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Delaying Retirement and China's Pension Payment Dilemma: Based on a General Analysis Framework

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ABSTRACT To cope with the aging of the population and strengthen the wealth of basic old-age insurance to ease the dilemma of pension payment, the Chinese government is actively formulating the policy of delaying retirement. Considering the different effects of the delaying retirement policy on the insured persons of ''old person'', ''middle person'', and ''new person'', we construct a general analysis framework of the effects of the delaying retirement policy on balance of China's basic pension. With three key variables of the delaying retirement policy simulated in a combined way, seven schemes are set up in detail to obtain the possible effects of the delaying retirement policy that may be formulated by the Chinese government. The study finds that the delaying retirement policy may not always have a positive and beneficial effect to alleviate the dilemma of pension payment, and its beneficial part accounts for about 15% of the whole. In addition, there is a U-shaped relationship between the key variable of the starting year (t_s) of policy implementation and the average effect of the policy. The other two key factors, the annual growth speed (Sp) of retirement age and the proportion (m) of annual growth speed of retirement age of female employees to that of male employees, change in the same direction with the policy average effect. Finally, some suggestions are provided for the Chinese government to formulate the delaying retirement policy.

INDEX TERMS Delaying retirement, pension, general analysis framework, actuarial simulation.

I. INTRODUCTION

The sustainability of the national basic old-age insurance system is closely related to whether the basic benefits of retirees can be paid in full and on time, affecting social stability, which has always been the the focus and hot topic of governments. There're lots of typical machine learning algorithms [1]–[3] introduced for the assessment of pension sustainability, such as support vector machines (SVM), K-nearest neighbors (KNN), Artificial Neutral Network (ANN), and Convolutional Neural Networks (CNN). However, due to the limited explanatory power of machine learning to the prediction results, the mainstream method of pension sustainability assessment is still an actuarial method. Thus, this paper will use the actuarial method to evaluate the effect of delaying retirement policy on pension sustainability.

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Low fertility rate and prolonged life expectancy have accelerated the aging process of global population, resulting in negative effects such as shortage of labor supply, lack of power for economic growth, overburdened public finances, and rapid increase in medical care costs [4]. In order to actively respond to the aging population, developed countries, such as the United States, Britain, Germany, and other countries, have generally adopted policies to increase the retirement age. Delaying retirement policy is not only related to the balance of supply and demand in the labor market of various countries and the sustainable development of the social security system, but also related to the individual needs and vital interests of each worker in society [5].

According to the *China Statistical Yearbook 2019*, we can know the age structure of the national population from 1997 to 2018. The trend of the proportion of the population of each age group in total population is shown in Fig.1, among which the proportion of the population in the

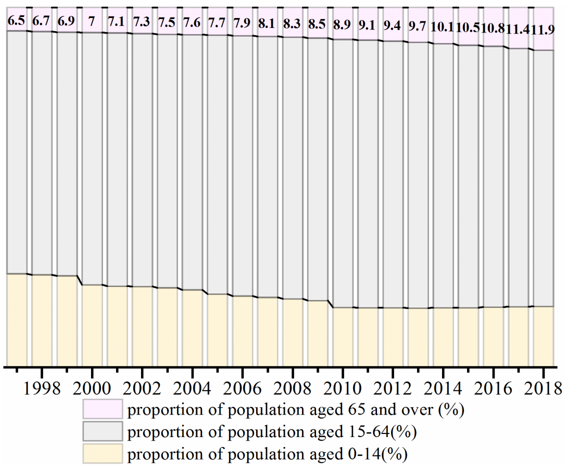

FIGURE 1. Age structure of China's population in 1997–2018.

age group 65 and above is rising rapidly, reaching 11.9% by the end of 2018, indicating that China is accelerating its entry into an aging population. Due to the aging population, China's basic old-age insurance system has begun to show signs of contribution incomes not being able to offset pension expenditures, and is gradually forming a pension payment dilemma, which has been confirmed by some previous literatures [6], [7]. *China Statistical Yearbook 2019* pointed out the pension expenditures of the urban employee basic old-age insurance fund in Liaoning, Heilongjiang, Hubei, and Qinghai provinces have already exceeded its contribution incomes in 2018. Among them, the financial situation of Heilongjiang Province is particularly severe, and the cumulative deficit has reached –57.72 billion yuan. This will make the expenditures of basic old-age insurance fund subsidized by public finance larger and larger, and the predicament of pension payment will gradually increase.

China's current retirement age policy is still the legal retirement age standard formulated in 1978: the retirement age of male employees is 60 years old, and that of female employees is simplified as 55 years old. The retirement age of employees in this retirement policy is too early, and it is now out of date. The Chinese government is currently actively formulating the delaying retirement policy in order to cope with the aging population and consolidate the wealth base of old-age insurance. However, there is still considerable disagreement in the academic community about the impact of delaying retirement on pension fund. Some studies [8]–[16] believe that raising the retirement age can help ease the payment pressure of pension fund. Other studies [17]–[23] believe that delaying retirement is difficult to play a role in alleviating the pension payment crisis. Even if it does, it has little effect. Thus, can the delaying retirement policy help alleviate the dilemma of China's pension payment? We need to solve this problem urgently, and provide useful suggestions for the Chinese government to formulate the delaying retirement policy.

II. LITERATURE REVIEW

The research on the effect of delaying retirement policy at home and abroad has been more mature and in-depth, mainly in its impact on labor supply, human capital accumulation and other economic aspects, as well as the financial impact of pension system. The delaying retirement policies have effects on labor supply, human capital accumulation and other economic aspects. Miyazaki [24] found that raising the legal retirement age on the one hand promotes the increase of total output by increasing the labor supply, on the other hand, reduces the total output by reducing the capital stock, and its net effect on total output should be determined by the capital output elasticity. Geng and Sun [25] reached the same conclusion. Fanti [26] showed that under the assumption that the old labor force and the young labor force are complete substitutes (or that the elasticity of substitution is infinite), raising the legal retirement age tends to reduce capital accumulation, and may reduce the young per capital income and pension benefits. Tanaka [27] re-examined the results of Fanti [26] and found that the results of Fanti [26] are only valid when the elasticity of substitution between the old labor force and the young labor force is sufficiently high, otherwise it is not. Kang [28] proposed that postponing retirement and increasing the pension contribution rate will reduce per capital stock, private savings, and young consumption, but postponing retirement can increase old-age consumption, which is better than the policy of increasing social contribution rates. Prescott *et al.* [29] pointed out that the policy of raising the retirement age by changing the pension receiving rules will make workers reduce the weekly working hours, but the policy of forcing the retirement age will cause some workers to increase the weekly working hours. Guo and Yan [30] put forward and tested the hypothesis that the degree of family intergenerational income transfer is affected by economic factors, and found that the delaying retirement age affects the substitution relationship between quantity and quality of family childbearing through this channel, and the direction of influence on the growth of labor supply depends on the relative attention of parents to the quantity and quality of children. Lu *et al.* [31] believed that the increase of labor force brings about by delaying retirement and its positive effect on consumption and investment can promote economic growth.

This paper focuses on the effect of the delaying retirement policy on the financial status of pension system. Although there have been a wealth of research at home and abroad, scholars have different views on the financial impact of pension system caused by delaying retirement policy. That is, there are two opposite views. Some scholars believe that delaying retirement can ease the payment pressure on pension fund and contribute to the sustainability of the fund. Cremer and Pestieau [8], Karlstrom *et al.* [9], Galasso [10], and Breyer and Hupfeld [11] have shown that extending the retirement age can improve the payment ability of the pension system. Yu and Zeng [12] and Jin *et al.* [13] successively used actuarial models to simulate the financial situation of China's pooling account pensions, and found that delaying retirement can reduce the gap size of pension fund and increase the sustainability of China's social pension fund system. Tian and Zhao [14], Yu *et al.* [15], based on the actuarial model, further simulation found that delaying retirement can significantly alleviate the payment pressure of pension fund and achieve the sustainability of the financial situation of China's social pension fund. Ren *et al.* [16] believed that the policy of delaying retirement age will not only increase pension incomes, but also reduce pension payments, which will have a cumulative effect on the size of pension fund and alleviate the increasing pressure on pension fund in China.

