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Assessing the Financial Sustainability of the Pension Plan in China: The Role of Fertility Policy Adjustment and Retirement Delay

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Abstract: Population aging is creating serious challenges for the sustainability of China's pension system. To mitigate the adverse impact of the demographic shift, China has recently introduced fertility and retirement policy reforms. The research presented in this paper primarily evaluates the impacts of recent reforms on the financial sustainability of China's Urban Employees' Pension Plan (UEPP). By using the Leslie matrix and actuarial models, the financial sustainability of the UEPP from 2019 to 2070 is projected and evaluated under a set of assumed policy reform scenarios. The results indicate that an imbalance in the pension fund would occur in the early 2020s and then expand under existing policies. Fertility adjustment, retirement delay, or combination reforms would not fundamentally solve this financial crisis in the long term. When 100% of couples have a second child and the retirement age is increased to 65, the current and accumulated pension deficits would drop by 50.05–67.56% and 35.88–54.23% between 2040 and 2070, respectively. Supplementary policy measures should be designed to encourage childbearing and retirement delay, including family support policies and top-designed pension system reform policies.

Keywords: basic pension plan; financial sustainability; fertility policy; retirement delay; actuarial analysis

1. Introduction

As population aging becomes a worldwide issue, the financial crises of existing pension plans have received extensive attention from government officials, academic scholars, and individuals. China is experiencing a much more rapid demographic transformation than most developing countries since the onset of an increasingly aging society in 2000. According to the 2015 1% mini census, 0.14 billion members of the population in China were aged 65 and over, which accounts for 10.47% of the total population; this proportion is 4.1% higher than less-developed regions [1]. An increasingly aging population exerts an upward payment pressure on China's pension system, particularly the Urban Employees' Pension Plan (UEPP) [2–4]. In 2015, the cash flow of the UEPP fund was negative in 25 of 31 provinces [5]. In this context, there is an urgent need for policies that address the pension payment crisis in China.

To meet the challenges caused by this demographic shift and improve the fiscal sustainability of the UEPP, two crucial reforms have been introduced by the Chinese government: one is the two-child policy, which replaced the well-known and iconic one-child policy, and the other is the statutory retirement delay. The two-child policy aims to increase the growth of the total population and the size of the future workforce. Raising the retirement age aims to increase pension revenue and decrease pension payment. Both policy measures are expected to mitigate population aging and, reduce the

negative socioeconomic impacts of aging, and thus relieve pension payment pressure. However, the implementation effects of fertility and retirement policy reforms on improvements in the financial solvency of the pension system are highly dependent on future demographic and socioeconomic developments. This uncertainty makes it essential to analyze the financial sustainability of the pension system through quantitative assessment models. Therefore, taking the UEPP as an example, the research presented in this paper uses actuarial models to assess the financial sustainability of China's pension plan, specifically by investigating the impacts of fertility and retirement policy adjustments and their interaction effects. The actuarial projection results could provide positive policy implications for China's structural and incremental reforms on the pension system, as well as offering experiences for developing countries under similar circumstances.

2. Literature Review

Sustainable pension development is of fundamental importance to socioeconomic development, as it has a close relationship with the stimulation of local economies and government income at a macroeconomic level [6], as well as changing household saving behaviors, fertility decisions and informal transfer at a microeconomic level [7–9]. Encouraging an increase in the fertility rate and delaying retirement are policy measures that are commonly adopted in countries across the globe to mitigate the adverse impacts of population aging process.

Previous studies have investigated the impact of delaying retirement on the sustainability of the pension system, but they have not reached a consensus. Some studies found that retirement delay offers a little help in relieving pension payment pressure. For example, by applying a general equilibrium model, Fehr et al. [10] examined the impact of an increased normal retirement age on Germany's pension scheme. They concluded that delaying retirement by 9 to 12 months, would achieve a 1.5% decrease in the contribution rate. Some studies showed that increasing retirement age could solve the financial crisis of pension schemes. Using Spain as an example, Díaz-Giménez and Díaz-Saavedra [11] simulated a delayed retirement situation by employing a multiperiod, general equilibrium, overlapping model economy. They argued that delaying retirement by three years would be sufficient to cope with the pension sustainability problem and keep the pension system sustainable until 2050. However, using a lifecycle framework included the utility from leisure, Lachance [12] found that longer working is incapable of reducing the negative impact of the pension reduction. Existing studies primarily focus on the sole impact of retirement delay on the pension system, and the results of these studies are often conflicting.

A decreasing fertility rate is another important reason for accelerating the population transition process [13–15]. Several studies have examined the impact of an increased fertility rate on the sustainability of pension fund. For example, using data from the seven largest countries in the Organization for Economic Co-operation and Development, Bongaarts [16] demonstrated that increasing the total fertility rate (children per woman) by 0.1 would reduce the pension expenditure ratio by 4% in 2050. Since the newborn population would not be qualified to participate in the pension system until they grow up, the fertility variation would have an unavoidable time-lag impact on the operation of pension plan [17]. A few studies have considered the fertility policy reform in China. Using actuarial models, Zeng et al. [18] demonstrated that the selective two-child policy would delay the pension deficits occurrence by nine years and reduce China's pension gap by 71.85% in 2090. Indeed, according to pension shortage, households would change their behavior at a microeconomic level. Having more children and delaying retirement would help them to save more money to prepare for their self-funded retirement, and both actions would conversely affect the financial viability of the pension system [7,9]. However, compared with the literature that has investigated the causes and mechanisms of falling fertility rates, studies on the impacts of fertility changes on pension fund sustainability are rather limited [13–15].

In recent years, the fiscal sustainability of China's partially funded pension system has received the attention of scholars. Salditt and Whiteford [19] analyzed pension sustainability issues and

pointed out that the limited coverage, low management level, empty individual account, poor returns, high replacement rates, and low retirement age compromise obstacles to the pension system. Using statistical models integrated with the Lee-Carter model, Zhao et al. [20] accessed the solvency of the pension plan and concluded that under existing socio-economic policies and pension regulations, the payment burden of the pension system would increase rapidly. Moreover, they observed that delaying retirement age could not fundamentally solve the sustainability crisis of the pension system. However, these conclusions were mainly drawn in the context of China's one-child policy and existing retirement policy i.e. that male employees retire at 60, female managers retire at 55, and female workers retire at 50.

Recently, China has adopted reforms regarding fertility and retirement policies. However, the impacts of policy changes on the sustainability of the pension fund have not been evaluated within international academia, particularly the impacts of policy interactions (see Table 1). This study aims to fill this gap, in view of the importance of fertility policy adjustment and retirement delay for economic and social development, especially pension sustainability. The remainder of this paper is structured as follows: Section 3 introduces the UEPP and describes its solvency ability. Section 4 outlines the method for building the forecasting models, including population projection and pension sustainability projection. Fertility scenarios, retirement scenarios, and data assumptions are described in Section 5. Section 6 presents an analysis of the sustainability estimations under assumed fertility and retirement scenarios. Section 7 presents the conclusions.

