A Simulation Study of the Effect of Delayed Retirement on Welfare of the Elderly: Evidence from China

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Abstract
In order to cope with population aging and emerging labor shortages, the Chinese government may soon introduce a policy to address this problem by raising the normal retirement age. However, the effects of planning for delayed retirement on the welfare of the elderly remain unknown. From an intergenerational support perspective, we develop a dynamic optimization model that can simulate changes in the welfare of the elderly over the years under different delayed retirement scenarios. Simulation results show that delaying retirement will produce a detrimental effect on old-age welfare. We further analyze strategies to mitigate this adverse effect and improve people’s welfare. First, the delayed retirement policy should raise the pension replacement rate, which could transfer part of the social welfare improvements from delayed retirement to the elderly through the transfer payment mechanism. Second, when adopting a defined-contribution pension system, the delayed retirement could increase the welfare of the elderly and the social well-being. Implications for future research and public policies concerning welfare effects of delayed retirement are discussed.

Keywords
delayed retirement, welfare of the elderly, intergenerational support, pension system, DB

Introduction
As a remarkable decline in fertility rates, population aging has become an issue of major concern to many countries of the world. This is particularly evident in Europe, where in less than 50 years older adults will have doubled in relation to people in working age between 15 and 64 years old, and are expected to reach 30% of population (United Nations, 2013). In this regard, many European countries are facing serious challenges of the sustainability of public pension systems as well as the financial crises of existing pension plans (Rey-Ares et al., 2018). Developing nation, like China, is also experiencing a rapid demographic transformation. According to the World Bank Open Data (WBOD), it has seen the percentage of population aged 65 years and above increase over the last years, from about 5.63% in 1990 to 10.35% in 2017. Meanwhile, the labor force participation rate of those aged 15 years and above fell by 11.15% from 1990 to 2019. The shifts of population structure in China reflect a demographic transition from a population pattern previously characterized by demographic dividend to aging population, raising considerable concerns about the pension arrangement and its sustainability (Shen et al., 2020). Facing this challenge, the Ministry of Human Resources and Social Security of PRC (MOHRSS) has been working to introduce a delayed retirement scheme for a number of years to tackle the payment pressure on pension system. So far, however, the specific plan for delayed retirement has not been officially announced. One important reason for this is that while the debate concerning the policy effects of postponing retirement is still on-going, a consensus has not yet been reached and less clear are the consequences of increasing retirement age on the welfare of the older people.

This paper, evaluating the welfare effects of delayed retirement policy, aims to contribute to the debate on the macroeconomic consequences of the retirement reform. Therefore, taking China as example, from an intergenerational perspective, we develop a dynamic optimization model which could simulate the evolution of the welfare of the elderly for different postponing retirement scenarios during the policy implementation phase (i.e., before 2030). We first assess welfare effects under the defined-benefit (DB) pension, the current design of pension system in China. Moreover, several mechanisms, such as raising the pension replacement rate and defined-contribution pension system (DC), are introduced to analyze whether they could improve the welfare of the elderly and the social well-being. Implications for future research and public policies concerning welfare effects of delayed retirement are discussed.

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when the delayed retirement policy is implemented. The remainder of this paper is organized as follows. In section 2, we discuss the literature on the welfare effect of postponing retirement age. Section 3 describes the background of pension system in China. Section 4 is the theoretical framework. Section 5 presents the simulated results and sensitivity analyses. In section 6, we further analyze the mechanisms to improve the welfare of postponing retirement. Finally, discussion and concluding remarks are in Section 7.

**Literature Review**

Previous researches have investigated the potential welfare effects caused by increasing the retirement age, but they have not reached a consensus. Several studies found that postponing retirement has positive effects. For instance, Cremer and Pestieau (2003) showed that increasing the age of retirement have a double dividend effect: it will free resources needed to meet the challenge of aging, and it may improve the lifetime welfare of those with low wages and poor health particularly in countries with redistributive social security schemes. Using a multi-period, general equilibrium and overlapping generations (OLG) model, Díaz-Giménez and Díaz-Saavedra (2009) studied the macroeconomic consequences of delayed retirement in Spain and found that the lower consumption tax rates resulting in welfare gains compensate the welfare costs brought about by the reduced pensions and leisure. Bielecki et al. (2016) evaluated the welfare effects of increasing the retirement age for various demographic scenarios under DB, notionally DC and funded DC system. The simulation results showed a universally welfare enhancing for all living and future cohorts regardless of different pension system, and welfare would further increase if productivity is relatively high at old ages. A. Chen and Groenewold (2017) analyzed the regional effects of increasing retirement age in China. They considered four policies to increase the retirement age from 60 to 61 and found that all policies increase welfare and reduce the interregional welfare gap.

On the other hand, some of the research work found a negative welfare effect of postponing retirement. Based on a life cycle framework including the utility from leisure, Lachance (2008) concluded that working longer does little to mitigate the negative impact of pension reductions on welfare, and supporting strategies are needed to enhance the effectiveness of delayed retirement policy. Using a dynamic rational expectations model in the case of Spain, Sánchez-Martín et al. (2014) found that although 2-year delays in retirement ages generate large increases in labor supply and sizable cuts in pension costs, these are achieved at the expense of very large welfare losses, especially among unemployed workers. Miyazaki (2014) studied the effects of raising-the-official-pension-age policy in an OLG model. Such a policy change does not always increase output in an economy and may reduce the social security benefit. Using the data from the Health and Retirement Study (HRS), the studies of Moore et al. (2019) showed an inequitable effect of raising the social security Full Retirement Age (FRA) on Blacks and low-wage workers: working longer is harmful to the welfare of Blacks and low-wage workers because they are unlikely to live long enough to recoup payments foregone as a result of delayed claiming.