However, other scholars question the effect of delaying retirement on relieving the pressure of old-age insurance payment. For example, Weller [17] and Miyazaki [24] found that delaying retirement is not only difficult to cope with the situation of expanding pension gap, but also leads to a decline in the tax base, especially significantly reduces the pension benefits of low-income groups. In the long term, delaying retirement is difficult to alleviate the pension payment crisis. Wang *et al.* [18] believed that delaying retirement can reduce the scale of fund gap in the short term, after the delaying retirement, due to the increase of pension payment standards, it will cause the fund gap to expand again. Yu [19] found that delaying the retirement age may not necessarily increase the ability to pay for basic old-age insurance. Pan [20], Cao and Lu [21] believed that even if raising the retirement age can alleviate the pressure of pension payment, this effect is quite small, and it cannot fundamentally make up for the gap. The problem of pension deficit in the future is still inevitable. Zou [22] found that delaying retirement could not solve the problem of future pension fund deficit from the root, which would not only reduce the pension benefits of current workers after retirement, but also increase the pension burden of several new generations after retirement. Yang *et al.* [23] also believed that the policy of delaying retirement is difficult to alleviate the plight of pension payment.

The above literature review shows that although domestic and foreign scholars have rich research on the impact of delaying retirement policy on pension finance, there are indeed two different views. The Chinese government has not yet officially issued the delaying retirement policy, so can the possible delaying retirement policy of China in the future help ease the payment pressure on pension fund? Or is it not conducive to alleviate the payment pressure on the pension fund? Or a combination of these two different views, that is, one part is favorable, while the other is unfavorable. Therefore, it is necessary to establish a possible set (i.e., a general analysis framework) that can include all possible delaying retirement policies issued by the Chinese government, and analyze the specific effect of possible delaying retirement policies on China's basic pension.

In addition, the above literature shows that scholars generally use generational overlap models and social insurance actuarial methods to study the effect of delaying retirement policy on the financial status of pension. In the specific study of the effect of delaying retirement on China's pension finance, the actuarial method of social insurance is generally used. This paper focuses on the possible effect of the Chinese government's future delaying retirement policy on China's pension finance. Therefore, we use the social insurance actuarial method to build the actuarial model to study the effect of the delaying retirement policy according to the key documents of China's pension payment standards, which is scientific and reasonable.

Compared with the existing literatures, the contributions of this paper mainly have the following two points. Firstly, considering the different effects of delaying retirement on the insured "old person", "middle person", and "new person", this paper constructs the possible set of China's future delaying retirement policies, establishes a general analysis framework of the effect of the delaying retirement policies on China's basic pension, and analyzes the specific impact of the delaying retirement policies. Secondly, the introduction of three key variables: the starting year (t_s) of policy implementation, the annual growth speed (Sp) of retirement age, and the proportion (m) of annual growth speed of retirement age of female employees to that of male employees, used to describe the characteristics of the delaying retirement policy, and the three variables are arranged and combined to simulate all possible effects of the delaying retirement policy.

This paper is divided into six sections. In the next section, taking the basic old-age insurance system of enterprise employees as the typical representative of China's basic old-age insurance system, we subdivide the different effects of the delaying retirement policy on the insured "old person", "middle person" and "new person", and construct a general analysis framework of the impact of the delaying retirement policy on balance of the incomes and expenditures of the old-age insurance. The fourth section, combined with the two key documents (the document of "Decision on Establishing a Unified Basic Pension System for Enterprise Employees", i.e. State Council Document 26 in 1997, and the document of "Decision on Improving the Basic Pension System for Urban Employees", i.e. State Council Document 38 in 2005), the actuarial model between retirement age and the incomes and expenditures of the old-age insurance are established. In the fifth section, the three key variables of the delaying retirement policy are simulated in a combined way, and seven kinds of schemes are specifically set up to obtain various possible effects of the delaying retirement policy on China's pension fund. In the last section, based on the conclusions, some suggestions are provided for the delaying retirement policy that the Chinese government is formulating.

III. GENERAL ANALYSIS FRAMEWORK OF THE EFFECT OF DELAYING RETIREMENT POLICY

China's basic old-age insurance system can be represented by the basic old-age insurance system for enterprise employees. The basic old-age insurance was established in 1951, matured in the State Council Document 26 in 1997, and improved in the State Council Document 38 in 2005. According to the

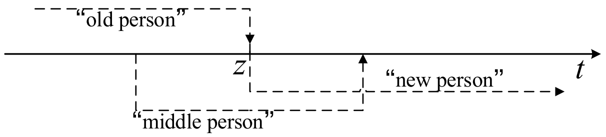

FIGURE 2. Three categories of insured persons.

State Council Document 26 in 1997, we can see that there are three categories of insured persons in the basic old-age insurance for enterprise employees, as shown in Fig.2.

Where t is the year, z is the implementation year of the State Council Document 26 in 1997, that is, $z = 1997$. According to this State Council Document, "old person" refer to the insureds who retired before the implementation year; "middle person" refer to the insureds who had been employed by firms before the implementation year and retired after the implementation year; "new person" refer to the insureds who took part in the first job after the implementation year.

It is assumed that the age of new employees who get the first job and participate in the old-age insurance is e. The retirement age of the insured is r, the retirement age of the insured without considering the delaying retirement is r_0. The ultimate age of the insured is ω. Then it can be inferred that the age ranges of the above three categories of insured persons are as follows: the age range of the "old person" is $[r_0 + t - z, \omega]$; that of the "middle person" is $[e + t - z, r_0 + t - z-1]$; that of the "new person" is $[e, e + t - z-1]$. With the passing of the year, the "old person" and "middle person" insured persons gradually disappeared until they were completely replaced by the "new person". In the following years, the insured persons are all "new person".

The Chinese government is actively formulating the policy of delaying retirement, so there is no official policy of delaying retirement in China at present. It can be seen from Fig.2 that the different initial year (t_s) of delaying retirement policy implementation and the annual growth speed (Sp) of retirement age have significantly different effects on the three categories of insured persons. In order to comprehensively and deeply analyze the impact of the Chinese government's possible delaying retirement policy on the basic pension balance, we establish a general framework for the analysis of the effect of delaying retirement policy on balance of pension incomes and expenditures. There are three specific cases, which are shown in Fig.3.

Where t_0 and T are the start year and end year of the measurement period, t_0 and T are set as 2017 and 2070 respectively; t_s and t_f are the start year and end year of the delaying retirement policy, respectively. The target retirement age is r_f, which is the final retirement age of employees in the year t_f when the implementation of the delaying retirement policy is completed. With the passage of year t, the age of the insured persons are increasing year by year. For the "old person" aged $x \in [r_0 + t-z, \omega]$, the lower limit of the age range (r_0+t-z) changes with the year t as shown in the age gradient line A in Fig.3, then the age change of the "old person" is between the age gradient line A and the horizontal line ω. For the "middle person" aged $x \in [e+t-z, r_0+t-z-1]$, the change of the lower limit of the age range $(e+t-z)$ with year t is shown in the age gradient line B in Fig.3, so the age change of the "middle person" is between the age gradient line A and line B. Then the age change of the "new person" is between the horizontal line e and the age gradient line B.