Table 1. Summary of representative studies on the impact of fertility policy changes and retirement delay on pension sustainability.

Contents	Author(s)	Main Conclusions
The impacts of delaying retirement on pension sustainability	Fehr et al. [10]	A 9- to 12-month delay of retirement would lead to a 1.5% decrease in contribution rate.
	Díaz-Giménez and Díaz-Saavedra [11]	A three-year delay of retirement would keep the pension sustainable.
	Lachance [12]	Working longer would offer little help in solving the financial crisis of the pension system.
The impacts of fertility changes on pension sustainability	Bongaarts [16]	Increasing the total fertility rate by 0.1 would reduce the pension expenditure ratio by 4% in 2050.
	Blake and Mayhew [17]	Increasing the fertility rate would have a time-lag effect on improving the sustainable development of the pension system.
	Zeng et al. [18]	The selective two-child policy would delay the occurrence of the pension deficit and reduce the pension gap in the long by 71.85% in 2090.
Influencing factors of pension sustainability	Lugauer et al. [7]	Micro-level influencing factors: the number of dependent children in the family, longer work, and saving rate.
	Salditt and Whiteford [19]	Institution-level influencing factors: coverage, contribution rate, replacement rate, pension management level, and interest.
	Mourao [6] Peinado [21]	Macro-level influencing factors: economy growth rate, government income, and labor market.
China's pension sustainability under the one-child policy and existing retirement policy	Zhao et al. [20]	The payment burden of the pension system would increase rapidly, and the pension gap would expand year by year.

3. Urban Employees' Pension Plan in China (UEPP)

China's pension system consists of three main parts: the UEPP, the Civil Servants and Public-Sector Employees' Pension Plan, and the Urban and Rural Residents' Pension Plan. Of these three parts, the UEPP is the most developed. Thus, the UEPP is applied as an example to investigate the impact of recent fertility and retirement policy reforms on the sustainability of the pension system.

The UEPP in China was introduced in 1951 and had a pay-as-you-go financing model for the pension fund in the early stages. According to the stipulations of China's Labor Insurance Regulation, the pension system aimed to protect workers in state-owned enterprises (SOE), who were solely

responsible for their pension contributions [22]. The burden of the public pension system severely hindered the process of privatization of SOEs in the wave of China's market economy reform since 1978. Thus, on July 16, 1997, the UEPP was transformed into a partially accumulated system, and the coverage was extended to all enterprises and their employees, including private enterprises, joint enterprises, and so forth [23].

The new pension scheme consists of two accounts: the social pooling account and the individual account. According to the stipulations of the Decision on Improving the Basic Pension System for Urban Employees [24], the enterprises contribute 20% of the total taxable payroll to the social pooling account, and insured employees themselves contribute 8% of their wages to the individual account. However, the government did not pay for the pension debt raised by the pension system transition from the pay-as-you-go system to a partially funded system. The premiums paid by the insured employees are misappropriated to pay for the pension benefits of retired people, including the accumulated pension fund in individual accounts, which belong to the insured individuals. In this way, the individual account only exists on paper with digital credits for the accumulated contributions. Thus, the individual account is a so-called "empty account." According to the stipulation, if the individual account is exhausted and the employee is still alive, the social pooling account would be responsible for the pension payment. Additionally, the annual pension adjustment and the unaccumulated pension entitlements for the old pensioners (referring to pensioners who retired before 1997) and the middle pensioners (referring to pensioners who retired after 1997) are also paid out of the social pooling account. In this context, the partially funded pension system of urban employees has essentially devolved into a pay-as-you-go system as it used to be.

Like most aging countries in the world, China's UEPP is presently under sustainable development threats. The pension revenue increased from CNY 227.85 billion in 2000 to CNY 3799.08 billion in 2016, and pension payments rose to CNY 3400.43 billion in 2016, which is 16.07 times greater than the figure in 2000. During this period, the average annual growth rate of pension revenue (19.23%) was slightly higher than pension expenditure (18.96%), which lead to the expansion of the cumulative net pension funds to CNY 4,396.52 billion in 2016. However, in the period of 2010–2016, the number of retirees continually increased at a pace (average annual growth rate of 21.15%) higher than the number of insured employees (average annual growth rate of 18.28%), which caused the annual growth rate of the accumulative pension funds to drop 8.5% below that of 2000–2016. These results indicate that the threats to the financial sustainability of the pension plan are already beginning to manifest.

4. Forecasting Models

4.1. Projection Models of Population

The cohort component method has been widely adopted to project the structural variations of the population in a certain area over a period [25,26]. The age-specific iterative transition equations play an important role in this method, and these equations can be expressed in a concise matrix form, known as the Leslie matrix [25]. The population of insured employees and retirees is determined by not only the total population and the urbanization rate but also the urban employment rate and the coverage rate of the public pension system. In this section, the cohort component method is utilized to project the age-sex-specific population in China, and this is then combined with several assumptions of relative proportion parameters to model the variation of the population of insured employees and pension beneficiaries.

The age-sex-specific population in each year can be expressed by iterative equations as follows:

$$P^f_{x+1,t+1} = P^f_{x,t} \times \left(1 - d^f_{x,t}\right) \quad (1)$$

$$P^m_{x+1,t+1} = P^m_{x,t} \times \left(1 - d^m_{x,t}\right) \quad (2)$$

$$P^f_{0,t+1} = \rho_{x,t} \times \sum_{x=15}^{49} \left(P^f_{x,t} \times b_{x,t} \right) \tag{3}$$

$$P^m_{0,t+1} = (1 - \rho_{x,t}) \times \sum_{x=15}^{49} \left(P^f_{x,t} \times b_{x,t} \right) \tag{4}$$

where the indexes $x, t, f,$ *and* m refer to age, year, female, and male; $P_{x,t}$ refers to the population aged x in year t; $d_{x,t}$ refers to the mortality rate of population aged x in year t; $b_{x,t}$ refers to the fertility rate of childbearing women aged x in year t; $\rho_{x,t}$ refers to the percentage rate of female births in year t; and ω refers to the age limit. Thus, the process of population development can be expressed in matrix form as:

$$\begin{bmatrix} P_{0,t+1} \\ P_{1,t+1} \\ \vdots \\ P_{\omega-1,t+1} \end{bmatrix} = \begin{bmatrix} b_{0,t} & b_{1,t} & b_{2,t} & \cdots & b_{\omega-2,t} & b_{\omega-1,t} \\ 1-d_{0,t} & 0 & 0 & \cdots & 0 & \cdots \\ 0 & 1-d_{1,t} & 0 & \cdots & 0 & \\ 0 & 0 & 1-d_{2,t} & \cdots & \cdots & \\ \vdots & \vdots & \vdots & \ddots & \cdots & \\ 0 & 0 & 0 & \cdots & 1-b_{\omega-2,t} & 0 \end{bmatrix} \times \begin{bmatrix} P_{0,t} \\ P_{1,t} \\ \vdots \\ P_{\omega-1,t} \end{bmatrix} \tag{5}$$

or

$$P_{t+1} = L_t \times P_t \tag{6}$$

The insured population is assumed to have the same demographic distribution as the total population. Based on Equation (6), the population of insured employees can be calculated by:

$$P_{a,t} = \left(\sum_{x=a_m}^{b_m-1} P^m_{x,t} + \sum_{x=a_f}^{b_f-1} P^f_{x,t} \right) \times u_t \times e_t \times c_t \tag{7}$$

