Optimization of Actuarial Model for Individual Account of Rural Social Pension Insurance

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Abstract This paper firstly analyzes different payment methods of individual account and the pension replacement rate under the pension payment method. Results show that it will be more scientific and reasonable for the individual account of new rural social pension insurance to adopt the actuarial model of payment according to proportion of income and periodic prestation at variable amount. The Guiding Opinions on New Rural Social Pension Insurance sets forth individual account should be paid at fixed amount, and the insured voluntarily selects payment level as per criteria set by the State. The monthly calculation and distribution amount of pension is the total amount of individual account divided by 139. Therefore, it should start from continuation of policies and make adjustment of payment level in accordance with growth of per capita net income of rural residents. When condition permits, it is expected to realize transition to payment as per income proportion and periodic prestation at variable amount.

Key words New rural social pension insurance, Individual account actuarial calculation, Optimization

1 Introduction

The individual account of new rural social pension insurance adopts defined contribution (DC) system. Namely, contribution level is defined in advance, and insured farmers select payment level as per their actual ability. When reaching the age that the pension can be received, appropriate benefit amount can be assigned through certain actuarial calculation according to accumulation of pension. Balance model of individual account actuarial calculation is established on the principle of actuarial present value (APV) of future benefit equal to APV of future contribution [1-2]. The APV of future benefit is the present value of gross future benefit promised for individual account, while the APV of future contribution is the gross future contribution accumulated in individual account of the insured farmers in the insurance period [3]. For individual account, there are two types of payment: contribution according to proportion of income and contribution at fixed amount. The pension benefit takes the form of annuity, which can be divided into level annuity and varying annuity [4]. Different combination of individual account pension contribution methods and future pension benefit methods constitutes different actuarial model of long term balance of pension revenue and expenditure. Therefore, estimation of theoretic reasonable future benefit on the basis of certain contribution level is a fundamental principle to be followed in keeping long-term scientific and rational pension revenue and expenditure balance [5]. This study makes comparative analysis on influence of actuarial models in different contribution and benefit methods of individual account of new rural social pension on pension income replacement ratio, and so as to optimize actuarial models of individual account.

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2 Building actuarial model for individual account of new rural social pension insurance

2.1 Prerequisite for model building

2.1.1 The fund for Individual account of pension insurance and composition methods. The fund for individual account of pension insurance adopts fully funded financing model, which takes the principle of long-term vertical balance. It requires, on the basis of expected pension insurance demand, determining a total contribution rate that can guarantee balance of revenue and expenditure in a long period, allocating the insurance premium into the entire coverage period of the insured, and handing part of income to a centralized fund for investment. When reaching the retirement age, this fund will fulfill the original pension promise to the insured at the fund accumulation amount [6]. Since the individual account of pension opens an account for every insurance participant, and provides future pension benefit as per ultimate yield of this account, so as to make it different from accounting on a cash basis. It not only can realize certain social mutual aid and intragenerational redistribution through government subsidy for individual account, but also can realize transfer of part of income of the insured from working time to the period after retirement [7].

Here, it is assumed that the individual account capital of pension insurance is a periodic cash flow, and consists of individual contribution, financial subsidy and fund income. Individual contribution is collected at the beginning of each year. This will be analyzed from two aspects: payment at fixed amount and payment at certain proportion of farmers' per capita net income of the preceding year. Local finance provides annual subsidy for the insured according to economic development level and specific implementation method of rural social pension insurance. From the date of establishment, the individual account will realize value preserving and appreciation according to relevant provisions.

2.1.2 Assuming insured farmers do not cancel the insurance and

not die before reaching the average life span. Some farmers interrupt or cancel the pension insurance. There is also the risk that farmers' actual life is higher or lower than the average life span. In other words, when building actuarial model for the pension insurance, it should draw lessons from actuarial calculation method of life insurance. With the aid of the life table and multiple decrement table, calculate the probability of each age of the insured remaining in the pension plan. Then, according to the APV of future contribution equal to the APV of future benefit in certain time, build the actuarial balance model [8]. However, such method is relatively complicated, and there is still not life table special for basic pension insurance. For purpose of calculation, this study assumes that actuarial calculation of individual account adopts "average person" method, namely, ignoring the probability of insurance interruption and cancellation, and the survival probability of the insured farmers from contribution to average life span equal to 1.