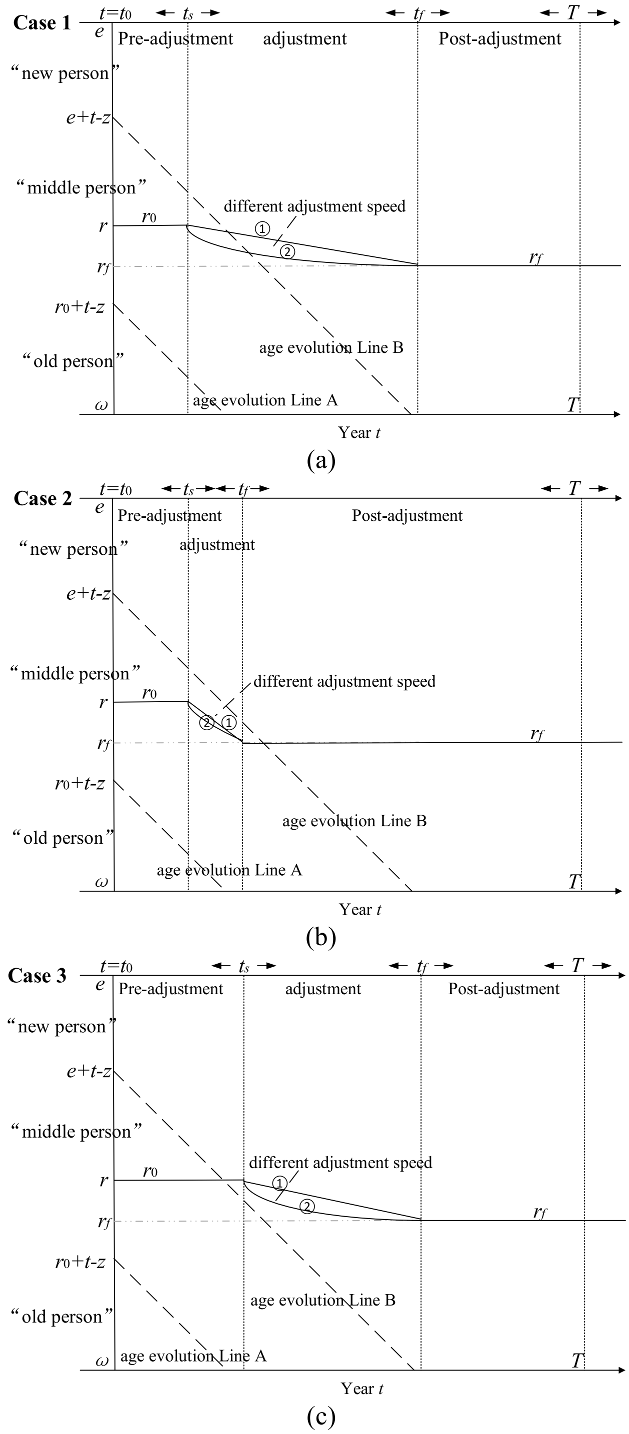

FIGURE 3. The general framework for the analysis of the effects of delaying retirement policy.

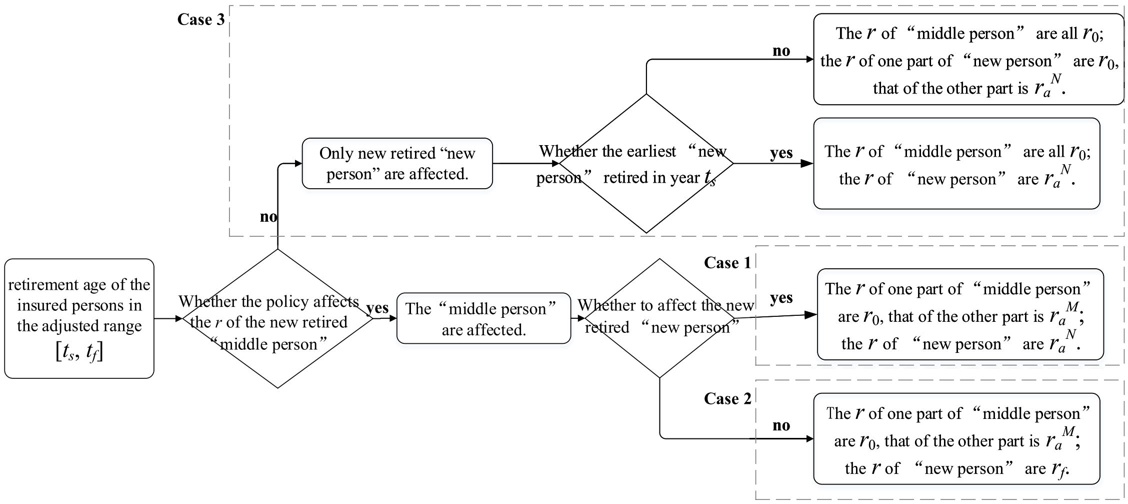

FIGURE 4. **Summary of the general analysis framework.**

Different implementation starting year (t_s) of delaying retirement policy and the annual growth speed (Sp) of retirement age have different effects on the pension incomes and expenditures of the three categories of insured persons. The effects of the possible delaying retirement policies generally include the three cases in Fig.3. The connecting line between r_0 and r_f in Fig.3 shows the changing process of the retirement age of employees, and the possible delaying retirement policies formulated by the government are shown in ① and ②. Situation ① shows that the annual growth speed (Sp) of retirement age is constant in [t_s, t_f], that is, the growth of delaying retirement age is linear and the annual increase of retirement age is the same. Situation ② means that the annual growth speed (Sp) of retirement age is changing in [t_s, t_f], and the growth of the delaying retirement age is non-linear.

During the period [t_s, t_f] of adjusting the retirement age of employees, Fig.3 (a) shows that in the starting year t_s of policy implementation, the on-the-job "middle persons" are in the retirement age adjustment range. The retirement age of one part of "middle persons" are in constant change, which is called adjusted retirement age, so the retirement age r of these people can be recorded as r_a^M. The retirement age of another part of "middle persons" are not affected by the policy, and their retirement age r are still r_0. In the termination year t_f of policy implementation, if all the on-the-job "middle persons" have retired before the end of the policy, the on-the-job "new persons" are also in the retirement age adjustment range, and their retirement age r can be recorded as r_a^N. Fig.3 (b) shows that in the year t_s, the on-the-job "middle persons" are in the retirement age adjustment range, in which the retirement age r of one part of them are r_a^M, and the retirement age r of another part of them are still r_0. In the termination year t_f, if there are still on-the-job "middle persons", the on-the-job "new persons" are not in the retirement age adjustment range, and their retirement age r are r_f after the adjustment is completed. Fig.3 (c) shows that in the year t_s, the on-the-job "middle persons" have retired completely, only the on-the-job "new persons" are in the retirement age adjustment range, the retirement age r of the "middle persons" are all r_0. There are two possibilities for the retirement age r of "new persons", the first is that the r of all the "new persons" are r_a^N, the second is the r of one part of the "new persons" are r_0 and that of another part of "new persons" is r_a^N. The above three cases in Fig.3 can also be summarized as the general analysis framework shown in Fig.4.

IV. ACTUARIAL MODELS FOR RETIREMENT AGE AND PENSION INCOMES AND EXPENDITURES

Since China's basic pension distribution standards are different from foreign countries, the mature pension actuarial models constructed in other countries, such as the United States and the United Kingdom, cannot be applied to China. Therefore, in accordance with the provisions of China's basic pension payment standard documents (State Council Document 26 in 1997 and State Council Document 38 in 2005), and based on the actuarial models of China's pension constructed by the existing classical literatures (Zeng *et al.* [32]; Yang and Shi, [33]; Zhang *et al.* [34]), we further improve their models and obtain the actuarial model suitable for this research.

Zeng *et al.* [32] constructed the actuarial model of extending retirement age and financial subsidy of individual accounts of basic pension in China, but the individual accounts pension only accounts for a small part of basic pension expenditures. Because China's basic pension expenditures include not only the expenditures of individual accounts pension, but also the expenditures of social pooling accounts pension. Yang and Shi [33] constructed the actuarial model of the basic pension incomes and expenditures of China's enterprise employees. Although their actuarial model is relatively consistent with the reality of China's basic pension payment standards, it focuses on the fiscal burden of China's basic pension of social pooling accounts at a certain measurement time point. Their actuarial model contains social pooling accounts pension, but does not contain individual accounts pension, which is exactly the opposite of Zeng *et al.* [32]. Therefore, based on the pension actuarial models of Zeng *et al.* [32] and Yang and Shi [33], we further expand and construct an actuarial model of retirement age and China's basic pension incomes and expenditures, which includes both individual accounts pension and social pooling accounts pension.

Zhang *et al.* [34] constructed the actuarial model of China's pension incomes and expenditures. Although their models include both individual accounts pension and social pooling accounts pension, there are two aspects of their models that do not conform to the reality of China's basic pension payment standards. Firstly, in their incomes model, the pension fund incomes are equal to the basic old-age insurance premiums paid by the ‘‘oldest-old-person’’, ‘‘middle-old-person’’, ‘‘middle-new-person’’, and ‘‘new-person’’ and their work units. In fact, according to the hypothesis of their model, the ‘‘oldest-old-person’’ and ‘‘middle-old-person’’ have retired after 2005, so these persons and their units do not need to pay old-age insurance premiums. Secondly, the individual accounts pension in their model increases with the year. In fact, according to the provisions of State Council Document 38 in 2005, it does not increase with the year. Referring to the model of Zhang *et al.* [34], we further improve the shortcomings of their model and obtain the actuarial model of this study.

In summary, based on the China's pension actuarial models of Zeng *et al.* [32], Yang and Shi [33] and Zhang *et al.* [34], we further improve and expand their models, and construct the following actuarial model of retirement age and pension incomes and expenditures in close combination with the relevant provisions of China's basic pension payment standard documents (State Council Document 26 in 1997 and State Council Document 38 in 2005). Therefore, the actuarial model in this paper is relatively scientific and reliable.