The population of retirees consists of two parts—the new arrivals meeting the retirement requirements and the survival retirees from previous years [20]. The population of retirees can be calculated by:

$$P_{b,t} = \left(P^m_{b_m,t} + P^f_{b_f,t} \right) \times u_t \times e_t \times c_t + \left(\sum_{x=b_m}^{\omega_m-1} P^m_{x,t-1} + \sum_{x=b_f}^{\omega_f-1} P^f_{x,t-1} \right) \times u_{t-1} \times e_{t-1} \times c_{t-1} \tag{8}$$

where a is the initial working age; b is the statutory retirement age; u_t is the urbanization rate in year t; c_t is the coverage rate of the public pension scheme; and e_t is the employment rate of urban employees.

4.2. Projection Models of Pension Sustainability

As mentioned previously, China's partially accumulated pension system of urban employees has devolved into a pay-as-you-go system that provides definite benefits for retirees. In this context, the present research uses current pension surpluses/deficits, accumulated pension surpluses/deficits, and the dependency ratio to monitor the financial sustainability of the public pension, all of which have been commonly adopted indicators for a defined-benefit pension system [20,27,28].

According to pension stipulations, the pension contribution receives payroll taxes from both enterprises and employees, and the scheduled benefits are paid by the pension plan when the retirees are eligible. Thus, current pension surpluses/deficits at the end of a given year are equal to annual pension contributions less annual pension expenditures, which indicates the financial liquidity status. The accumulated pension surpluses/deficits at the end of a given year, which assess the financial gap, are identified as the assets at the beginning of that year plus annual fiscal surpluses/deficits and annual interest income. The dependency ratio for a given year is the comparison of retirees to

insured workers that monitors the stresses brought by the demographic shift to the pension system and indicates the burden on employees placed by the retirees. As the aim of this study is to quantify and analyze the financial sustainability of the pension system, subsidies and administrative expenses are not included. Therefore, we construct actuarial projection models for monitoring the financial sustainability status of the pension system as follows.

The contributions of the public pension are expressed as:

$$I_t = W_t \times \left(c_t^1 + c_t^2\right) \times P_{a,t} \tag{9}$$

where I_t is the pension income in year t; c_t^1 is the enterprises' contribution rate of the public pension in year t; c_t^2 is the employees' contribution rate of the public pension in year t; and W_t is the average wages of employees in post in year t.

Assuming that x-year-old workers retire in year $t-(x-b)$, the social average wage in the year before retirement is $W_{t-(x-b)-1}$, the pension replacement rate of a retiree aged x in year t is r_t, the annual growth rate of average social wage in year t is g_t, and the annual pension growth rate is τ_t. Thus, the average wage of the retiree in the year before retirement is $W_{t-(x-b)-1} = \mathrm{W}(t)/\prod_{j=0}^{x-b}(1+g_{t-j})$, and the annuity received by the retiree in the retirement year is $W_{t-(x-b)-1} \times r_{t-(x-b)-1}$. Accordingly, the total pension expenditure in year t can be presented as:

$$E_t = \sum_{x=b}^{\omega-1}\left(W_{t-(x-b)-1} \times r_{t-(x-b)-1} \times \prod_{j=t-(x-b)-1}^{t}(1+\tau_j)^{t-j}\right) \times P_{x,t} \tag{10}$$

Based on the equations above, the current pension surpluses/deficits, the accumulated pension surpluses/deficits, and the support ratio of the public pension can be calculated using the following equations:

$$D_t = I_t - E_t, \tag{11}$$

$$T_t = D_t + T_{t-1} \times (1 + r_t) \tag{12}$$

$$DR_t = P_t^1 / P_t^2 \tag{13}$$

where D_t refers to the annual pension surpluses/deficits in year t; T_t refers to the accumulated pension surpluses/deficits in year t; r_t refers to the return rate of the public pension fund in year t; DR_t refers to the dependency ratio in the pension system in year t; P_t^1 refers to the number of beneficiaries in year t; and P_t^2 refers to the number of insured working employees in year t.

5. Scenario and Data Assumptions

5.1. Scenario Assumptions

5.1.1. Fertility Scenarios

China introduced the one-child policy in 1979 to impede the rapid population growth. The strict policy led to a significant fall in the total fertility rate (TFR) from an estimated 2.90 births per woman in 1979 to 1.19 in 2010. Following this trend, the total fertility rate has continued to fall and now is far below the replacement rate of 2.10. To promote sustainable population development, the Chinese government decided to conduct the "selective two-child policy" in November 2013, which allows couples to have a second child if either the husband or the wife is an only child. However, the new fertility policy did not achieve as much success as expected. According to official sources, only 1.69 million couples applied for a second child as of August 2015, which accounts for 15.40% of the 11 million couples that are estimated to be eligible [29].

The 2015 1% mini-census data shows that the overall TFR in China continued to decline at 1.05, indicating that the desire to bear a second child is weak and the impact of the selective two-child

policy is mute. The TFR of 1.05 may underestimate the actual TFR in China due to the phenomenon of concealment, and the practical TFR is estimated to be around 1.50 [30,31], which is still below the replacement level and indicates that the population would continue to contract in the future. It was in this context that the Chinese government implemented the "universal two-child" policy on January 1, 2016 and announced that all couples are eligible to have a second child. If the fertility policy reform could increase the TFR, the aging transition would be mitigated, and the sustainability of the pension fund could be improved. To gauge the impact of the universal two-child policy, four fertility simulation scenarios are proposed.

Given that the effect of the selective two-child policy is insignificant, we assume that the TFR remains constant at the level of 1.50 in 2015 as the baseline scenario, reflecting the TFR under the one-child policy. Next, after considering variations in women's willingness to bear a second child, the TFR was simulated with 20%, 60%, and 100% of eligible couples having a second child as fertility scenarios 1, 2, and 3, respectively. The 2015 1% mini census data showed that the proportion of couples having only one child was 49.53%. We assume this proportion remained unchanged during the projection period.

5.1.2. Retirement Scenarios

Retirement age is a key parameter affecting the sustainability of UEPP, as it connects both pension revenue and pension expenditure. According to the stipulations of China's Labor Law, male employees retire at 60, female managers retire at 55, and female workers retire at 50 [32].