Moreover, some scholars argued that the welfare effect of delayed retirement policy remains ambiguous and it depends on the type of pension system. For instance, by extending the OLG model, Fehr (2000) quantified the welfare effects of pension reform proposals in Germany. Simulation results revealed that with increased retirement age the welfare gains or losses result from the strength of the link between pension contributions and benefits. Using a two-staged model incorporating government decision in redistribution level of the pension system, Lacomba and Lagos (2010) found that if the retirement age is postponed, the individual’s welfare is determined by the degree of intra-generational redistribution of the pension system. Makarski and Tyrowicz (2019) analyzed the welfare effects of raising the retirement age by developing an OLG model accounting for longevity and found that postponing retirement age will reduce fiscal imbalances under the DB pension system while it has no direct fiscal and pension income effect under the DC system.

This paper attempts to fill the gap of existing research concerning the impacts of delayed retirement on the welfare of the elderly. First, different from the most previous studies which largely focused on advanced countries, we offer a new insight into the welfare changes among older people in China, a rapidly growing country while facing the challenges of an aging population. Second, due to the inadequate pension system in China, intergenerational support is crucial for improving old-age welfare. This article examines the welfare effects of delayed retirement from a perspective of intergenerational support. Our findings have important implications for future comparison studies on the welfare benefits of retirement reform and pension system design. Finally, building on our model, we further analyze the feasible mechanisms which could mitigate the potentially unfavorable effects on older people’s well-being. This may provide valuable information for other countries’ policy reform aimed to reduce the pressure of population aging on pension system while maintaining the level of social welfare.

**Institutional Background**

The China’s pension system consists of the public, occupational, and commercial pension. Among them, the public pension is the most developed and widespread. It is comprised of three main types of pension scheme: the Urban Employees’ Pension Plan (UEPP) and the New Rural Pension Scheme (NRPS), and the Urban Resident Pension Scheme (URPS). In order to reduce the rural-urban inequality in social welfare, since 2014 the NRPS and the URPS have been gradually merged into a unified public pension scheme.
for rural and urban residents (URRPS). Both the UEPP and URRPS are characterized by a DB pension system. For now, the statutory retirement age in China is 60 for male and 50 for female workers while the retirement age can be postponed to 55 for those females who are government officer. On the other hand, civil servants working for more than 30 years are entitled to retire early and receive pension benefits, and non-employed residents aged 60 or above are eligible for the pension benefits from URRPS.

The China’s public pension is characterized by a two-pillar pension scheme. Taking the UEPP as an example, the first pillar is the social pooling account contributed by enterprises with a 20% of the total taxable payroll, and the second pillar is the individual account contributed by employees with an 8% of their wage. It is usually viewed as the partially funded system, which has two advantages. On one hand, the PAYG arrangements in social pooling account can achieve the goal of intergenerational transfer through social coordination. On the other hand, financing objectives can help to increase personal responsibility and capital accumulation of individual pension accounts (Liu & Sun, 2016). However, since the government did not pay for the pension debt raised by the system transition from PAYG to partially funded system, the individual account in fact is an “empty account” and thus the UEPP is eventually developed to be a PAYG system (Wang et al., 2019). By the end of 2019, the China’s public pension system covered around 967.54 million people (434.88 million people covered by the UEPP and 532.65 million people covered by the URRPS), which accounts for 69.3% of the total population. About 283.42 million people received pension benefits, including 123.1 million retired workers and 160.32 million non-employed residents (Ministry of Human Resources and Social Security of PRC [MOHRSS], 2019).

In recent years, however, China’s public pension replacement rate has been staying at around 47% (China Statistics Press, 2018), which is far below the target pension replacement rate, 59.2%, according to the policy of MOHRSS.

It is worth noting that the public pension system is no longer large enough to cope with the accelerated aging of the society as the deficit has not been covered. Due to high payment proportion, Chinese enterprises are already heavily burdened, and it is difficult to improve this situation any further. Meanwhile, it is also difficult to enlarge the scale of occupational pension in a short term. Thus, the development of personal pension schemes characterized by private savings is very important. For this reason, in April 2018, the Chinese government selected Fujian Province, Shanghai City, and Suzhou industrial park as the pilot region to implement a pension pilot program, which was designed to carry out the personal tax-deferred model of the commercial endowment pension. This is a milestone event in the reform of China’s public pension system in the new era. It is also an important institutional reform for coping with the payment pressure of population aging on pension system and to defuse longevity risk in the future.