A. RETIREMENT AGE AND PENSION CONTRIBUTION INCOMES

According to the two key State Council documents, referring to the model built by Yang and Shi [33], and improving the first shortcomings in the model of Zhang *et al.* [34], the following model of retirement age and pension contribution incomes can be obtained. The employees of aged $x \in [e, r-1]$ are required to pay insurance premiums for the basic pension, and the enterprises in which they work also need pay basic pension insurance premiums. Let the contribution rate of old-age insurance paid by the employees themselves be c_t, and the contribution rate of old-age insurance paid by the enterprise for the employees be q_t. The number of insureds aged x in year t is $L_{t,x}$. The proportion of the payment salary to the statistical salary is d_t, and the salary of insured employees at age x in year t are $S_{t,x}$, so the payment salary is equal to the product of the insured employee's last year's salary $(S_{t-1,\ x-1})$ and d_t. Thus, the contribution incomes C_t for the basic pension can be expressed as:

$$C_t = (c_t + q_t) \sum_{x=e}^{r-1} L_{t,x} \cdot d_t S_{t-1,x-1} \tag{1}$$

where $S_{t,x} = (1+s) \cdot S_{t,x-1} = \cdots = (1+s)^{x-e} S_{t,e}$ and $S_{t,x} = (1+g_t) \cdot S_{t-1,x-1}$. The $S_{t,e}$ is the salary of new entrants in year t, the s is the growth rate of seniority salary, g_t is the growth rate of salary in year t, so the $S_{t,x}$ in the forecast period can be calculated.

B. RETIREMENT AGE AND PENSION EXPENDITURES

1) PENSION EXPENDITURES FOR ‘‘OLD PERSON’’

According to the model built by Yang and Shi [33] and the relevant regulations of the two key documents of the State Council, the ‘‘old person’’ aged $[r+t-z, \omega]$ only receive basic pension. The retirees of the ‘‘old person’’ disappear gradually with the passage of years, and will disappear completely when $t > z + \omega - r$. The pension of the ‘‘old person’’ aged x in year t is approximately equal to the salary in the last year $(S_{t-(x-r)-1,\ r-1})$ when they retired multiplied by the pension replacement rate $(\hat{R}_{t-(x-r)})$ in the year of retirement. Then pension expenditures for the ‘‘old person’’ (P_t^O) is

$$P_t^O = \sum_{x=r+t-z}^{\omega} L_{t,x} \cdot \hat{R}_{t-(x-r)} S_{t-(x-r)-1,\ r-1} \cdot \prod_{h=t-(x-r)}^{t} (1+\rho_h) \Big/ (1+\rho_{t-x+r}) \tag{2}$$

where ρ_t is the pension growth rate in year t.

2) PENSION EXPENDITURES FOR RETIRED ‘‘MIDDLE PERSON’’

The age range of retired ‘‘middle person’’ is initially $[r,\ r+t-z-1]$ years old. When the ‘‘new person’’ begin to retire, that is, $t \geq z + 2 + l_m$, then the age range becomes $[r+t-z-1-l_m,\ r+t-z-1]$ years old, where $l_m = r-e-1$, so the age range can be summarized as $[\max(r,\ r+t-z-1-l_m),\ r+t-z-1]$ years old. According to the provisions of the two key documents of the State Council, pension expenditures (P_t^M) of the retired ‘‘middle person’’ include basic pension, transitional pension and individual accounts pension expenditures:

$$P_t^M = \sum_{x=\max(r,\ r+t-z-1-l_m)}^{r+t-z-1} L_{t,x} \cdot \left(B_{t,x} + T_{t,x} + I_{t,x}\right) \tag{3}$$

where $B_{t,x}$, $T_{t,x}$, $I_{t,x}$ are the basic pension, transitional pension and individual accounts pension received by the insured at the age of x in year t respectively. Referring to Zeng *et al.* [32] and Yang and Shi [33], as well as improving the second shortcomings in the model of Zhang *et al.* [34], the general formulas of $B_{t,x}$, $T_{t,x}$ and $I_{t,x}$ can be expressed in detail as follows:

$$B_{t,x} = \frac{\bar{S}_{t-(x-r)-1}}{2}\left(1+\frac{1}{\min(t-(x-r)-z,\,r-e)}\sum_{k=1}^{\min(t-(x-r)-z,\ r-e)}\frac{d_{t-(x-r)-k}S_{t-(x-r)-k-1,r-k-1}}{\bar{S}_{t-(x-r)-k}}\right) \times \min(t-(x-r)-z,\,r-e)\,\% \times \frac{\prod_{h=t-(x-r)}^{t}(1+\rho_h)}{1+\rho_{t-(x-r)}} \tag{4}$$

$$T_{t,x} = \frac{\bar{S}_{t-(x-r)-1}}{t-(x-r)-z} \times \left(\sum_{k=1}^{t-(x-r)-z}\frac{d_{t-(x-r)-k}S_{t-(x-r)-k-1,r-k-1}}{\bar{S}_{t-(x-r)-k}}\right) \times [r-e-(t-(x-r)-z)] \times \varepsilon \times \frac{\prod_{h=t-(x-r)}^{t}(1+\rho_h)}{1+\rho_{t-(x-r)}} \tag{5}$$

$$I_{t,x} = I_{t-(x-r),r} = \frac{12}{m_r} \times \sum_{k=\max(z,\ t-(x-r)-1-l_m)}^{t-(x-r)-1} \times \left[c_k d_k S_{k-1,x+(k-1)-t} \cdot \prod_{h=k+1}^{t-(x-r)}(1+j_h)\right] \tag{6}$$

where $\bar{S}_t$ is the average salary of employees in year t, ε is the pension transition coefficient, m_r is the stipulated months that the individual accounts pension of the retiree should be paid, and j_t is the bookkeeping interest rate of the individual accounts pension.

3) PENSION EXPENDITURES FOR RETIRED "NEW PERSON"

The age range of "new person" is initially $[r,\ r+t-z-1-l_m-1]$ years old, which can be abbreviated as $[r,\ t-\ z+e-1]$ years old. The "new person" constantly replace "old person" and "middle person" with the passage of years. When $t\ \geq z-e+\omega+1$, all the retired persons are "new person", and the "old person" and "middle person" have disappeared successively. With reference to Yang and Shi [33] and Zhang *et al.* [34] and the provisions of the two key documents of the State Council, the pension expenditures for retired "new person" (P_t^N) include basic pension and individual accounts pension:

$$P_t^N = \sum_{x=r}^{t-z+e-1} L_{t,x} \cdot \left(B_{t,x} + I_{t,x}\right) \tag{7}$$

where $B_{t,x}$ and $I_{t,x}$ correspond to the formulas (4) and (6) respectively.

4) REFUND OF REMAINING AMOUNT OF INDIVIDUAL ACCOUNTS

The return of remaining amount of individual accounts is recorded as I_t^D. According to Zhang *et al.* [34] and the provisions of the two key documents of the State Council, it includes the return of the remaining amount when the employees die during their working period and the retirees die within the number of stipulated payment months. The formula is as follows:

$$I_t^D = \sum_{x=e}^{r-1}\sum_{k=0}^{\min(t-z,x-e)} \times \left[c_{t-k}d_{t-k}S_{t-k-1,x-k-1} \cdot \frac{\prod_{n=0}^{k}(1+j_{t-n})}{(1+j_t)}\right] \cdot D_{t,x} + \sum_{x=r}^{\min(r+t-z-1,\ r+[m_r/12]-1)} \left(\frac{m_r}{12}-x+r\right) \cdot I_{t,x} \cdot D_{t,x} \tag{8}$$

where $D_{t,x}$ is the number of insured deaths aged x in year t.

In summary, the contribution incomes for the basic pension is C_t, and the pension expenditures of the three categories of insured persons is P_t. It can be seen from the above that $P_t = P_t^O + P_t^M + P_t^N + I_t^D$. The increase in retirement age r will cause changes in C_t and P_t, which will affect the balance of contribution incomes and expenditures of the basic pension.

V. SIMULATION ANALYSIS OF THE EFFECT OF DELAYING RETIREMENT POLICY

A. SPECIFIC SIMULATION SCHEMES

The starting year (t_s) of policy implementation and the annual growth rate of retirement age (Sp) are the key parameters to describe a delaying retirement policy, which can be used as the significant variables to simulate the effect of the delaying retirement policy. As the final delaying retirement policy issued by the government may belong to any of the three cases in Fig.3, the value range of t_s and Sp in the simulation need to be relatively broad to fully cover the above three cases.