Raising the legal retirement age has been a popular policy adopted worldwide as a response to aging populations as well as the financial crisis of pension schemes. For example, the UK government has raised the retirement age from 60 to 65, and further increases are underway [33]. The US is scheduled to take measures to raise the age threshold for claiming full pension benefits from 65 to 67 between 2002 and 2027. Phasing in from 2024 to 2027, Denmark will lift the statutory age limit from 65 to 67 and then link it to life expectancy at age 60 [34]. Compared to most developed countries, China's legal retirement age is remarkably low. In the "Thirteenth Five-year Plan," China's government decided to progressively raise the retirement age to better adapt to the socioeconomic development. However, this specific policy has not yet reached the public. Considering the trend of China's delayed retirement age, we assume three retirement scenarios: one baseline scenario and the other two delayed retirement scenarios. Both delayed retirement scenarios 1 and 2 will start from 2021 to 2050 with the target retirement age of 62 and 65, respectively, as follows.

Baseline Scenario: retain existing retirement policy. Male employees retire at 60, female managers retire at 55, and female workers retire at 50.

Retirement Scenario 1: increase the retirement age to 62. First, delay female workers' retirement by 6 months and female managers' retirement by 3 months every year from 2021, and in 2040, the female retirement age will be unified at 60; second, both males and females delay retirement and the retirement age will finally reach 62 in 2050.

Retirement Scenario 2: increase the retirement age to 65. First, delay female workers' retirement by 8 months and female managers' retirement by four months every year from 2021, and in 2035, the female retirement age will be unified to 60; second, both males and females will delay retirement by 4 months every year from 2036, and the retirement age will finally arrive at 65 in 2050.

5.1.3. Combination Scenarios

In practice, policies are often implemented simultaneously. To investigate the interaction impact of fertility adjustment and retirement delay on the sustainability of UEPP, we consider a series of combination policies consisting of six different arrangements of fertility policy adjustment and retirement delay (see Table 2).

Table 2. Combination Scenarios.

Combination Scenarios	Proportion of Couples Having a Second Child	Retirement Age
Combination Scenario 1	20% (Fertility Scenario 1)	62 (Retirement Scenario 1)
Combination Scenario 2	20% (Fertility Scenario 1)	65 (Retirement Scenario 2)
Combination Scenario 3	60% (Fertility Scenario 2)	62 (Retirement Scenario 1)
Combination Scenario 4	60% (Fertility Scenario 2)	65 (Retirement Scenario 2)
Combination Scenario 5	100% (Fertility Scenario 3)	62 (Retirement Scenario 1)
Combination Scenario 6	100% (Fertility Scenario 3)	65 (Retirement Scenario 2)

5.2. Data Assumptions

(1) Initial population data: Given the mute effect of the selective two-child policy, this study takes the age-sex-specific population data from the 2015 1% mini census as the initial population data. The 2015 1% mini census was designed and conducted by China's National Bureau of Statistics and provides one of the most authoritative data that reflects the distribution features of Chinese population size and structure under the one-child policy [35].According to the 2015 1% mini census data, 16.15% of the population are aged 60 years or older (221.82 million).

(2) Sex ratio at birth. The official data reveals that the sex ratio at birth dropped from 117.29 in 2000 to 112.55 in 2015. However, this is still far greater than the generally accepted theoretical value of 102–107 [36]. To regress the sex ratio to a normal range, the Chinese government drew up the National Population Development Plan (2016–2030) and set the target for the sex ratio at birth to 112 in 2020 and 107 in 2030 [37]. Therefore, it can be assumed that the sex ratio at birth would linearly decrease from 112.55 in 2015 to 107 in 2030 and remain unchanged in the forecast period.

(3) Survival rate: In this research, the life tables of the population are calculated from age-sex-specific death data from the 2015 1% mini census [38]. The survival rates data for the female and male population were obtained.

(4) Migration rate: According to the 2015 1% mini census data, China's population has reached 1.38 billion [38,39]. Compared with the enormous total population of China, the international migrant population is negligible. In this research, international migration in China is assumed to be zero.

(5) Urbanization rate: Data from the Statistic Bureau shows that China's urbanization level for the total population increased from 36.22% in 2000 to 56.10% in 2015. However, most developed countries, such as Japan (93.50%), the USA (81.62%), and France (79.52%), had reached a high urbanization level in 2015 [40]. Considering the process of urbanization in China will continue to speed up, and by reference to the urbanization levels of the developed nations, a logistic model is employed to simulate and predict the future urbanization rate of China with a maximum value of 80%. The logistic model can be expressed as $urban_t = 0.8/\left(1 + 2.436 \times e^{-(t-1990)}\right)$ $(adjusted\ R^2 = 0.9997, RMSE = 0.0013,\ SSE = 0.000)$, where $urban_t$ is the urbanization rate in year t, $RMSE$ is the root mean square error, and SSE is the sum of squared error.

(6) Contribution rate: Referring to the provisions specified in the State Council No.38 Document in 2005 [24], enterprises' contribution rate to the social pooling account is 20% of the taxable payroll and employees' contribution rate to the individual account is 8% of taxable wages. To relieve the financial burden of the enterprises, the Ministry of Human Resources and Social Security and the Ministry of Finance jointly decided to reduce the enterprises' contribution rate to 19% in 2016 [41].

Thus, it is assumed that the total contribution rate of UEPP is 27%, including a contribution rate of 19% for the social account and 8% for the individual account.

(7) Coverage rate: The coverage rate is defined as the proportion of pensioners to the population supposed to be insured. The data released by the National Statistics Bureau shows that the pension coverage rate arrived at 64.3% in 2015 [42]. According to China's Thirteenth Five-year Plan, the government has set the target coverage rate to be 90% in 2020. Therefore, the average pension coverage rate is assumed to be 80% during the forecast period.

(8) Working age: The working age refers to the age when an individual begins to work after education. As prescribed by China's Labor Law, the minimum legal age of employment is 16. According to the census data, the average working age had increased from 16.92 years of age in 2000 to 18.76 years of age in 2015 [38]. Considering prolonged education [27], we set the working age to be 20 years during the prediction period. China's 2015 1% mini census data show that the labor force that is aged between 20 and 59 covers 59.86% of the total population (850.52 million).

(9) Urban employment rate: Data from China's Yearbooks show that the urban employment rate during the past 20 years stably remained at about 85% [42]. Thus, the urban employment rate is assumed to remain at this level in the long-term forecast interval.

(10) Pension replacement: The pension replacement rate is defined as the proportion of pension benefits to the salary in the year before retirement [43]. The target of the pension replacement rate was set to 58.5% [23,24]. However, in practice, the average replacement rate declined from 71.23% in 2000 to 48.4% in 2015 [38]. Because of the impact of the rapid population aging and other related unprecedented socioeconomic factors, the UEPP will continue to suffer from the payment pressure. In this study, the pension replacement rate is assumed to be 40% in the forecast interval.

(11) Return rate: Referring to previous studies [44,45] and recent interest variations, it is assumed that the yearly interest remains at 0.03 in the long term.