The Theoretical Framework

The Model

There are several assumptions on the building the theoretical model. First, we assume that the product and factor markets are equilibrium and complete. Second, the labor participation rate and employment rate are held constant because the impact of delayed retirement on factor productivity is not considered in our study. Third, we conduct the analyses under a closed economy without consideration of international trade and debt issues. Finally, the Cobb-Douglas (CD) form function is used as the production function where the return on the scale and the share of capital contribution remain unchanged. Following the works of Lu and Cai (2014), Miyazaki (2014) and H. Yang (2016), the economy is populated by overlapping generations containing three periods: adolescent, working-age adult, and old age. The adolescents and the elderly are not involved in production activities and social decision-making. Working-age adults, the main labor force and wage earner, acts as a sole role in making family decisions. In the context of China, fertility has two attributes including investment and inheritance. We view fertility as exogenous because child-birth is strictly controlled in China. Also, supporting the elderly in China is not just a kind of duty, but more like a virtue. Given the traditional culture of raising children and supporting the elderly, they are considered in our study. Therefore, the utility function of working-age adult in each period includes the individual’s consumption, savings, the expenses of raising children, and the expenses of supporting the elderly. Based on the features of the China’s pension system, the pension income from pooling account depend on intergenerational support from children while the pension from personal account depend on individual’s saving, and thus the current pattern for Chinese old-age support can be viewed as a combination of intergenerational support and saving.

For the utility function, we follow the works of Barro and Becker (1989) and H. Yang (2016). The inter-temporal substitution elasticity of consumption is set to $\sigma$, and the weight given to future consumption is $\beta$. For the consumption of adolescents and the elderly, the weights are $\gamma$ and $\chi$, respectively. According to the DB system in China, the family supporting ratio (i.e., pension replacement rate) is assumed to be $\phi$, reflecting the ratio of intergenerational support for the elderly to wages. The rate of the expenditure to raise a child is set to $\mu$. The consumption and savings in the period $i$ are set to $C_i^1$ and $S_i$, respectively, and the consumption in period $i+1$ is set to $C_{i+1}^2$. The size of population aged $j$ in period $i$ is set as $P_i(j)$, while the number of workers to be withdrawn from the labor market is set as $J_i$. Because the current age at which people exit from the labor market is 54 years old in China (MOHRSS, 2018), we can get $J_i = P_i(54)$. The number of working-age adults, $L_i$, and the number of older people, $O_i$, will be affected by different retirement systems through the number of workers.
who are going to retire $J_i$. The number of adolescents, wage, human capital, and interest rate of period $i$ are denoted by $H_i,w_i,h_i$ and $r_i$, respectively.

Under the DB pension system, the intergenerational support level represents the welfare of the elderly. If we take period $i$ as an example, the intergenerational support for each older adult in period $i$, denoted by $\phi_i$, is a fixed ratio of the wages $w_i$ of working-age adults. Thus, the total expenditure of supporting the elderly in period $i$ is $\phi_iw_iO_i$. Since the proportion of the expenditure of raising a child to the salary $w_i$ is $\mu$, and thus the total expenditure for raising children in period $i$ is $H_i\mu w_i$. If the total output of period $i$ is $Y_i$, the first budget constraint faced by working-age adults in period $i$ is as follows:

$$Y_i = C_i^1 + S_i + H_i\mu w_i + \phi_i w_i O_i$$  \hspace{1cm} (1)

Next, we consider the consumption $C_i^2$ in period $i+1$. The first part of the consumption is determined by $S_i(1+r_{i+1})$, where $r_{i+1}$ is the interest rate in period $i+1$. Based on the traditional Chinese culture of intergenerational support, the retired elderly will receive the financial support from those working young adults. We should consider how much return can be obtained in the period $i+1$ if the working population have spent $H_i\mu w_i + \phi_i w_i$ to raise children and support the elderly in period $i$. The return of the working population is approximately equal to the support obtained by those who just retired in period $i+1$. If the rest of working population are still working in period $i+1$, the expenditure will occur because raising children and supporting the elderly have not been converted into their pension resources. Assuming that the survival rate is $\pi_i$, so the return of raising children can be calculated as $\pi_iJ_i\phi_i w_i$, and the expenditure of supporting the elderly equals to $(H_i\mu w_i + \phi_i w_i)J_i / L_i$. That is to say, raising children and supporting the elderly in period $i$ produces a return of $\pi_iJ_i\phi_i w_i - (H_i\mu w_i + \phi_i w_i)J_i / L_i$ to the working population $L_i$ in period $i+1$. Therefore, the second budget constraint faced by working-age adults in period $i$ is as follows:

$$C_i^2 = S_i(1+r_{i+1}) + \pi_iJ_i\phi_i w_i - (H_i\mu w_i + \phi_i w_i)J_i / L_i$$  \hspace{1cm} (2)

The utility function of the working population is modeled by the form of the power function, and the exponent of power is $\sigma$. We assume that the utility of working population is determined by consumption, savings, expenditure of raising children, and expenditure of supporting the elderly, and thus the utility function can be expressed as follows:

$$U_i = \left(C_i^1\right)^\sigma + \gamma (H_i\mu w_i)^\sigma + \chi (O_i\phi_i w_i)^\sigma + \beta \left(C_i^2\right)^\sigma$$  \hspace{1cm} (3)

Under the DB pension system, the working population in period $i$ should decide how to optimally allocate the output to consumption, savings, raising children, and supporting the elderly. Maximizing the utility function as described in (3), while it subjects to budget constraints (1) and (2). They are as follows:

$$\max \{U_i \mid \mbox{subject to constraints (1) and (2)}\}$$

$$\begin{cases}
Y_i = C_i^1 + S_i + H_i\mu w_i + O_i\phi_i w_i \\
0 \leq \sigma,\beta,\gamma,\chi,\phi_i,\mu,\pi_i \leq 1
\end{cases}$$  \hspace{1cm} (4)