During simulation, the starting year t_s can be set within the range of [2020, 2050]. In order to simplify the calculation during the simulation, the linear growth represented by ① in Fig.3 is selected as the retirement age increase style. The annual growth rate Sp of retirement age in style ① can be set as $1/12*n$, and the n is a positive integer, which means that the retirement age of employees will increase by $1/12*n$ years-old each year during the adjustment period $[t_s,\ t_f]$. In the simulation, the n can be specifically set to an integer from 1 to 24. In addition, according to the actual conditions in China, the current retirement ages of male and female employees are different, among which the retirement age (r_0) of male employees is 60 years old and that of female employees is simplified as 55 years old. Since the current retirement age of female employees is lower than that of male employees, the annual growth rate (Sp^{femal}) of the retirement age of female employees may be greater than that of male employees (Sp^{man}), and the Sp^{femal}/Sp^{man} can be set as m. In the simulation, the value range of m can be specifically set from 1 to 2, with a step size of 0.05, such as 1.00, 1.05, 1.10... 2.00. Finally, we assume that the starting year (t_s) of the policy implementation is the same for male and female employees.

To sum up, the effects of delaying retirement policies can be simulated in depth from the three variables (t_s, Sp and m). Since these three variables are relatively independent, the following 7 specific simulation schemes can be simulated in a combined way.

Scheme 1: t_s is changing, Sp and m are fixed, such as $t_s \in [2020, 2050]$, $Sp = 6/12$, $m = 1$.

Scheme 2: Sp is changing, t_s and m are fixed, such as $Sp = n/12$, $(n = 1, 2, 3 \ldots 24)$, $t_s = 2020$, $m = 1$.

Scheme 3: m is changing, t_s and Sp are fixed, such as $m = 1.00, 1.05, 1.10 \ldots 2.00$, $t_s = 2020$, $Sp = 6/12$.

Scheme 4: t_s and Sp are changing, m is fixed, such as $t_s \in [2020, 2050]$, $Sp = n/12$, $(n = 1, 2, 3, \ldots, 24)$, $m = 1$.

Scheme 5: t_s and m are changing, Sp is fixed, such as $t_s \in [2020, 2050]$, $m = 1.00, 1.05, 1.10 \ldots 2.00$, $Sp = 6/12$.

Scheme 6: Sp and m are changing, t_s is fixed, such as $Sp = n/12$, $(n = 1, 2, 3 \ldots 24)$, $m = 1.00, 1.05, 1.10 \ldots 2.00$, $t_s = 2020$.

Scheme 7: t_s, Sp and m are all changing. $t_s \in [2020, 2050]$, $Sp = n/12$, $(n = 1, 2, 3 \ldots 24)$, $m = 1.00, 1.05, 1.10 \ldots 2.00$.

In addition, the result without considering the delaying retirement policy is taken as the control group: the retirement age r is always equal to r_0, and the three variables (t_s, Sp and m) are all not involved.

B. ESTIMATION OF MODEL PARAMETERS

1) THE ESTIMATION OF THE NUMBER OF INSURED PERSONS IN THE BASIC OLD-AGE INSURANCE

The number of insured persons x years old in year t ($L_{t,x}$) is equal to the product of the number of national people at the age of x in year t ($P_{t,x}$) and the labor participation rate, urbanization rate, old-age insurance coverage rate and proportion of the insureds number of enterprise employees to the insureds number of urban employees in year t. Then, multiplying the number of insured persons of each age and sex ($L_{t,x}$) by the employee's mortality rate of x years-old in year t ($q_{t,x}$), the number of deaths of insured persons of each age and sex ($D_{t,x}$) can be obtained.

The China's national population by age and sex in year t ($P_{t,x}$) is estimated using the cohort element method to construct a population prediction model. According to the data of the United Nations Population Division in 2019, China's net migration population in 2018 was −174.2 million, accounting for only 0.125% of the total population, and the impact is very small, so the international migration of population is not considered. Without considering the international migration, the general form of China's population structure prediction model is as follows:

$$\begin{cases} P_{t,x} = P_{t-1,x-1} \cdot (1 - q_{t,x}), & x > 0 \\ P_{t,0} = \dfrac{SRB_t}{1 + SRB_t} \cdot \sum\limits_{x=15}^{49} P_{t,x}^{F} \cdot FR_{t,x} & \\ \quad + \left(1 - \dfrac{SRB_t}{1 + SRB_t}\right) \cdot \sum\limits_{x=15}^{49} P_{t,x}^{F} \cdot FR_{t,x}, & x = 0 \end{cases} \tag{9}$$

where $P_{t,x}^{F}$ is the number of women of childbearing age at the age of x in year t, $FR_{t,x}$ is the fertility rate of women of childbearing age at the age of x in year t, and SRB_t is the sex ratio of newborns in year t.

According to *China Population and Employment Statistical Yearbook 2019*, the population distribution by age and gender in 2018 is divided by the corresponding sampling ratio, and the result obtained is used as the initial population distribution. The fertility rate of women of childbearing age ($FR_{t,x}$) for each year of the forecast period can be calculated by $TFR_t \cdot \bar{h}_x$, where TFR_t is the total fertility rate in year t, and $\bar{h}_x$ is the average standardized fertility coefficient. The annual total fertility rate TFR_t for each year of the forecast period refers to the results of the intermediate scene predicted by the United Nations Population Division in 2019. According to the *China Population and Employment Statistics Yearbook* in 2001–2019, the average fertility rate of urban women of childbearing age ($FR_{t,x}$) in 2000–2018 can be obtained, and the total fertility rate (TFR_t) of corresponding year can be obtained through formula $TFR_t = \sum_{x=15}^{49} FR_{t,x}$, then the standardized fertility coefficient ($h_{t,x}$) of these 19 years can be obtained through formula $h_{t,x} = FR_{t,x}/TFR_t$, and the average value of these years is taken as the average standardized fertility coefficient ($\bar{h}_x$) of each year in the prediction period. The sex ratio of newborn (SRB_t) in each year of the prediction period also refers to the intermediate scene's results predicted by the United Nations Population Division in 2019. The mortality rate $q_{t,x}$ during the forecast period comes from the "Far East" life table model in PADIS-INT software, which is one of the mainstream software for international population forecasting.

According to *China Population and Employment Statistics Yearbook 2019*, the average registered urban unemployment rate from 1978 to 2018 is 4.02%, and the available labor participation rate is 95.98%. Using the ARIMA (1, 1, 0) model to fit the sample data of the proportion of urban population from 1980 to 2018 in *China Statistical Yearbook 2019*, Wang and Ge [35] assumed that the upper limit of urbanization rate in China was 80%. Thus, in the years when the rate exceeds 80% in the forecast results, the 80% is taken as the proportion of urban population. With reference to Yang and Liao [36], the old-age insurance coverage rate has increased by one percentage point year by year from 85% in 2015 to 95% in 2025, and will remain unchanged in the following years. According to *China Human Resources and Social Security Yearbook 2019*, the proportion of the insureds number of enterprise employees to the insureds number of urban employees in 1990–2018 was obtained, and their average value of 94.32% was taken as the value of this proportion in each year of the forecast period.

2) OTHER PARAMETERS

The State Council Document 38 in 2005 stipulated that the individual contribution rate c is 8%, and "*The Comprehensive Scheme on Reducing Social Insurance Contribution Rates*" stipulated that the enterprise contribution rate q is 16%. The age (e) for employees to get their first job and participate in the basic old-age insurance is set at 20. The ultimate age (ω) of the insured is set at 100. The target retirement age (r_f) for male and female employees is 65 years old. According to the table of individual accounts pension stipulated payment months in the State Council Document 38 in 2005, the stipulated payment months (m_r) corresponding to the integer retirement age r can be obtained. When the delaying retirement policy is implemented, if the retirement age r is non integer, the number of stipulated payment months corresponding to the integer part of the retirement age r is taken as the m_r of the non integer retirement age r.