(12) Growth rate of pension benefits: According to China's government working report from 2005 to 2015, the annual growth rate of UEPP benefits was maintained at approximately 10% [46]. The high-speed pension benefits growth rate resulted in increased payment pressure. Hence, China's Ministry of Human Resources and Social Security and the Ministry of Finance announced a reduction in the pension growth rate to 6.5% in 2016, 5.5% in 2017, and then 5% in 2018. In the long run, the pension growth rate is assumed to be 5%.

(13) The growth rate of the average social wage: Since China's economy has grown in a relatively balanced manner, the so-called "new normal phase," the current growth rate of the social wage is less than the double-digit growth rate in the period from 2000 to 2010. Official data shows that the growth rate of the social wage in 2015 was 8.5%. Based on previous research [47], it is assumed that the growth rate of the social wage will remain at 7% before 2020 and will then decrease by 1% every 10 years.

6. Analysis of the Simulation Results

Scenario analysis has been widely adopted to evaluate the impacts of policy changes [48–50]. In the research presented in this paper, the scenario analysis method is employed to evaluate the financial sustainability of the UEPP from 2019 to 2070, as well as the impact of the fertility policy adjustment and delayed retirement. For comparison purposes, the sustainability of the public pension system is assessed first under the one-child policy and the current retirement policy (defined as the Baseline Scenario). This is followed by an evaluation of the sustainability of the pension plan under the situation of (a) conducting the two-child policy (defined as Scenario 1), (b) delayed retirement policy (defined as Scenario 2), and (c) implementing the combination policies (defined as Scenario 3).

6.1. Baseline Scenario: Retaining the One-child and Current Retirement Policy

The development of the insured population and the operation of the urban employee's pension system were simulated under the Baseline Scenario. Figure 1 presents the trend of the insured employees, retirees, and total population. The population of insured retiree group would exceed that of the insured employee group in 2042 and reach its peak (389.34 million) in 2050. Meanwhile, the dependency ratio in the pension system would increase from 0.45 in 2019 to 1.67 in 2070, implying an increasing burden being placed on the contributors.

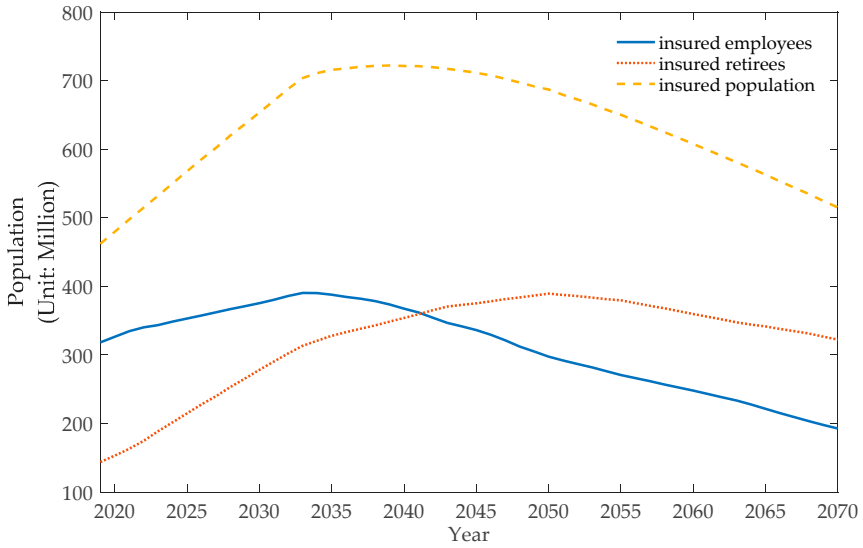


Figure 1. The trend of the insured population

Table 3 provides the simulation results. Both the pension revenue and pension expenditure would increase year by year. However, the growth rate of the former is much higher than that of the latter. As described by the data (see Table 3), the current pension deficits and the accumulated pension deficits would occur in 2020 and 2024, respectively, and both would remain negative after that. In 2070, the current deficits would reach CNY 74.23 trillion, and the accumulated pension deficits would arrive at CNY 1694.89 trillion. These trends indicate that the public pension system would suffer from severe financial pressure, and further policies should be introduced to improve the sustainability capacity of the pension system.

Table 3. Pension fund sustainability under the baseline scenario with the one-child policy and current retirement policy.

Year	Pension Revenue (Trillion CNY)	Pension Expenditure (Trillion CNY)	Current Surpluses/Deficits (Trillion CNY)	Accumulated Surpluses/Deficits (Trillion CNY)	Dependency Ratio
2019	5.23	5.14	0.09	4.76	0.45
2020	5.63	5.85	−0.22	4.55	0.47
2021	6.06	6.66	−0.60	3.95	0.49
2022	6.47	7.62	−1.15	2.80	0.51
2023	6.86	8.81	−1.94	0.86	0.55
2024	7.31	10.03	−2.72	−1.86	0.58
2025	7.78	11.37	−3.60	−5.46	0.61
2030	10.06	18.67	−8.61	−38.18	0.74
2035	12.65	27.15	−14.50	−99.04	0.85
2040	14.57	36.01	−21.44	−191.22	0.96
2045	15.46	46.49	−31.03	−327.70	1.12
2050	15.86	57.88	−42.02	−515.54	1.17
2055	16.72	67.36	−50.64	−751.33	1.40
2060	17.77	75.66	−57.89	−1026.32	1.45
2065	18.38	84.69	−66.31	−1339.74	1.54
2070	18.55	92.78	−74.23	−1694.89	1.67

6.2. Scenario 1: Implementing the Two-child Policy

In this section, the impact of the two-child policy on the sustainability of the UEPP is investigated, while retaining the current retirement policy and other variables. The results can be found in Table 4 and Figure 2. The two-child policy involves a time-lag effect that the second child under the new fertility policy in 2016 will not participate in the pension system until 2036. In comparison with the baseline scenario of the continuous implementation of the one-child policy, the second-child policy would relieve the supporting pressure of the pension system. Although the dependency ratio would increase from 0.45 in 2019 to 1.54, 1.41, and 1.34 in 2070 when 20%, 60%, and 100%, respectively, of the couples would bear a second child, the ratios are lower than the baseline scenario. This result implies that the new fertility policy would mitigate payment pressure in the future.

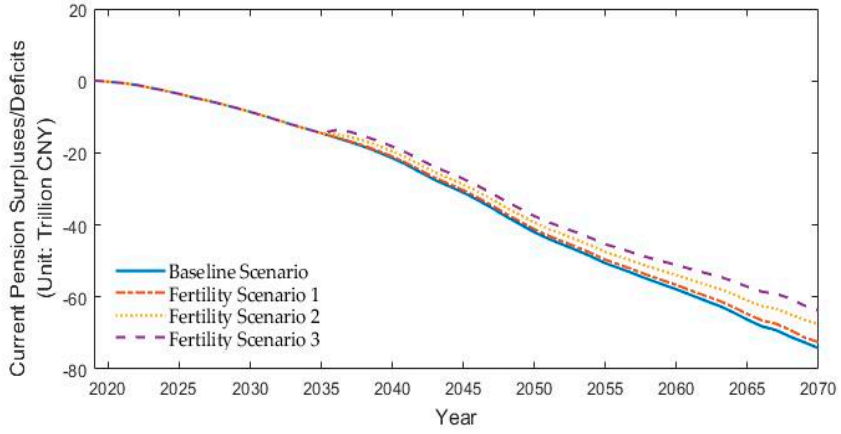
Table 4. Predicted dependency ratio of UEPP under the two-child scenario.