Since the parameters $\sigma,\beta,\phi_i,\gamma,\chi,\mu,\pi_i$ are determined by the exogenous system, such as culture and social rules, they could be viewed as the constants in a certain period. Variables $H_i, L_i, O_i$ and $J_i$ in the past few years are determined by the historical population, newborn population, mortality rate, and different retirement scenarios. If the population distribution of the past several years is known and the mortality rate is unchanged, these variables can be viewed as exogenous and calculated by applying the fertility level in different retirement scenarios. As the delayed retirement policy influences family decisions through variables $L_i, O_i, J_i$, the key to obtaining the values of $H_i, L_i, O_i, J_i$ in different postponing retirement scenarios is to know the fertility level in the future.

To avoid controversy over the actual fertility level under the China’s universal two-child policy, the fertility level is set at the policy level (2.0). We next consider how to predict the number of adolescents $H_i$, the number of working-age adults $L_i$, the number of elderly people $O_i$, and the number of people who are going to leave the labor market $J_i$. To facilitate the calculations, it is assumed that people who are 100 year old will exit the model in the next period and labor population participation rate and the unemployment rate are not considered in our study. Therefore, we only need to calculate the number of people aged 0 to 100 classified by age and gender for each of the subsequent years. The number of people who are 0 year old is determined by the number of women of childbearing age and the fertility level. Members of the population aged between 1 and 100 are determined by the people aged between 0 and 99 in the previous year and the survival rate of the year.

The population data classified by age and gender come from the Population Sample Survey of China in 2015. The mortality rate by age and sex for each of the subsequent years comes from the Chinese population census in 2010. Based on the 2010 population census data, the total fertility rate of women of childbearing age is 1.18, thus we can predict the age-specific fertility rate under the universal two-child policy, and assume that it remains unchanged in the following years. Considering that the sex ratio of newborns may be improved under the universal two-child policy, the gender ratio of newborn babies is assumed to be 110:100. By calculating the population by gender in major age groups under
normal retirement, we add up the population by gender to obtain the total population of each age group in the future. Accordingly, in next few years, the values of variables \( H_i, L_i, O_i, \) and \( J_i \) are obtained. The number of newborn babies depends on the number of women of childbearing age (15–49) and the fertility level. Therefore, the number of newborn babies by gender is as follows:

\[
\begin{align*}
    p_i^{female} (0) &= \frac{100}{100 + 110} \sum_{j=15}^{49} \text{TFR}^j \text{female} (j) p_i \text{female} (j) \\
p_i^{male} (0) &= \frac{110}{100 + 110} \sum_{j=15}^{49} \text{TFR}^j \text{male} (j) p_i \text{female} (j)
\end{align*}
\]  

(5)

Where \( p_i^{female} (0) \) and \( p_i^{male} (0) \) represent the number of newborn girls and boys in period \( i \), respectively. \( p_i^{female} (j) \) and \( \text{TFR}^j \text{female} (j) \) represent the number of women at the age of \( j \) in period \( i \) and the corresponding fertility level. Since the population of those who are 1 to 100 years old is determined by the population of those who are 0 to 99 years old in the previous year and by the survival rate of that year, then the survival rates of women and men of age \( j \) at period \( i \) are \( s_i^{female} (j) \) and \( s_i^{male} (j) \), respectively. Therefore, the population of those who are 1 to 100 years old, classified by gender in period \( i \) is that:

\[
\begin{align*}
p_i^{female} (j) &= s_{i-1}^{female} (j-1) p_{i-1}^{female} (j-1) \\
p_i^{male} (j) &= s_{i-1}^{male} (j-1) p_{i-1}^{male} (j-1)
\end{align*}
\]  

(6)

where \( j = 1, 2, \ldots, 100 \)

According to the population movement rules mentioned above, we can know the number of people aged 1 to 100 by age and gender in any year in the future. By adding up the number of people by gender and age, the total population by age in the next few years can be calculated as:

\[
P_i (j) = p_i^{female} (j) + p_i^{male} (j) \quad \text{where} \quad j = 0, 1, \ldots, 100
\]  

(7)

Because 16 is the legal age for working and the average age of people exiting the labor market in China is 55 (MOHRSS, 2018), we define the total population under the age of 16 as the adolescents \( H_i \) and define the total population over 55 years old as the older people \( O_i \). For those who are 54 years old are defined as the persons to be withdrawn from the labor market \( J_i \), while people who are 16 to 54 years old is the working-age adults \( L_i \). Due to the present of labor participation rate and unemployment rate, the number of people of working age is not strictly equal to the actual number of working people. We set the employment rate by age \( ER(j) \) according to the data from the Chinese population census in 2010 and the employment rate by age is held constant in the following years. If the retirement system has not changed, then variables \( H_i, L_i, O_i, J_i \) in period \( i \) can be calculated by following equations:

\[
\begin{align*}
    H_i &= \sum_{j=0}^{15} (p_i^{female} (j) + p_i^{male} (j)) \\
    L_i &= \sum_{j=16}^{54} ER(j) (p_i^{female} (j) + p_i^{male} (j)) \\
    O_i &= \sum_{j=55}^{100} (p_i^{female} (j) + p_i^{male} (j)) \\
    J_i &= p_i^{female} (54) + p_i^{male} (54)
\end{align*}
\]  