Referring to Yang and Shi [33], the growth rate of seniority wage (s) is set as 1.363%. According to Jin [37], the pension transition coefficient (ε) is generally controlled between 1% and 1.4%, taking the median value of 1.2%. According to *China Human Resources and Social Security Yearbook 2019*, it can be seen that the average pension level of retired employees in 2018 and the average salary of on-the-job employees in 2017 are 29880 yuan and 72703 yuan respectively. Divide the average pension level in 2018 by the current official pension replacement rate of 67.5%, and then divide the average salary of on-the-job employees in 2017 to obtain the proportion of the payment salary to the statistical salary (d_t). The calculated value of d_t is 60.89%, which is assumed to remain unchanged during the forecast period. Since the earliest year of the average pension level data of retired employees in the *China Human Resources and Social Security Yearbook 2019* is 1998, the data of this year are used to estimate the pension replacement rate ($\hat{R}$) of the "old person". According to the Yearbook, the average pension level of retired employees in 1998 and the average salary of on-the-job employees in 1997 were 5304 yuan and 7405 yuan respectively. Divide the average pension level of retired employees by the average salary of on-the-job employees to get pension replacement rate ($\hat{R}$), which is 71.63%.

Base on the *2018 National Graduate Salary Survey Report* released by China compensation network, the average annual income of 2018 graduates of higher vocational colleges were 52212 yuan, which is taken as the average salary of new employees. Referring to the methods of Yang and Shi [33], the salary growth rate in 2018 and before is consistent with the average salary index of urban employees in the year corresponding to the *China Labor Statistics Yearbook*. The salary growth rate (g) is 7.7% in 2019–2020, 6.6% in 2021–2025, 5.7% in 2026–2030, and 4.8% in other years. According to the past practice, the pension growth rate (ρ) is usually 40% – 80% of the salary growth rate, taking 75% here, thus the annual pension growth rate can be obtained. According to the benchmark interest rate of RMB one-year deposits issued by the People's Bank of China, the compound annual interest rate from the end of 1995 to the end of 2015 is about 3.27%. The average bookkeeping interest rate of individual accounts of basic old-age insurance for urban employees in 2016–2018 published by the general office of the Ministry of human resources and social security and the general office of the Ministry of finance is 7.18%. Then the bookkeeping interest rate in 2015 and before is 3.27%; in 2016 and after is 7.18%.

C. THE KEY INDICATORS TO MEASURE THE EFFECT OF DELAYING RETIREMENT POLICY AND ITS EFFECT ANALYSIS

1) THE SELECTION OF SUITABLE INDICATOR FOR POLICY EFFECT SIMULATION

From the actuarial model of the retirement age and the China's pension incomes and expenditures constructed above, it can be seen that increasing the retirement age r will not only affect the pension contribution incomes C_t, but also the pension expenditures P_t. Thus, the age r has the profound effect on China's pension financial situation. With reference to the methods of Zeng *et al.* [32], Yang and Shi [33], and Zhang *et al.* [34] and other literatures, the indicators commonly used to measure the financial effect of delaying retirement policies on China's pension are: (1) changes in the current balance of each year, (2) the average change of the current balance during the forecast period, (3) the change of the accumulative balance at the end of the forecast period, etc.

The balance of pension incomes and expenditures is set as B_t, and the balance B_t is equal to the pension income C_t- pension expenses P_t. Let the accumulative balance of pension be AB_t, which means if $AB_{t-1} \leq 0$, then $AB_t = AB_{t-1} + B_t$; if $AB_{t-1} > 0$, then $AB_t = AB_{t-1}\times (1+i_t)+ B_t$, where i_t is the pension investment return rate. The changes in the current balance of each year of indicator (1) can be recorded as B'_t, then $B'_t = B^N_t - B^O_t$. Where the B^O_t refers to the balance without considering the delaying retirement policy, when $t \in [t_s, T]$, the retirement age r is all equal to r_0, which is recorded as the control group. The B^N_t is the balance in each year when the retirement age r changes during $[t_s, T]$ under the implementation of the delaying retirement policy. The average change of the current balance during the forecast period of indicator (2) can be recorded as $\overline{B}$, then $\overline{B} = \sum_{t=t_s}^{T} B'_t \Big/ (T - t_s)$, where $T = 2070$. The change of the accumulative balance at the end of the forecast period of indicator (3) can be recorded as AB'_T, then $AB'_T = AB^N_T - AB^O_T$, where the AB^O_T refers to the accumulative balance without considering the delaying retirement policy. The AB^N_T is the

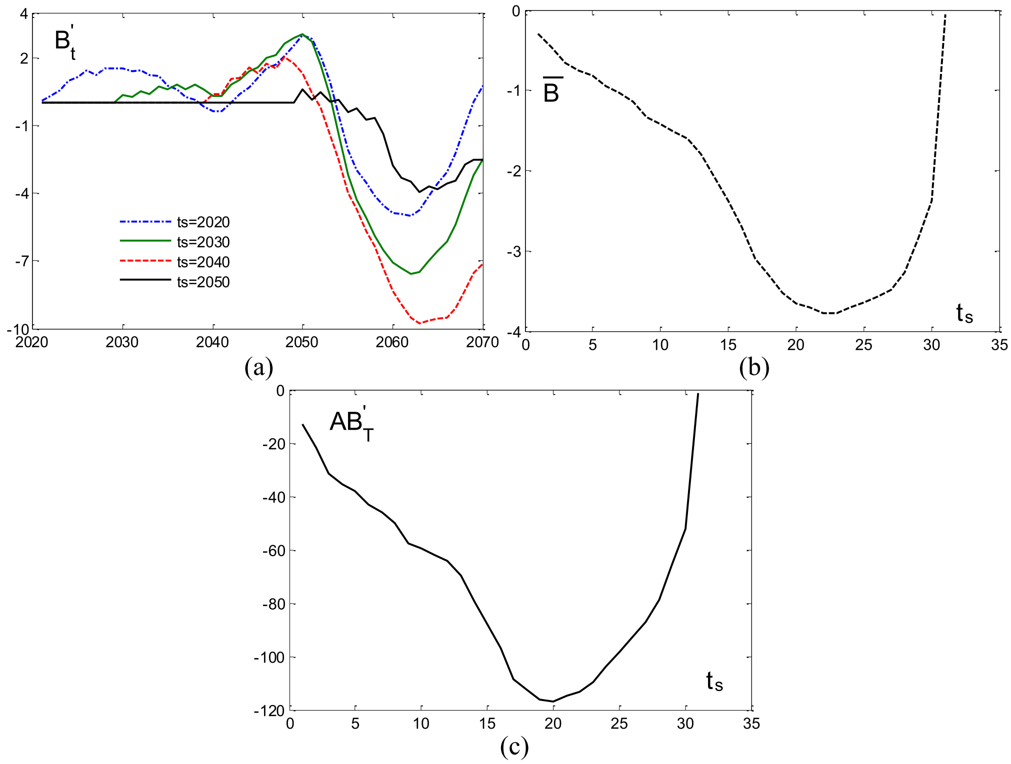

FIGURE 5. Comparison of the results of the three indicators to measure the effect of scheme 1.

accumulative balance in each year when the retirement age r changes during $[t_s, T]$ under the implementation of the delaying retirement policy.

Which of the above three indicators is more suitable to measure the effect of the delaying retirement policy on China's pension financial situation? We can judge by comparing the three indicators to respectively measure the effect of the simulation scheme 1 of the delaying retirement policy, and select the more suitable indicator. According to *China Labor Statistics Yearbook 2018*, the initial accumulative balance ($t = t_0$) of basic old-age insurance fund for Chinese enterprise employees in 2017 is 41385.2 trillion yuan. The investment return rate of basic pension in 2017 and 2018 published by the National Social Security Fund Council in China is 5.23% and 2.56% respectively, taking its average value of 3.90% as the investment return rate during the forecast period, thus the pension accumulative balance of each year in the forecast period can also be calculated. Then, the results of using indicators (1), (2) and (3) to measure the effect of the simulation scheme 1 are shown in Fig.5 (a), Fig.5 (b) and Fig.5 (c), respectively. The unit of ordinate is trillion yuan.