2.1.3 Assuming the benefit of individual account of pension insurance is a term annuity due. This study assumes that the benefit of individual account of pension insurance is a term annuity due, which will be analyzed in two types: level annuity and varying annuity. The level annuity means the annual benefit amount is fixed and the time of distribution is also fixed, generally, within several years after retirement, which is called the benefit period. In comparison, the varying annuity means the annual benefit amount is varying (which is adjusted according to the growth rate of per capita net income of farmers), but the time of distribution is fixed, generally, within several years after retirement [9]. This assumption is made mainly on the basis of the provision that "the monthly calculation and distribution amount of pension is the total amount of individual account divided by 139". Although the pension benefit is lifelong, in fact, this provision is made on the basis of certain average life expectancy. Thus, in theory, it is the judgment on the basis of periodic payment.

2.1.4 Assuming the administrative expenses and transaction cost are zero in the process of management of individual account fund. In the process of management of individual account fund, there will be administrative cost and transaction cost, such as principal – agency risk generated from subcontract of management function of the fund, trusteeship management fee, account management cost and investment management cost generated from fund entrusting management, as well as securities transaction tax generated from securities transaction. In this study, the administrative expenses and transaction cost are assumed to be zero in the process of management of individual account fund.

2.1.5 The pension replacement rate. Generally, social pension insurance functions as guaranteeing basic life level of retired employees, which is of great significance to social stability and individual life. Therefore, keeping moderate level of pension benefit is basic requirement for sustainable development of the pension system. Too high pension benefit will exert high pressure on the fund for pension insurance, and will not be favorable for working enthusiasm of employees in post, and there is moral risk of retirement in advance; too low pension benefit can not guarantee basic life of retired employees [11-12]. Therefore, it needs an index to measure the pension income relative to the in-service wage, namely, the replacement rate. The pension replacement rate is generally defined as the ratio of pension income of retired employees to the wage before retirement [13], signified by β. In general, the income of retired employees is less than their wage before retirement, thus, the replacement rate shall satisfy $0 < \beta < 1$. In this study, the replacement rate of new rural social pension is defined as the rate of the pension income obtained by the insured farmers who reach the retirement age to the per capita net income of local rural residents in the preceding year.

2.2 Building actuarial model for individual account of new rural social pension insurance by classes

2.2.1 Proposal I: payment as per income proportion and varying annuity. Firstly, calculate the accumulation value model for the individual account of pension of the insured farmers in the retirement year. For this end, suppose the insured farmer purchases pension insurance in a years old, take the per capita net income of farmers in the preceding year as payment base number. He continues paying the pension premium annually till the retirement year. Set the contribution rate of individual account of insured farmer as λ, and the retirement age is b. Suppose the insured farmer annually receives the pension since the retirement age, the rate of return on pension investment is r, the contribution base number of the base year for calculation is W_0, the growth rate of per capita net income of farmers is g. Assume $r \neq g$, the annual government subsidy is T, which is not changed in the contribution period. Then, the accumulation value model for the individual account of pension of the insured farmers in the retirement year is as follows:

$$\begin{aligned} M &= \lambda W_0[(1+r)^{b-a} + (1+g)(1+r)^{b-a-1} + L + (1+g)^{b-a-1}(1+r)] + T[(1+r) + (1+r)^2 + L + (1+r)^{b-a}] \\ &= [\sum_{t=1}^{b-a} \lambda W_0 (1+r)^{b-a-t+1}(1+g)^{t-1} + \sum_{t=1}^{b-a} T(1+r)^{b-a-t+1}] \\ &= \left\{ \frac{\lambda W_0[(1+r)^{b-a+1} - (1+g)^{b-a}(1+r)]}{r-g} + \frac{T[(1+r)^{b-a+1} - (1+r)]}{r} \right\} \end{aligned} \tag{1}$$