(8)

If we want to calculate the optimal solution of the family decision in period \( i \), we need to know the values of variables \( w_i, w_{i+1} \) and \( r_{i+1} \), which are mainly determined by the production department. To calculate wages and interest rates, a CD production function containing human capital with a constant return to scale is introduced. In this function, \( A \) is the total factor productivity, \( K_i \) is the capital stock, and \( h_i \) is the human capital. If capital and labor contribution is represented by \( \alpha \) and \( 1 - \alpha \) respectively, then the production function of period \( i \) is:

\[
Y_i = A(K_i)^\alpha (h_i L_i)^{1-\alpha}
\]  

(9)

The market is assumed to be competitive and complete. In general equilibrium, the household sector maximizes utility, the production sector maximizes profit, the marginal income of labor equals the marginal cost of labor, and the marginal income of capital equals the marginal cost of the interest rate of capital. When the producers achieve maximum profits, current wages \( w_i \), the wages of the next period \( w_{i+1} \), and the interest rate of the next period \( r_{i+1} \), are calculated as follows:

\[
\begin{align*}
    w_i &= A(1-\alpha)(K_i)^\alpha (h_i L_i)^{-\alpha} \\
    w_{i+1} &= A(1-\alpha)(K_{i+1})^{\alpha} (h_{i+1} L_{i+1})^{-\alpha} \\
    r_{i+1} &= A\alpha(K_{i+1})^{\alpha-1} (h_{i+1} L_{i+1})^{1-\alpha}
\end{align*}
\]  

(10)

In the equation determining the factor prices, the capital contribution share and the total factor productivity are assumed to be constant, anworking population \( L_i \) can be computed. If we want to calculate the values of \( w_i, w_{i+1} \), and \( r_{i+1} \), we need to know the capital stock \( K_i \) and the human capital \( h_i \). Assuming that the depreciation rate of capital stock in each period is \( \delta \), the savings \( S_{i-1} \) are equal to the investment \( I_{i-1} \), and the capital stock \( K_i \) of period \( i \) is equal to the capital stock of the previous year \( K_{i-1} \) minus the depreciation \( \delta K_{i-1} \), plus the savings of the previous year \( S_{i-1} \), the capital stock of period \( i \) can be expressed as follows:

\[
K_i = (1-\delta)K_{i-1} + S_{i-1}
\]  

(11)

The depreciation rate \( \delta \) is a constant, and the variables of the previous year \( S_{i-1}, w_{i-1} \) and \( L_{i-1} \) are known. If the initial
capital stock $K_{2015}$ is known, and $S_i, w_i, L_i$ can be expressed by parameters and known variables, then the capital stock $K_t$ and $K_{t+1}$ can be calculated. Following Barro and Lee (2013), we use the average years of education of the working population $s_i$ to calculate the human capital of working population $h_i$. The average years of education of the working population $s_i$ is equal to the number of working people in each age group $L_i(j)$ multiplied by the average years of education at the corresponding age $s_i(j)$, and then divided by the size of the total working population $\sum_j L_i(j)$, that is:

$$s_i = \frac{\sum_j L_i(j) s_i(j)}{\sum_j L_i(j)} \quad (12)$$

To compute the human capital level by age group, we use the generational segmentation calculation approach (Huang, 2011) and the data from survey concerning the education status of Chinese people born after 1980, which is conducted by Shanghai Jiaotong University in 2014. The survey shows that the average years of education of the “post-80s” generation (people born between 1980 and 1989), post-90s generation (people born between 1990 and 1999) and post-00s generation (people born between 2000 and 2009) are about 12.5, 14.5, and 16, respectively. Following the study of Lu and Cai (2014), the human capital level of the initial year is set to $h_{2015} = 1$, and the association between human capital level $h_i$ and the average years of education of working population $s_i$ is defined as $h_i = e^{\alpha s_i - \varphi s_i}$. Given that the returns to education between different levels of education may vary, the $\varphi(s_i)$ is written by following equations:

$$\varphi(s_i) = \begin{cases} 
0.134*(4-s_i), & s_i \leq 4 \\
0.134*4 - 0.101*(s_i - 4), & 4 < s_i \leq 8 \\
0.134*4 + 0.101*4 + 0.068*(s_i - 8), & 8 < s_i \end{cases} \quad (13)$$

Based on the values of the parameters and variables, the working population faces following optimization problem:

$$\text{Max } U = \left( C_i^a + \gamma (H_i w_i)^\beta + \chi (O_i \phi_i w_i)^\beta + \beta (C_i^2)^\alpha \right),$$

$$Y_i = C_i^\alpha + H_i w_i + S_i + O_i \phi_i w_i$$

$$C_i^\alpha = S_i \left( 1 + r_{i-1} \right) + \pi_i h_i \phi_i w_{i-1} - \frac{L_i}{L_{i-1}} \left( H_i w_i + O_i \phi_i w_i \right)$$

$$w_i = A(1-\alpha)(h_i)^{-\alpha} (K_i)^\alpha (L_i)^{-\alpha}$$

$$s.t. \left\{ 
\begin{array}{l}
w_{i+1} = A(1-\alpha)(h_{i+1})^{-\alpha} (K_{i+1})^\alpha (L_{i+1})^{-\alpha} \\
r_{i+1} = A\alpha (h_{i+1})^{-\alpha} (K_{i+1})^{-1} (L_{i+1})^{\alpha} \\
K_{i+1} = (1-\delta)K_i + S_i \\
h_i = e^{\rho_i(1-\varphi i)} \\
0 \leq \alpha, \beta, \gamma, \phi, \mu, \pi, \sigma \leq 1 
\end{array} \right\} \quad (14)$$