From the result of measuring the effect of scheme 1 with indicator B'_t in Fig.5 (a), it can be seen that in scheme 1, the starting year $t_s \in [2020, 2050]$, such as $t_s = 2020$, 2030, 2040 and 2050, during the whole forecast period, the effect of these delaying retirement policies on China's pension financial situation is generally beginning to show a favorable effect, and the degree of this favorable effect will gradually increase and then start to weaken until it turns into a negative effect. In the later stage of adverse effects, the degree of adverse effects will be gradually increased and then gradually weakened. It can be seen that indicator B'_t can clearly show the change process of policy effect in scheme 1 in the whole forecast period [2020, 2070], but it cannot show the overall effect of the policy on the forecast period. Compared with the indicator B'_t, the indicator $\overline{B}$ can exactly show the average effect of the policy on the overall forecast period. As shown in Fig.5 (b), $t_s \in [2020, 2050]$, it shows the change process of the overall average effect of the delaying retirement policy on the forecast period, so this indicator is more suitable for measuring the remaining six schemes of policy effect simulation. From Fig.5 (c), the measurement result of indicator AB'_T is similar to that of indicator $\overline{B}$, but the calculation of indicator AB'_T is more complicated than that of indicator $\overline{B}$. To sum up, indicator $\overline{B}$ is the most appropriate indicator to measure the effect of delaying retirement policy compared with indicator B'_t and indicator AB'_T. In the next policy effect analysis, we use indicator $\overline{B}$ to formally measure the effect of the delaying retirement policy of each schemes.

2) ANALYSIS OF THE EFFECT OF DELAYING RETIREMENT POLICY

Based on the pension incomes and expenditures model and the general analysis framework principle of Fig.4, the simulation effects of delaying retirement policy under seven specific schemes is obtained by substituting the value of relevant parameters into the calculation.

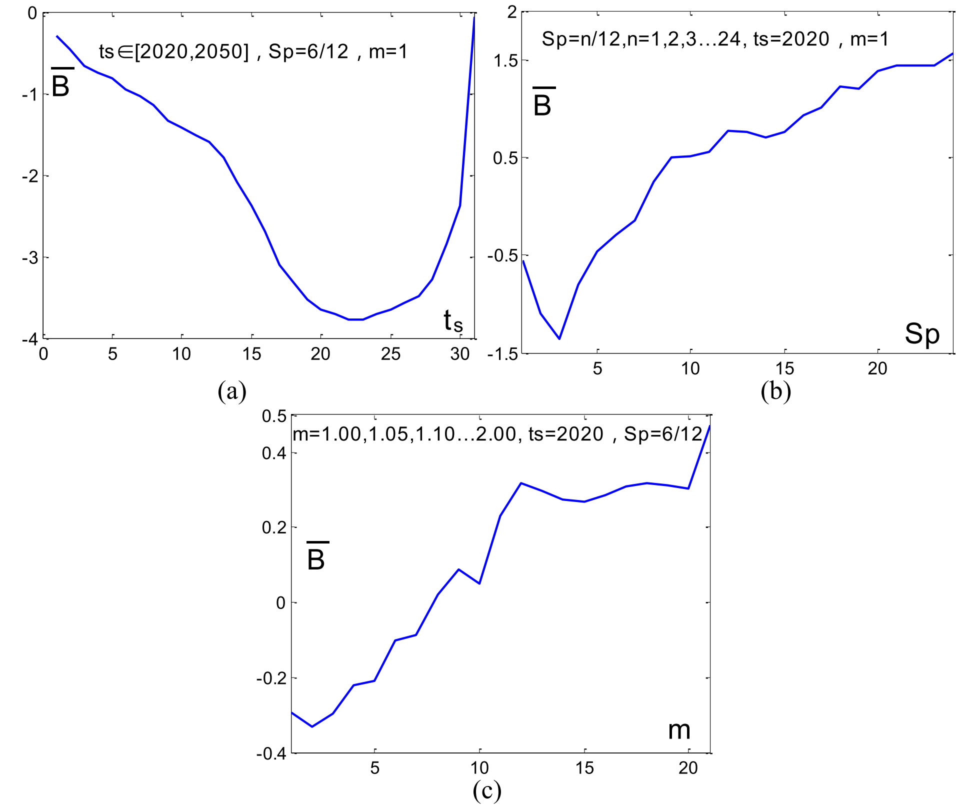

FIGURE 6. Simulation effects of delaying retirement schemes with single variable change.

Only one of the variable (t_s, Sp and m) is changing, and the remaining two variables are fixed, that is, the schemes 1, 2, 3 of the seven schemes. The simulation results of these schemes are shown in Fig.6, where the ordinate unit is trillion yuan. When the abscissa $t_s = 1$ in Fig.6 (a), it means the first year from 2020, which is equal to 2020; $t_s = 31$, it means the 31st year from 2020, which is 2050. When the abscissa $m = 1$ in Fig.6 (c), it means $Sp^{femal} / Sp^{man} = 1.00$; $m = 21$, it means $Sp^{femal} / Sp^{man} = 2.00$.

It can be seen from Fig.6 (a) that the overall average effect ($\overline{B}$) of scheme 1 on China's pension balance is negative, which indicates that scheme 1 will increase the financial burden of pension. With the passage of t_s, the adverse effect will gradually deepen first and then slow down, roughly showing a U-shaped relationship, with a turning point about after the 23rd year, i.e. 2042. As can be seen from Fig.6 (b), in Scheme 2, the average effect ($\overline{B}$) and the annual growth rate of retirement age (Sp) are roughly linearly sloping upward to the right, indicating that with the increase of Sp, it has a stronger and stronger positive effect on the pension balance. From Fig.6 (c), the effect of Scheme 3 is similar to that of Scheme 2. With the gradual increase of the proportion (m) of annual growth speed of retirement age of female employees to that of male employees, the positive beneficial effect on China's pension balance is more powerful.

The simulation results of schemes 4, 5, and 6 when two of the three variables (t_s, Sp and m) change simultaneously are shown in Fig.7, where the ordinate unit is trillion yuan.

From Fig.7 (a) and Fig.7 (b), with the positive extension of the t_s coordinate axis, the overall effect surface of the two figures shows the change trend of first concave down and then convex up, which is generally consistent with the change trend between t_s and $\overline{B}$ in Fig.6 (a). It shows that in scheme 4 with t_s and Sp both changing and scheme 5 with t_s and m both changing, the variable that have great influence on the $\overline{B}$ are the starting year t_s. From Fig.7 (c), with the positive extension of Sp coordinate axis, the effect surface of scheme 6 is gradually extending upward, which is generally consistent with the change trend of Sp and $\overline{B}$ in Fig.6 (b). However, the change trend of m and $\overline{B}$ in Fig.6 (c) is not clearly shown in Fig.7 (c), which shows that the influence of Sp change on $\overline{B}$ is greater than that of m change on $\overline{B}$ in scheme 6. In summary, in the degree of influence of the three variables (t_s, Sp and m) on the $\overline{B}$, the degree of influence of t_s > the degree of influence of Sp > the degree of influence of m.

Scheme 7 is the overall average effect of the simultaneous changes of three variables (t_s, Sp and m) on the pension balance. If the average effect ($\overline{B}$) $\geq$ a certain value (PN), when $PN \geq 0$, it means that the delaying retirement policy has a favorable effect on the pension balance, which is conducive to alleviating the pension payment dilemma. Here PN is set to 1.65, which means that the implementation of delaying

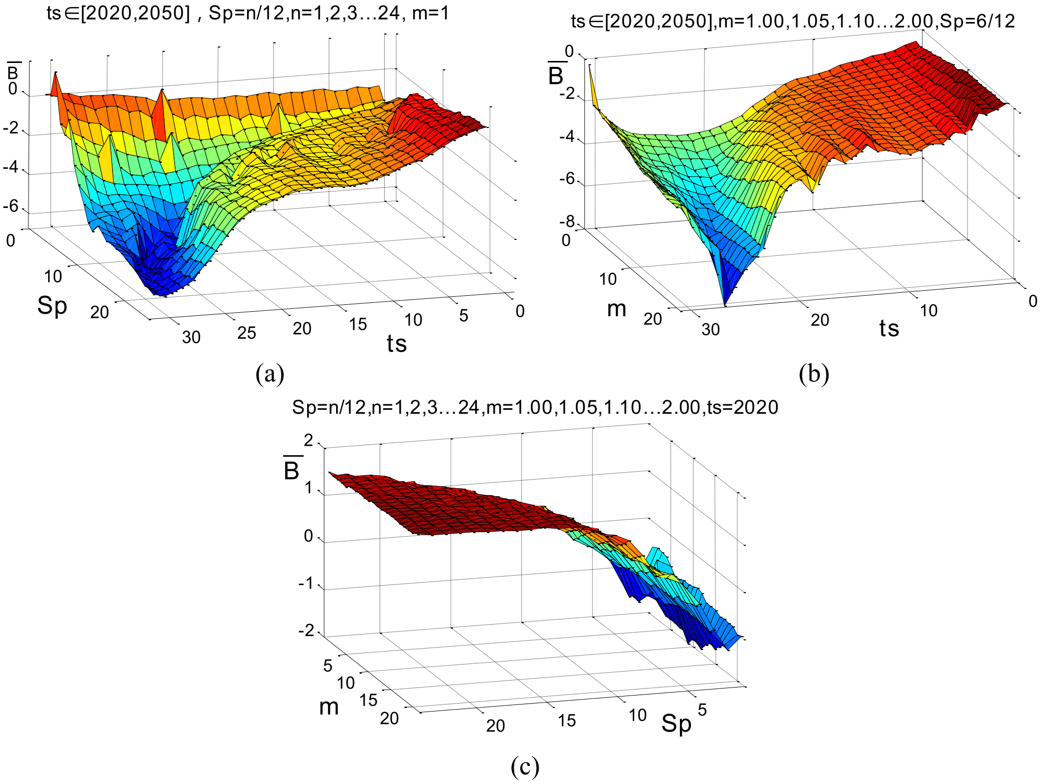

FIGURE 7. Simulation effects of delaying retirement schemes with two variables change.