Secondly, calculate the benefit model for individual account of pension. Suppose the replacement rate of individual account of pension income is β and keeps not changed in the survey period, the average life is ω, and other symbols are the same as the above. Then, the APV of future benefit for the insured farmer in average life is as follows:

$$\begin{aligned} N &= \beta W_0 (1+g)^{b-a} \left(1 + \frac{1+g}{1+r} + \frac{(1+g)^2}{(1+r)^2} + L + \frac{(1+g)^{\omega-b}}{(1+r)^{\omega-b}}\right) \\ &= \beta W_0 (1+g)^{b-a} \sum_{m=0}^{\omega-b} \frac{(1+g)^m}{(1+r)^m} \\ &= \beta W_0 (1+g)^{b-a} \frac{[(1+r)^{\omega-b+1}] - (1+g)^{\omega-b+1}}{(r-g)(1+r)^{\omega-b}} \end{aligned} \tag{2}$$

2.2.2 Proposal II: payment as per income proportion and level annuity. In this proposal, the accumulation vale model for the individual account of pension of the insured farmers in retirement year is the same as Proposal I. Suppose the future annuity of the insured farmer within the average life is H, the APV of future benefit in the retirement year will be:

$$N = H\left(1 + \frac{1}{1+r} + \frac{1}{(1+r)^2} + K + \frac{1}{(1+r)^{\omega b}}\right) = H\frac{\left[(1+r)^{\omega-b+1} - 1\right]}{r(1+r)^{\omega-b}} \quad (3)$$

2.2.3 Proposal III: contribution at fixed amount and benefit at varying annuity. Firstly, calculate the accumulation value model for the individual account of pension of the insured farmers in the retirement year. Set the fixed amount of annual contribution of insured farmer is K and other symbols are the same as the above, then the accumulation vale model for his individual account of pension in retirement year will be:

$$M = (K+T)\left[(1+r) + (1+r)^2 + K + (1+r)^{b-a}\right] = (K+T)\frac{\left[(1+r)^{b-a} - 1\right](1+r)}{r} \quad (4)$$

The calculation model for APV of future benefit of pension for the insured farmer in average life is the same as Proposal I.

2.2.4 Proposal IV: contribution at fixed amount and benefit at level annuity. In this proposal, the accumulation vale model for the individual account of pension of the insured farmers in retirement year is the same as Proposal III, while the calculation model for APV of future benefit of pension for the insured farmer in average life is the same as Proposal II.

3 Analogue comparison of actuarial model for individual account of new rural social pension insurance

3.1 Parameter setting

3.1.1 Individual contribution standard and government subsidy. According to *Guiding Opinions on New Rural Social Pension Insurance*, the contribution standard includes 5 levels: 100 yuan, 200 yuan, 300 yuan, 400 yuan, and 500 yuan. The insured can voluntarily select contribution level. The State will make timely and appropriate adjustment of the contribution levels on the basis of growth of per capita net income of rural residents. Set the initial payment year is 2008 (since this study is to optimize models, although the pilot work of new rural social pension insurance started from 2009, this will not impair the credibility of conclusions), and the contribution standard of initial payment year of all farmers is 100 yuan. When contribution at fixed proportion of farmers' income, from per capita net income of farmers in 2007 $W_0 = 4\ 140$ yuan, and $\lambda W_0 = 100$ yuan, the percentage of annual contribution into per capita net income of farmers in preceding year is 2.42%; if contribution at fixed amount, the annual contribution amount will be 100 yuan. For the government subsidy, it adopts the minimum amount 30 yuan specified in *Guiding Opinions on New Rural Social Pension Insurance* and keeps not changed.

3.1.2 Growth rate of per capita net income of farmers. The "demographic dividend" has long been thought an important source of China's remarkable economic performance. According to World Bank estimates, China's advantageous population age structure brought about by such a dividend has contributed more than 30% to the country's economic growth over the past decades. Both domestic and foreign economists agree that China's demographic dividend will continue to last about 15 years. This means that China's economy will still be benefited from such dividend and have rapid growth, and per capita net income will also keep certain growth rate. As to stage of economic development, China is approaching to medium economic development level. According to the *Plan for National Economic and Social Development of the People's Republic of China*, by the middle of the 21st century, China's economic development level will reach the level of medium developed countries (MDC) [14]. Therefore, with reference to relevant data in China's Statistical Yearbook, this study assumes the annual average growth rate of per capita net income of farmers is 5%.

3.1.3 Age of joining the pension insurance, age of receiving the pension, and average life expectancy of farmers. In this study, the age of joining the pension insurance is set at 25 years old, age of receiving the pension is set 60 years old, and average life expectancy of farmers is 75 years old.