In our analysis, the welfare of the elderly is measured by the intergenerational support from the working population. Under the DB pension system, the rate of intergenerational support and the wage, represented by $\phi_i$, is unchanged. The welfare level of each older adult can be expressed by following function:

$$O_{i+1} = \phi_i w_i = \phi_i \left( 1-\alpha \right) A \left( h_i \right)^{1-\alpha} \left( \frac{K_i}{L_i} \right)^\alpha$$

### Parameter Setting

Knowing the demographic variables, capital stock, human capital, and other parameters in the model, the effects of different delayed retirement scenarios on the welfare of the elderly can be simulated according to equations (14) and (15). Given that the above model is a nonlinear dynamic optimization, there is usually no analytical solution in this scenario, and thus we use the `fmincon` function designed to solve the nonlinearity optimization problem in the MATLAB toolbox to obtain the numerical solution for each period. The initial values of parameters are set based on previous studies and the reality in China, as presented in Table 1. It should be noted that, to ensure the reliability of the simulation results and avoid arbitrariness of the parameter settings, some core parameters that may affect the simulation results are analyzed with sensitivity in the following sections. It is necessary to emphasize two important assumptions in our study. First, the market is completed and there is no structural distortion. The production factors are determined by the marginal contribution, and savings equals investment. Second, to avoid controversy, we do not consider technological progress in the model. Actually, prior researches concerning the impact of increasing retirement age on technology or productivity produced mixed results. For example, using data from the Current Population Survey (CPS), Burtless (2013) found little evidence the aging workforce has hurt productivity. The findings of Mahlberg et al. (2013) also confirmed that firm productivity is not negatively related to the share of older employees it employs. The study of Miyazaki (2014) showed an increase in labor supply by raising the retirement age but the aggregate output does not necessarily increase. Gabriele et al. (2018) showed that the increase of retirement age locked older employees into the workplace with a negative impact on productivity.

### Simulation Results

We first define the current retirement policy as the benchmark scenario (BI), where the average age of withdrawal from the labor market is 54 years old (MOHRSS, 2018). Next, we compare two retirement scenarios: the gradually delayed retirement (GDR) and immediately delayed retirement (IDR). The GDR is the withdrawal of a cohort from the labor market every other year (i.e., a half-year delay in each year). For
example, a cohort aged 54 in the first year withdraws from the labor market while no cohort withdraws from the labor market in the second year and a cohort at age 55 in the third year withdraws from the labor market. Until 2035, when a cohort aged 64 starts to withdraw from the labor market, the age at which subsequent cohorts start to withdraw from the labor market is fixed at age 64. In terms of IDR, the cohort aged 54 will retire in the first year, after which people who are not retired have to reach the age of 64 before exiting the labor market. Based on the above settings, it can be seen that all types of delayed retirement schemes are almost completed by 2035, the simulated interval is therefore placed between 2015 and 2035.

The Basic Results

Figure 1 displays the simulated results of the welfare effect of different delayed retirement scenarios. Of all the cases (BI, GDR, and IDR), the intergenerational support for the elderly appear to an upward trend, suggesting that the welfare of older people will be improved in the future. However, there is a difference of welfare effect between delayed and non-delayed retirement. Specifically, before 2030 the welfare effects of GDR and IDR are lower than that of BI. This implies that if government raise the retirement age, it would produce a detrimental effect on the welfare of the elderly. We can also see that the magnitude of welfare effect vary by the year of policy implementation: the later the delay in retirement, the greater the welfare loss to the elderly. After 2030, the welfare of the elderly under the policies of GDR and IDR appear to be higher than that of BI. These results suggest that, under the DB pension system, postponing retirement will not significantly improve people’s welfare in a short term and may even have a negative impact.

Here, we try to explain the reason for the negative effects of postponing retirement on the welfare of the elderly. From the equation $OI_{ij} = \phi_i w_j = \phi_i (1-a) A(h_j) \alpha K(L_j)^\alpha$, it is easy to find that the level of intergenerational support received by each older person in the pooled accounts is just a fixed proportion $\alpha$ of the average social wage $w_j$, and it is not directly related to the size of the working population and the number of the elderly. The capital contribution share $\alpha$ is constant if the pension replacement rate is exogenously given and at the same time not adjusted accordingly to the retirement scenarios. Delaying retirement will increases the size of the workforce compared to the non-delayed retirement, and the level of education of the working population retained under delayed retirement is lower than that of the new entrants to the labor market. This will leads to a lower level of human capital $h_j$ and excessive working population reduces the capital-labor ratio $K_j / L_j$. For this reason, the delayed retirement policy reduce the social average wage $w_j$ (Miyazaki, 2014; Zou & Ye, 2015), which will lead to a decrease in the intergenerational support level for the elderly $OI_{ij}$.