TABLE 1. Values of three variables when $\overline{B} \geq 1.65$.

t_s	Sp	m	t_s	Sp	m	t_s	Sp	m
1	18	21	1	22	21	31	3	2
1	19	19	1	23	13	31	3	3
1	19	20	1	23	14	31	3	4
1	19	21	1	23	15	31	3	5
1	20	17	1	23	16	31	3	6
1	20	18	1	23	17	31	3	7
1	20	19	1	23	18	31	3	8
1	20	20	1	23	19	31	3	9
1	20	21	1	23	20	31	3	10
1	21	16	1	23	21	31	3	11
1	21	17	1	24	11	31	3	12
1	21	18	1	24	12	31	3	13
1	21	19	1	24	13	31	3	14
1	21	20	1	24	14	31	3	15
1	21	21	1	24	15	31	3	16
1	22	14	1	24	16	31	3	17
1	22	15	1	24	17	31	3	18
1	22	16	1	24	18	31	3	19
1	22	17	1	24	19	31	3	20
1	22	18	1	24	20	31	3	21
1	22	19	1	24	21	—	—	—
1	22	20	31	3	1	—	—	—

retirement policy has a perfectly positive effect, which can effectively ease the dilemma of pension payment. To make $\overline{B} \geq 1.65$, the values of the three variables (t_s, Sp and m) are shown in Table 1. The $t_s = 1$ in the table 1 means that the starting year of the delaying retirement policy is 2020; $t_s = 31$ means that the starting year of the delaying retirement policy is 2050.

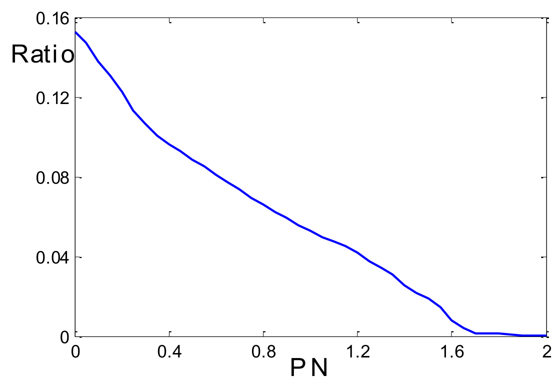

FIGURE 8. Change tendency in the *Ratio*.

From Table 1, in order to achieve better effect of delaying retirement policy, t_s is either equal to 1 or equal to 31, because its effect on $\overline{B}$ presents a U-shaped relationship, and the values of Sp and m have no obvious constraints. Furtherly, it was found that when $t_s = 31$ (2050), $Sp = 3$, $m = 20$ (i.e., $Sp^{femal}/Sp^{man} = 1.95$), the implementation of the delaying retirement policy can achieve the maximum effect and ease the predicament of pension payment to the greatest extent.

In Scheme 7, the total number of combinations of the three variables (t_s, Sp and m) is 31 × 24 × 21, for a total of 15624 combinations. The ratio of the number of combinations meeting the condition ($\overline{B} \geq PN$) to all the combinations can be recorded as *Ratio*. When *PN* is traversed from 0 to 2 with a step size of 0.05, the change tendency of *Ratio* can be observed, as shown in Fig.8.

It can be seen that when $PN = 0$, that is, $\overline{B} \geq 0$, there are nearly 15% of the number of combinations (nearly 2344 combinations) in the combination space of the three variables (t_s, Sp and m) in Scheme 7 can make the delaying retirement policy produce positive and favorable effects, which can effectively alleviating the dilemma of pension payment. When PN is gradually increasing, it means that the beneficial effects of delaying retirement policies are getting stronger and stronger, the *Ratio* is continuously decreasing. When $PN = 1.65$, the *Ratio* is close to 0.

VI. CONCLUSION

There is no official delaying retirement policy in China at present. This paper analyzes the effect of the government's possible delaying retirement policy on China's pension payment dilemma. According to the State Council Document 26 in 1997, the people participating in the basic old-age insurance can be divided into three categories: "old person", "middle person" and, "new person". Due to different delaying retirement policies, the effects on the three categories of insured persons are different. So we establish a general analysis framework, which is applicable to analyze the impact of various possible delaying retirement policies on pension balance. By combining simulation of the three key variables (t_s, Sp and m) of the delaying retirement policy to explore the effect of the delaying retirement policy, and specifically simulating the seven schemes, the following conclusions can be obtained.

First, the effect of the delaying retirement policy on the pension balance is essentially a combination of two opposing views in the above literature review. On the one hand, it may have a positive and beneficial effect on China's pension balance, and alleviate the pressure of pension payment; on the other hand, it may also have no or even a negative impact on pension balance and aggravate the pension payment dilemma. From the simulation results of scheme 7, it can be seen that the probability of delaying retirement policy having a positive beneficial effect on China' pension balance which is about 15%. Because the increase of retirement age on the one hand will increase the contribution incomes of basic old-age insurance, on the other hand, it will also gradually increase the treatment level of retirees, and increase the pension expenditures. When the contribution incomes of basic old-age insurance are not less than the increase of pension expenditures, the delaying retirement policy can have a positive and favorable effect, which is conducive to alleviate the dilemma of China's pension payment; otherwise, the delaying retirement policy has a negative effect, which is not conducive to alleviate the dilemma of pension payment.

Second, the change trend of between the t_s and the policy average effect ($\overline{B}$) shows a U-shaped relationship in the forecast period, and the turning point is around 2042. The change trend of the annual growth rate of retirement age (Sp) and the average effect of policy generally shows the same direction of change, and the ratio m and the policy average effect also exhibits the same direction of change during the forecast period. When two of the three variables (t_s, Sp, and m) are allowed to change at the same time, the degree of influence of t_s > the degree of influence of Sp > the degree of influence of m.

Based on the above conclusions, the following policy recommendations can be obtained. First, the government needs to perfect the policy of delaying retirement that it is formulating to produce favorable effects, because delaying retirement policies is not necessarily conducive to enhancing China's pension payment capacity, and the policy that can produce positive effects is only part of the whole. Second, the Chinese government needs to accelerate the formulation and implementation of the delaying retirement policy to make the starting year (t_s) as small as possible. Because there is a U-shaped relationship between t_s and the policy average effect ($\overline{B}$), and its turning point is around 2042. According to China's actual situation, the delaying retirement policy is likely to be implemented between 2020 and 2042, so the t_s needs to be as much as possible small. The annual growth rate of retirement age (Sp) of delaying retirement policy can be increased appropriately, and the increase rate of retirement age of female employees can be faster than that of male employees.

Research limitations. The analysis on the effect of the delaying retirement policy may not be comprehensive and in-depth. This article focuses on the effect of the delaying retirement policy on China's basic pension fund finance, that is, whether the policy can help alleviate China's pension payment dilemma, and selects the more concise and appropriate indicator from the three indicators (indicator B'_t, indicator $\overline{B}$, and indicator AB'_T) to measure the effect of the delaying retirement policy, but ignores other effects of the delaying retirement policy, such as the effect on the level of pension benefits and pension contribution rate of retirees. Moreover, the three measurement indicators compared may not be comprehensive, and we will expand these in future research.

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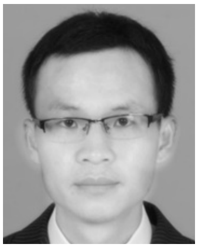

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