of their children is decreased accordingly, thereby attenuating the human capital stock of the next generation of labor force. On the other hand, the increase in the fertility rate directly results in an increase in both the quantity of labor supply and the total supply of working time, which, along with the learning-by-doing effect of the labor process, leads to higher accretion of work experience and work skills, thereby promoting the accretion of human capital among young people.

Regarding the delayed retirement policy, the impact is significant in the lower stages of economic output, and the contribution decreases in the later stages until it tends to zero growth.

5.3. Survival Probability, Pension Rate, and Economic Growth

Figure 3 shows that the effect of the individual pension contribution rate (τ) on the total output exhibits a $\cap$-shaped distribution, and the correlation between the survival probability in old age (P) and total output is relatively stable and generally increasing. With the population aging, the government often uses social tax leverage to regulate social resources for retirement. The increase in the overall tax rate exerts a double effect. On the one hand, it lowers the saving rate and education investment rate of families, which induces excessive resources to the elderly, thereby squeezing out savings and education investment and decreasing the accretion of physical and human capital, while the tax rate increase also has the incentive function of human capital investment, which boosts economic growth by enhancing the quality of the labor force.

5.4. Time Discount Rate, Time Discount Factor of Consumption, and Economic Growth

Figure 4 shows that the effect of subjective discount rate (ψ) on the total output is relatively smooth and the change in the subjective discount rate exerts an insignificant impact on the change in total output. The consumer time discount factor (β) positively correlates with aggregate output, and higher consumer time discount rates tend to lead to a larger total social output. In addition, the subjective discount rate is the discounted value of the utility created by consumption in old age relative to the utility generated by consumption in young age, which has a stable rate of substitution between them and, therefore, exerts little effect on the change in the total output. The time discount factor reflects the time preference of actors in their current and future consumption choices. The larger the value, the more significant the stimulus to economic growth at the present stage, as it means that the overdraft of post-retirement consumption is used to satisfy current consumption. Furthermore, the formation of the time discount factor comprises negative factors, such as mortality risk, household size, and health conditions, which makes consumers unwilling to delay consumption and to choose more real consumption.

6. Discussion

The purpose of this study is to explore the correlation between demographic variables and economic development in China. The factors include changes in, e.g., delayed retirement, total fertility rate, and life expectancy. With a general equilibrium two-period OLG model, we parameterize, numerically solve, and simulate our model. Compared with the existing literature, we pay more attention to the impact of demographic structure variables on China's economy. In this section, we discuss the key findings and implications of the simulation results.

First, the total output level positively correlates with the survival probability, and further generates the second demographic, which is consistent with previous research results [3,29,30,35]. The relationship between demographic dividend and economic growth can be pessimistic for some countries, or optimistic for others depending upon the conditions and sensitivity of the economic policy towards the demographic change. For instance, China's demographic transition has been a success. This result can be clarified from the savings theory perspective, in which a larger survival probability over the whole life cycle implies a longer life expectancy and more leisure time after retirement, needing an increase in the personal savings rate. Thus, the root cause of the secondary demographic dividend is the savings effect.

In addition, there exists a critical point in the range of α, the level of aggregate output increases and then decreases as the value of T(P) increases, and the correlation between the two demonstrates a ∩-shaped curve. The output elasticity of capital positively correlates with the level of industrialization; when it exceeds 0.5, the negative effect of capital output starts appearing because of the significant increase in exterior liabilities [67]. With the advance of industrialization, the role of human capital exceeds that of material capital, which can better attain long-term, sustainable economic growth, which is consistent with previous research results [31,36,40]. Irmen A. [67], for example, addresses this question in a new macroeconomic model of automation where competitive firms perform tasks to produce output. New automation technologies may depreciate the acquired human capital so that the potential effect of these tendencies on the incentive to automate, growth, and factor shares remains elusive, warranting further investigations.