Sensitivity Analyses

To test the robustness of the results, the sensitivity analyses are conducted in terms of the core parameters of the model.
We adjust the parameters including the inter-temporal substitution elasticity \( \sigma \), the discount factor \( \beta \), the weight \( \gamma \) assigned to the expense of raising child, and the weight \( \chi \) assigned to the expense of supporting the elderly. For the above parameters, two sets of values different from the baseline scenario are taken and then simulated separately. Results are presented in Figures 2 to 5.

First, a change in the elasticity of substitution \( \sigma \) across periods does not influence the results of the comparison between delayed retirement and the benchmark scenario, but it changes the absolute value of old-age benefits for different retirement scenarios. Figure 2 shows that the greater the elasticity of substitution across time and the more patient the population is, the higher level of old-age benefits for the elderly in the future. Second, a change in the discount factor \( \beta \) also has little impacts on the results of the comparison between the delayed retirement and the benchmark scenario, but it changes the absolute value and trend characteristics of the old-age benefits in the different retirement scenarios. Figure 3 shows that the larger the discount factor, the higher level of old-age benefits for the elderly, and it is likely to show an upward trend. Finally, for the weight on raising children \( \gamma \) and the weight on supporting the elderly \( \chi \), the simulated results are also similar. Both of them do not change the results of the comparison between different delayed retirement scenarios, but change the absolute value of old-age welfare, as shown in Figures 4 and 5. Overall, the simulation results of sensitivity analyses are similar to the basic results, suggesting that our results are reliable.

**Further Analyses**

From the results of the previous analyses, the delayed retirement has a negative impact on the welfare of older people. In
this section, we investigate some possible strategies to mitigate this adverse effect so as to achieve the goals of policy reform in welfare improvement. We first introduce a subsidy mechanism to analyze whether this policy design could improve old-age benefits and social welfare. Next, we change the pension system from a DB to a DC system to examine the welfare effects of the elderly.

The Subsidy Mechanism

Before looking at subsidy policies, we simulate the effects of different retirement scenarios on social welfare, which is measured by output per capita. As displayed in Figure 6, the social welfare shows an increasing trend in all cases of BI, GDR and IDR. Moreover, the social welfare under delayed retirement policy (GDR and IDR) are higher than that of non-delayed retirement (BI), and the welfare of IDR is higher than GDR. It can be seen that delayed retirement does improve the overall welfare of society to some extent. This raises an interesting question: can the social welfare enhancements be used to compensate for the loss of older people’s welfare and thus achieve a Pareto improvement in delayed retirement policy? The key to this is to ensure that the value added to social benefits under each deferred retirement option is greater than the corresponding loss of benefits for older persons.

Figure 7 shows that the introduction of transfer payments can compensate for the loss of welfare of the elderly due to delayed retirement, while also contribute to improve the overall welfare of society. So, how does the transfer payment mechanism set up? Since delayed retirement improves social welfare, it would lead to a decrease in the average level of social wage for different delayed retirement scenarios as compared to the unchanged retirement policy. For this reason, only if the replacement rate for the level of intergenerational support, $\phi_1$, is increased in line with the value added to social welfare by delayed retirement, it is possible to achieve improvements in social welfare while avoid the welfare losses of the elderly. In a word, under the DB pension system, the old-age benefits can be improved by increasing the replacement rate for pensions, which transfers part of the social welfare improvements from delayed retirement to the elderly through the transfer payment mechanism.

The DC Pension System

We further analyze the changes of welfare under the DC pension system, where the intergenerational support from working population to the elderly is not just dependant on the average of social wage. The intergenerational support level is a fixed ratio $\phi_2$ of the total income of the working population $w_iL_i$. The working population makes the decision about the allocation of total output, which is distributed into consumption $C^i_1$, savings $S_i$, raising children $H_iw_i$ and supporting the elderly $\phi_2w_iL_i$. Raising children and supporting the elderly are not just related to investment, but also related to consumption because they can enjoy time with the family. Therefore, $C^i_1$, $H_iw_i$ and $\phi_2w_iL_i$ are included into the utility function. In period $i+1$, saving $S_i$ has a total return $S_i(1+r_{i+1})$. Based on intergenerational support culture and DC pension system, the expenditure of raising children and supporting the elderly in period $i$ (i.e., $H_iw_i+\phi_2w_iL_i$) produces returns of $\phi_2w_{i+1}L_{i+1}\frac{\pi J_{i+1}}{O_{i+1}} - (H_iw_i+\phi_2w_iL_i)\frac{J_i}{L_i}$ in period $i+1$. The wages and interest rates in the current and the next period are also determined by the profit maximization conditions of the production sector, and the population movement equation is determined by the fertility policy. The capital movement equation, the human capital movement equation is determined by the production sector, and the population movement equation should be introduced into the model. Under the DC pension system, the working population faces following objective function and constraints:

$$\text{Max} U_i = \left( C^i_1 \right)^\alpha + \gamma (H_iw_i)^\sigma + \chi (\phi_2w_iL_i)^\beta + \beta \left( C^i_2 \right)^\sigma$$