3.1.4 Fund yield rate. At present, China has strict limitation on investment and operation of the fund for basic pension insurance. Therefore, the fund for individual account of new rural social pension insurance is mainly based on reference for treasury bond for the corresponding period and agreement deposit interest rate [15]. Besides, it also refers to relevant researches in the *Calculation and Management of China's Pension Insurance Fund Program supported* by the Legislative Affairs Department of Ministry of Labor Security in 2001. This study sets the fund yield rate at 4%.

3.2 Calculation results For Proposal I: from M = N, we can get formula (1) = formula (2), substitute data in parameter assumption into this formula, we can obtain $\beta \approx 5.3\%$.

For Proposal II: from M = N, we can get formula (1) = formula (3), substitute data in parameter assumption into this formula, we can calculate H. Then from $\beta = \frac{H}{W_0(1+g)^{b-a}}$, we can get $\beta \approx 6.76\%$.

For Proposal III: from M = N, we can get formula (4) = formula (2), substitute data in parameter assumption into this formula, we can obtain $\beta \approx 2.53\%$.

For Proposal IV: from M = N, we can get formula (4) = formula (3), substitute data in parameter assumption into this formula, we can calculate H. Then from $\beta = \frac{H}{W_0(1+g)^{b-a}}$, we can get $\beta \approx 3.6\%$.

From the above calculation results, it can list the influence of different contribution methods (contribution according to proportion of income and contribution at fixed amount) and different benefit methods on the income replacement rate of individual account of pension, as shown in Table 1.

Table 1 The income replacement rate of individual account of pension of the insured farmers in different contribution and benefit methods %

	Contribution according to income proportion (2.24%)	Contribution at fixed amount (100 yuan)
Periodic prestation at varying amount	5.3	2.53
Periodic prestation at fixed amount	6.67	3.6

From the comparison of contribution methods, no matter what kind of pension benefit, the replacement rate of contribution according to income proportion is higher than that of the contribution at fixed amount. This is because contribution according to income proportion can make the insured farmers increase the contribution amount in accordance with their income growth, to keep the contribution standard consistent with the growth of per capita net income of farmers, accumulate more fund for individual account, and finally to increase actual pension benefit level of the insured farmers. From the perspective of management, the contribution at fixed amount is convenient for calculation. Nevertheless, the actual pension benefit is not better than the contribution at income proportion. Considering this, it should make timely and proper adjustment of contribution standard in accordance with growth of per capita net income of farmers on the precondition of keeping relatively stable contribution rate. From the comparison of benefit methods, in both contribution methods, the income replacement rate of periodic prestation at varying amount for individual account of pension is lower than that of periodic prestation at fixed amount. This is because the periodic prestation at varying amount progresses by certain index in the benefit period. In the model of this study, it is adjusted as per growth rate of per capita net income of rural residents, while the periodic prestation at varying amount keeps constant in the entire benefit period.

4 Conclusions

According to the above analyses, the contribution as per income proportion can better keep the coordination of financing of individual account of pension insurance and socio-economic development, and is more favorable for increase in actual benefit of the pension after retirement of farmers. At the same contribution proportion, the pension of periodic prestation at fixed amount is higher than periodic prestation at varying amount. However, with constant economic development, in the periodic prestation at fixed amount, due to growth of per capita net income of rural residents, inflation and other factors, the income replacement rate of future pension of the insured farmers will constantly decrease, consequently failing to meet actual demand of the insured farmers for old-age security. In addition, considering extending trend of actual average life expectancy, if continue to distribute pension on the basis of the provision that "the monthly calculation and distribution amount of pension is the total amount of individual account divided by 139", it is difficult to solve the longevity risk of calculation and distribution of individual account of pension. Therefore, it should establish corresponding index standard for adjustment of pension calculation and distribution. Meanwhile, supported with adjustment of relevant parameters of actuarial model, it can mitigate risk of drop of future pension benefit for the insured farmers. For this end, it will be more scientific and reasonable for the individual account of new rural social pension insurance to adopt the actuarial model of payment according to proportion of income and periodic prestation at variable amount. Therefore, it should start from continuation of policies and make adjustment of payment level in accordance with growth of per capita net income of rural residents. When condition permits, it is expected to realize transition to payment as per income proportion and periodic prestation at variable amount.

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