In the end, the results show that the effect of the individual pension contribution rate (τ) on the total output exhibits a ∩-shaped distribution. With populations aging, governments often uses social tax leverage to regulate social resources for retirement. The increase in the overall tax rate exerts a double effect. On the one hand, it lowers the saving rate and education investment rate of families, which induces excessive resources to the elderly, thereby squeezing out savings and education investment and decreasing the accretion of physical and human capital, while the tax rate increase also has the incentive function of human capital investment, which boosts economic growth by enhancing the quality of the labor force. These findings are consistent with the results of the studies on pension system reform [65,67,68]. Our results prefer a reform of the PAYG system along these lines above a movement to a fully funded private system, both from the perspective of employment, growth, and welfare. Finally, our results show the pension tax rate has a double effect, and its adjustment adopts a gradual strategy.

7. Conclusions

This study examines the correlation between demographic variables (e.g., delayed retirement, total fertility rate, and life expectancy) and economic development in China based on the overlapping generations (OLG) model and numerical simulation method. The calibration of model parameters is based on the reality of China. The conclusions are as follows:

(1) The total social output level positively correlates with the survival probability, and a higher probability of survival implies a longer life expectancy and higher total output, which could lead to a second demographic dividend and, thus, achieve sustainable social development.

(2) Aging is represented in this model by the change in survival probability and a decrease in fertility. Therefore the "growth" effect of aging is the fact that there is suddenly more labor in the "old", and it also means that agents save more, hence there is more capital accumulated. The contribution of the aging labor force (retirement age delay) significantly contributes to the total output and is a crucial source of sustainable economic growth. Retirement age delay decides the creation of the secondary demographic dividend through its endogenous effects on fertility and individual retirement pension income and has dual effects. On the one hand, the current delayed retirement policy leads to negative effects such as lower savings and lower capital and per-capita output. On the other hand, delayed

retirement increases labor supply and increases the level of aggregate output, the net effect of which often depending on the strength of both.

(3) The total output increases first and then decreases with the increase in the individual pension contributions rate, and the correlation between the two is an ∩-shaped curve. With the aging of society's population, governments tend to use the leverage of the social integration tax rate to regulate social pension resources. The increase in the integrated tax rate exerts a double effect. First, it lowers the saving rate and education investment rate of families, which induces excessive resources to the elderly, thereby squeezing out the saving and education investment and decreasing the accretion of material capital and human capital. Second, the increase in the tax rate also has the incentive function of human capital investment, which boosts economic growth by enhancing the quality of the labor force.

Furthermore, the proposal for China to attain sustainable development in its demographic transition is:

(1) Economic transformation is the trend of the times. China's economy is in a critical stage of transformation and upgrading, that is, from speed-based growth to quality-based development, from the original foreign technology introduction model to the independent R&D and innovation model, and the focus of industrial development has also shifted from manufacturing to services. Thus, from the standpoint of demographic dividend, the source of boosting sustainable social development is also shifting from quantitative dividend or human-resource–based dividend to qualitative dividend or human-capital-based dividend.

(2) A focus on human development and utilization. Despite the near-complete liberalization of China's fertility restriction policy, the seventh national census data displays that the fertility rate is sluggish and population growth is slowing down in the long run. Thus, a single fertility policy will not exert a fundamental impact on the secondary demographic dividend. This study suggests that the market mechanism regulation should be used to stimulate, encourage, and support family reproductive behavior. Meanwhile, we should follow up with a series of social security measures such as taxation, education, medical care, housing, stimulating family reproductive behavior, discovering the potential of human capital, increasing the capital-based demographic dividend, and activating the gender dividend by decreasing the cost of raising a family.

(3) The Chinese government should improve the social security system and build a multi-level security system. At the national level, China should vigorously develop the economy and increase financial input to ensure a stable source of social security expenditure. However, if the social security level is too high, it affects residents' savings, and if it is too low, it cannot cover all the elderly. Therefore, the proportion of social security should be controlled reasonably. At the social level, we should attract the idle funds of enterprises and private funds to invest in the pension industry, reduce the entry threshold of pension enterprises, and vigorously develop the emerging pension technology industry. At the individual level, the pension security system should be improved, the return rate of pension investment should be increased, and individual pension fund investment should be increased so as to ease the financial burden of the government.

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