Year	One-child Policy (Baseline Scenario)	Two-child Policy		
		20% of Couples Having a Second Child (Fertility Scenario 1)	60% of Couples Having a Second Child (Fertility Scenario 2)	100% of Couples Having a Second Child (Fertility Scenario 3)
2019	0.45	0.45	0.45	0.45
2020	0.47	0.47	0.47	0.47
2030	0.74	0.74	0.74	0.74
2035	0.85	0.85	0.85	0.85
2040	0.96	0.94	0.85	0.79
2045	1.12	1.07	0.97	0.90
2050	1.17	1.11	1.00	0.91
2055	1.40	1.33	1.18	1.07
2060	1.45	1.36	1.19	1.05
2065	1.54	1.42	1.20	1.03
2070	1.67	1.54	1.41	1.34

Figure 2 depicts the current and accumulated pension deficits under the one-child policy and the two-child policy with different proportions (20%, 60%, and 100%) of couples who are willing to bear a subsequent child. Due to the time-lag effect, the occurrence of current pension deficits and accumulated pension deficits would not be delayed and would happen in 2020 and 2024, respectively, regardless of the proportions of couples willing to bear a second child. Subsequently, both current pension deficits and accumulated pension deficits would increase year by year.

When 20% of couples are willing to have a second child, the current deficits would increase from CNY 15.63 trillion in 2036 to CNY 72.53 trillion in 2070, and the accumulated pension deficits would

arrive at CNY 1,662.09 trillion in 2070. Compared with the Baseline Scenario, the current deficits would decrease by 0.69–2.60% from 2037 to 2070, while the accumulated deficits would decrease by 0.09–1.97%. When 100% of the couples are willing to bear a second child, in 2070, the current pension deficits and accumulated pension deficits would increase to CNY 63.76 trillion and CNY 1522.04 trillion, respectively, decreasing by 10.53–16.71% and 2.63–11.62% from 2036 to 2070 when compared with the Baseline Scenario. When 60% of couples are willing to have an additional child, the impact of Fertility Scenario 2 on the pension balance would be similar to Fertility Scenarios 1 and 3. Detailed descriptions are provided in Table 4 and Figure 2.



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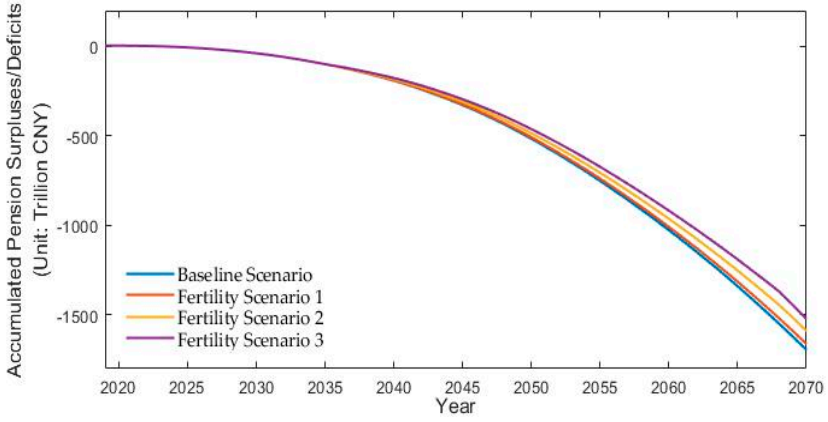

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Figure 2. Trends of pension surpluses/deficits under the two-child policy while retaining the existing retirement policy. (**a**) Current pension surpluses/deficits; (**b**) accumulated pension surpluses/deficits.

Overall, the two-child policy could mitigate the payment burden of the public pension system. However, the pressure-relieving effect of the new fertility policy relies on the couple's willingness to have a subsequent child. The greater the willingness of couples to parent a second child, the more payment pressure of the pension plan could be relieved. Due to the low levels of pension deficits reduction, the impact of the two-child policy on pension sustainability is limited.

6.3. Scenario 2: Delayed Retirement

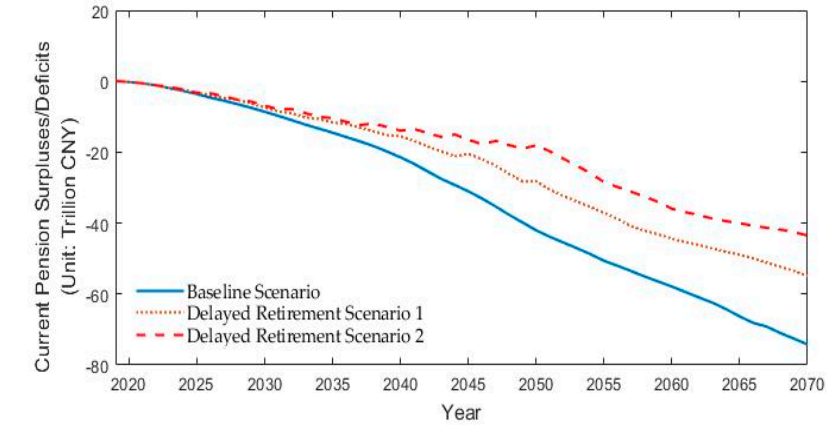
In the context of aging, the existing retirement policy is no longer suitable for China's socioeconomic development, and thus delaying retirement is absolutely necessary. To further investigate how a delayed retirement policy affects the sustainability of the UEPP, the operation process

of the public pension was simulated under the retirement age of 62 (Delayed Retirement Scenario 1) and the retirement age of 65 (Delayed Retirement Scenario 2), and the results were compared with current retirement age (Baseline Scenario). As presented in Table 5, the dependency ratio shows a slowly increasing trend under Delayed Retirement Scenarios 1 and 2, accounting for 66.5% and 53.3%, respectively, of the ratios under the Baseline Scenario in 2070. Since the dependency ratios under delaying retirement scenarios are lower than those under fertility scenarios, it can be concluded that delaying retirement would better reduce the supporting pressure of the pensioned employees.

Table 5. Predicted dependency ratio under delayed retirement scenarios.