$$C^i_1 = Y_i - S_i - H_iw_i - \phi_2w_iL_i$$

$$C^i_2 = S_i(1+r_{i+1}) + \phi_2w_{i+1}L_{i+1}\frac{\pi J_{i+1}}{O_{i+1}} - (H_iw_i+\phi_2w_iL_i)\frac{J_i}{L_i}$$

$$w_i = A(1-\alpha)(h_i)^{-\alpha}(K_{i+1})^{\alpha}(L_i)^{-\alpha}$$

$$w_{i+1} = A(1-\alpha)(h_{i+1})^{\alpha-\alpha}(K_{i+1})^{\alpha}(L_{i+1})^{\alpha-\alpha}$$

$$r_{i+1} = 1 - \delta L_i + S_i$$

$$h_i = e^{\theta(t)\cdot q(v)}$$

$$0 \leq \sigma, \beta, \phi_2, \gamma, \chi, \mu, \pi, \leq 1$$

$$(16)$$
According to the features of DB system, the total intergenerational support level for the elderly in each period is equal to the total labor income $w_i L_i$ multiplied by the pension replacement rate $\phi_2$. Again, the old-age welfare is measured by the intergenerational support level. Therefore, the welfare level of each older adult in period $i$ can be expressed as follows:

$$O_{I,i} = \phi_2 w_i L_i / O_i$$

$$= \phi_2 (1 - a) A(h_i)^{1-a} (K_i)^a (L_i)^{1-a} / O_i \quad (17)$$

Figures 8 and 9 show the welfare effect of simulation under the DC pension system. On one hand, the delayed retirement scenarios (GDR and IDR) enhance the welfare of the elderly as compared to the benchmark retirement scenario (BI), which show little effect on the old-age welfare. On the other hand, delayed retirement has improved social welfare and the welfare effect of IDR is larger than that of GDR.

Unlike the DB pension system, increasing retirement age under the DC system influences income distribution primarily through affecting the size of the working people and old-age cohorts. From equation (17), we can see that the intergenerational support level for each older person does not only depend on the average of social wage $w_i$, but also depend on working population $L_i$ and the number of older people $O_i$. While postponing retirement reduces human capital $h_i$ and the capital-labor ratio $K_i / L_i$, it increases the number of working population $L_i$ and reduces the number of elderly $O_i$, and the effect of the latter is larger than the effect of the former. Therefore, delaying retirement with a DC pension system could increase the welfare of the elderly and the social well-being.

### Discussion and Conclusion

To meet the challenges of an aging population and potential labor shortages, the plan for raising the normal retirement age in China has been considered for a long time and may soon be introduced. The interesting question is: Does the delayed retirement policy increase the welfare of the elderly? In a sense, this determines the effectiveness of policy implementation and related supporting arrangements. Based on intergenerational support perspective and the DB pension system, we develop a dynamic optimization model to evaluate the potential effects of different scenarios postponed retirement on older people’s welfare, which is characterized by intergenerational support. The results of simulation show that, in comparison to non-delayed retirement system, the older people gain a lower level of intergenerational support.
under the delayed retirement policy before 2030, indicating a negative impact of delayed retirement on the welfare of the elderly. When comparing the welfare effects between different delayed retirement patterns, the negative effect of IDR is greater than that of the GDR. Moreover, the detrimental effects on welfare become larger when the delayed retirement policy is implemented later. Our results are robust to the sensitivity analysis on core parameters, which suggested that, in the context of China, the delayed retirement policy would reduce older people’s welfare if the DB pension system is not changed.

Given the welfare loss from the postponing retirement age in the case of DB system, we analyze several possible mechanisms which could improve the welfare of older people when the delayed retirement policy is implemented. First, we introduce the transfer payment mechanism and raise the pension replacement rate according to the different delayed retirement scenarios. Because the replacement rate of the intergenerational support denoted by coefficient $\Phi$ increases, the delayed retirement policy improve the overall welfare of the society without jeopardizing the welfare of the elderly and thus a Pareto improvement can be achieved. Second, we consider a new pension system, the DC pension system, to simulate the welfare effects of delayed retirement policy. Results show that postponing retirement age not just significantly improves the overall welfare of the society, but also increases the well-being for the elderly to a certain extent. Our finding has important implications for policy reform to avoid the detrimental effects of raising retirement age on welfare, particularly in the cultural context that intergenerational support is a typical feature in many East Asian families. On one hand, if government wants to reduce the loss of welfare under the existing DB pension system, a transfer payment mechanism is needed to raise the pension replacement rate for different postponing retirement scenarios. On the other hand, if the DB pension system is not necessary, the DC system might be a policy option for the government to minimize the potential for harmful effects from delayed retirement.

It is essential to consider a few limitations in the present study. First, technical factors are not considered in the model setting. Nonetheless, technological progress plays an important role in human capital accumulation and more research is needed to investigate this. Second, due to data limitations, we are not able to verify the welfare effect of retirement reform at individual level. Additional research with available data sources will help to further strengthen our findings. Third, to simplify the analysis, we do not consider the international trade, debt issues and heterogeneity in policy setting. The model assumes that the numerical simulation analysis is conducted under a closed economy and all production departments follow a unified framework for delayed retirement policy. Our results remain a preliminary finding and more research is needed to explore reality of policy practice. Finally, our research is specific for the case in China. The effect of delayed retirement on the welfare is likely impinged on by economic conditions and cultural background, which calls for caution in generalizing our results to other countries.

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