Year	Current Retirement Age Policy (Baseline Scenario)	Retirement Age: 62 (Delayed Retirement Scenario 1)	Retirement Age: 65 (Delayed Retirement Scenario 2)
2019	0.45	0.45	0.45
2020	0.47	0.47	0.47
2025	0.61	0.58	0.58
2030	0.74	0.67	0.62
2035	0.85	0.71	0.65
2040	0.96	0.74	0.68
2045	1.12	0.77	0.71
2050	1.17	0.89	0.74
2055	1.40	0.98	0.78
2060	1.45	1.05	0.87
2065	1.54	1.08	0.88
2070	1.67	1.11	0.89

Figure 3 presents an increasing trend for both current pension deficits and accumulated pension deficits under different retirement scenarios. Similar to encouraging the bearing of a second child, delaying retirement would not suspend the occurrence of pension deficits, but it would significantly reduce the pension deficits. If Delayed Retirement Scenario 1 is implemented, in 2050, the current pension deficits and the accumulated pension deficits would increase to CNY 28.19 trillion and 376.90 trillion, respectively, which are 32.92% and 26.89% less than the pension deficits under the baseline scenario, respectively. Under Delayed Retirement scenario 2, the current pension deficits and the accumulated pension deficits would increase to CNY 18.11 trillion and CNY 302.51 trillion in 2050, respectively, accounting for 43.06% and 58.68% of the Baseline Scenario. The results indicate that delaying retirement would help to improve pension sustainability, and the effect of increasing target retirement age would be more significant than that of the two-child policy.



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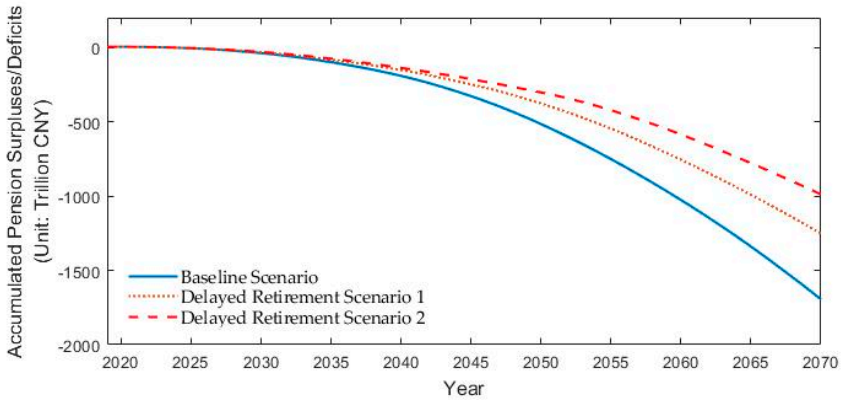


(b)

Figure 3. Trends of pension surpluses/deficits under the delayed retirement policy while retaining the fertility policy. (**a**) Current pension surpluses/deficits; (**b**) Accumulated pension surpluses/deficits.

However, after 2050 when the retirement reform ends, the pension deficits would begin to increase at a faster rate, and the effect of delaying retirement on reducing pension deficits would begin to decline. For example, the current pension deficits of Delayed Retirement Scenario 1 would be CNY 43.48 trillion in 2070, which is a reduction of 41.42% compared with the Baseline Scenario. Overall, delaying the retirement age would improve pension sustainability to a greater degree than encouraging fertility. However, the reduction in pension deficits achieved by retirement reform mainly exists between 2020 and 2050, and when the reform ends, the pension deficits would increase rapidly again.

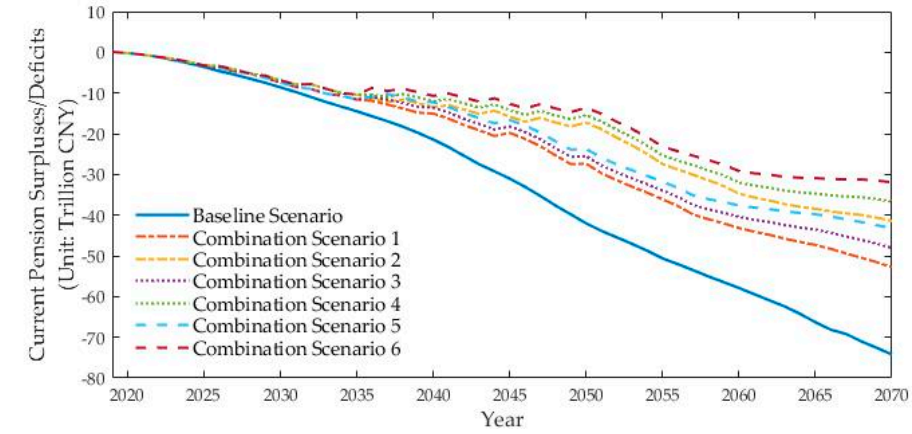
6.4. Scenario 3: Combination of Two-child Policy and Delayed Retirement Policy

In this section, the impact of the combination policies on the sustainability of the UEPP is investigated. Referring to the assumptions of the fertility scenarios and the delayed retirement scenarios, we put forward six scenarios of combination policies. Table 6 presents the actuarial simulation results of the impacts of combination policies on the sustainability of the public pension plan and the predicted dependency ratio. The dependency ratio under combination scenarios would be much lower than that when implementing the two-child or delayed retirement policy alone. However, the occurrence of the current pension deficits and the accumulated pension deficits would not be delayed, occurring in 2020 and 2024, respectively, which is similar to implementing fertility adjustment or retirement reform alone (see Figure 4).

Table 6. Pension fund sustainability under combination scenarios.

Year	Fertility Scenario 1: 20% of Couples Having a Second Child						Fertility Scenario 2: 60% of Couples Having a Second Child						Fertility Scenario 3: 100% of Couples Having a Second Child					
	Retirement Scenario 1: Delaying Retirement to 62 (Combination Scenario 1)			Retirement Scenario 2: Delaying Retirement to 65 (Combination Scenario 2)			Retirement Scenario 1: Delaying Retirement to 62 (Combination Scenario 3)			Retirement Scenario 2: Delaying Retirement to 65 (Combination Scenario 4)			Retirement Scenario 1: Delaying Retirement to 62 (Combination Scenario 5)			Retirement Scenario 2: Delaying Retirement to 65 (Combination Scenario 6)		
	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭	⑮	⑯	⑰	⑱
2019	0.09	4.76	0.45	0.09	4.76	0.45	0.09	4.76	0.45	0.09	4.76	0.45	0.09	4.76	0.45	0.09	4.76	0.45
2020	−0.22	4.55	0.47	−0.22	4.55	0.47	−0.22	4.55	0.47	−0.22	4.55	0.47	−0.22	4.55	0.47	−0.22	4.55	0.47
2025	−3.24	−4.75	0.58	−3.24	−4.40	0.58	−3.24	−4.75	0.58	−3.24	−4.40	0.58	−3.24	−4.75	0.58	−3.24	−4.40	0.58
2030	−7.42	−32.24	0.67	−6.89	−29.92	0.64	−7.42	−32.24	0.67	−6.89	−29.92	0.64	−7.42	−32.24	0.67	−6.89	−29.92	0.64
2035	−11.62	−82.24	0.71	−10.40	−75.11	0.67	−11.62	−82.24	0.71	−10.40	−75.11	0.67	−11.62	−82.24	0.71	−10.40	−75.11	0.67
2040	−15.06	−150.71	0.72	−13.51	−136.25	0.79	−13.59	−144.35	0.67	−12.04	−129.89	0.72	−12.26	−137.27	0.62	−10.71	−122.81	0.66
2045	−19.81	−244.41	0.75	−15.84	−208.65	0.65	−18.20	−230.28	0.69	−14.22	−194.52	0.60	−16.65	−215.93	0.64	−12.67	−180.17	0.56
2050	−27.37	−368.89	0.85	−17.29	−294.51	0.62	−25.53	−346.04	0.78	−15.45	−271.69	0.57	−23.71	−323.16	0.72	−13.63	−248.83	0.53
2055	−36.12	−533.66	0.94	−27.47	−409.71	0.75	−33.97	−500.73	0.85	−25.31	−376.80	0.69	−31.82	−467.81	0.78	−23.16	−343.90	0.64
2060	−43.18	−737.52	1.00	−34.75	−567.65	0.82	−40.44	−692.24	0.89	−32.00	−522.40	0.74	−37.62	−646.79	0.80	−29.18	−476.98	0.67
2065	−47.34	−966.17	1.16	−38.46	−753.47	0.83	−43.58	−904.20	0.98	−34.70	−691.53	0.72	−39.79	−841.78	0.85	−30.91	−629.13	0.64
2070	−52.83	−1,218.72	1.02	−41.44	−954.18	0.83	−48.07	−1,134.94	0.86	−36.68	−870.42	0.71	−43.33	−1,050.69	0.75	−31.94	−786.20	0.62

Notes: Columns ①④⑦⑩⑬⑯ are current pension surpluses/deficits (units: trillion CNY); columns ②⑤⑧⑪⑭⑰ are accumulated pension surpluses/deficits (units: trillion CNY); columns ③⑥⑨⑫⑮⑱ are dependency ratios.



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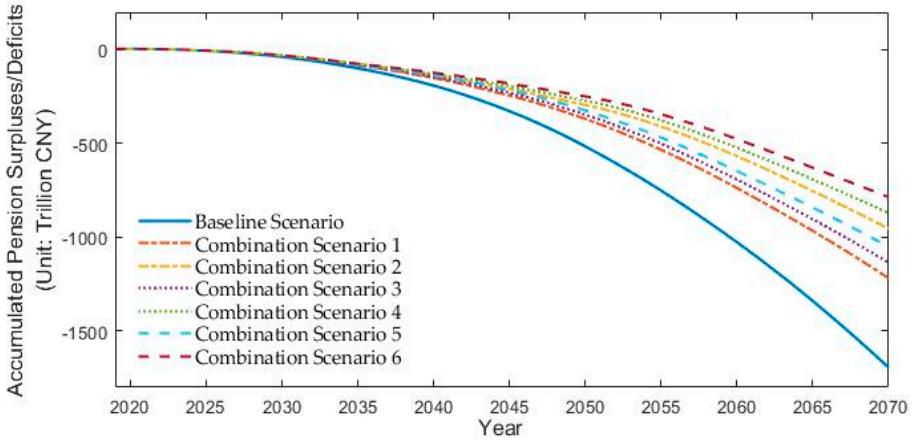

(b)

Figure 4. Trends of pension surpluses/deficits under combination scenarios. (**a**) Current pension surpluses/deficits; (**b**) accumulated pension surpluses/deficits.

The sustainability of the UEPP would be improved to the most considerable degree if 100% of couples were to have a second child and the statutory retirement age is increased to 65 (Combination Scenario 6). In Combination Scenario 6, the dependency ratio increases from 0.47 in 2020 to 0.53 in 2050 and 0.62 in 2070, indicating approximately two pensioners raising one beneficiary during the calculation period. The current pension deficits and the accumulated pension deficits under Combination Scenario 6 would increase to CNY 31.94 trillion and CNY 786.20 trillion, respectively in 2070, which show a reduction of 56.96% and 53.61% from the Baseline Scenario. Under Combination Scenario 1 (20% of couples having a second child and delayed retirement age 62), the dependency ratio would be reduced by 27.35% in 2050 and 38.92% in 2070 compared with the Baseline Scenario. The current pension deficits would increase to CNY 52.83 trillion in 2070 with 28.83% less than the Baseline Scenario, while the accumulated pension deficits would arrive at CNY 1,218.72 trillion, 28.09% less than the Baseline Scenario. The remaining combination scenarios would result in similar outcomes ranging between Combination Scenarios 1 and 6.

The results indicate that when the two-child policy and the delayed retirement policy are implemented simultaneously, the pension deficits would be diminished more significantly compared to a single reform. However, due to the relatively weak pension-deficit-reducing effect of the two-child policy, the implementation effect of the combination scenarios depends mainly on the delayed retirement scenario. Hence, as presented in Figure 4, the pension deficits would increase slowly before 2050 and increase again after 2050.

7. Conclusion

The research presented in this paper sheds light on the financial sustainability of China's UEPP by investigating the role of fertility policy adjustment and delayed retirement reform. By using the Leslie matrix and building actuarial models, the financial sustainability of the pension plan is evaluated for the years 2019 to 2070 under a series of scenario assumptions. The simulation results show that the UEPP would face severe pension payment pressure. In general, we summarize the most important findings as follows:

- We found that if China continually implements the one-child policy and maintains the current legal retirement age, then an imbalance of the pension plan would occur in the early 2020s. This occurrence is earlier than that found by previous studies [30,51]. This is because both the social pooling account and the individual account are holistically considered in this paper. Since the empty individual account is pervasive in China [3,22,52], our findings could be more in line with reality.
- Scenario analysis indicates that both encouraging fertility and delaying retirement would improve the solvency of the pension system but with different policy effects. The latter would help more in reducing pension gaps. The analysis of the combination scenarios further indicates that simultaneous policy reforms are more effective than a single reform.
- In the long run, neither the fertility policy adjustment nor the retirement delay would fundamentally solve the pension payment crisis. The results of the general trend of an expanding pension gap are consistent with the findings of Zhao et al. [20] as well as Tian and Zhao [43].

Based on the above empirical analysis, we suggest that the government introduce a series of family support policies to raise people's willingness to have more children. Meanwhile, the government should also implement the retirement reform as soon as possible.

It should be noted that there are several limitations in this study that merit discussion. First, some designs of the fertility and retirement policy options that assumed in this research have yet to be realized in practice. In future studies, scenario assumptions should be adjusted based on the actual situation. Second, the pensioners are assumed to have the same demographic distribution as the total population. This may lead to an underestimation of the aging level within the UEPP because members of the labor force, such as migrant workers, may choose to terminate the pension relationship or they may opt for another public pension plan [53]

Regarding this point, the UEPP may be facing a more severe pension crisis than otherwise anticipated. In addition, both pension payment and pension contribution are closely related to socio-economic development. The complexity of the projection of pension sustainability would be increased by influencing factors, such as household savings, economic growth, labor market, and government income [6,8,9]. Parameter assumptions should thus be reconsidered in any future study. Finally, consequences play an important role in scenario analysis. It should be noted that to understand the results well and take measures towards positive and effective reforms would be more significant than to estimate what is likely to occur.

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