

Research on Estimation of Replacement Rate of Occupational Annuity

Yang Yu^{1,a}, Lin Sun^{1,b}, and Yuan Zhang^{1,c,*}

¹ Capital Normal University, No. 56 West Third Ring Road, Haidian District, Beijing, 100048 China.

^ayuyang@cnu.edu.cn, ^bhisunline@163.com, ^cyuaner.cn@gmail.com

*Corresponding author

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Abstract. Occupational annuity is a kind of supplementary measure of old-age security for staff of government organizations which is also an important means of promoting the reform of the pension system for public institutions. This paper quantifies the occupational pension replacement rate and puts forward some policy optimization suggestions. Firstly, it builds an annuity replacement rate calculation model. Secondly, it analyzes the variables that affect the annuity replacement rate. Through design the calculation formula of occupational annuity replacement rate, it analyzes how return rate of annuity investment and staff retirement age influence the annuity replacement rate. It finds out that delaying retirement and increasing the return on investment of annuity can impressively increase the annuity replacement rate.

1. Introduction

According to the study of the World Bank, pension replacement rate of employees has to reach 70%-85% to protect the living standard before retirements. If the replacement rate is about 60%, it can only maintain basic life of employees after retirement. The *Convention on Social Security Minimum Standard of Living* regulates that employees may struggle with life after retirement if the pension replacement rate is lower than 55% and government shall pay high attentions to it. According to the top-level design of Ministry of Human Resources and Social Security of the People's Republic of China to the elderly-care policy, the basic pension replacement rate of Chinese residents with social insurance finally is going to reach 60% and the supplementary annuity replacement rate will reach 20%, thus reaching a total target replacement rate of 80%. This is enough to guarantee the prosperous life of employees after retirement.

In the present study, replacement rate of occupational annuity was estimated by the modeling method of actuarial studies. Firstly, the formula of total contribution of occupational annuity was set up. Secondly, the formula of total pensions to retirees was built up. Since the accumulation amount and total pensions in accounts of workers are equal, the simplified formula to calculate replacement rate of occupational annuity could be gained.

2. Estimation Model of Replacement Rate of Occupational Annuity

2.1. Hypothesis for Estimation of Occupational Annuity

(1) Measures on Occupational Annuity in Government Departments and Public Institutions regulate that occupational annuity is collected from both employees and employers. The contribution proportion of employers is 8% of wage of the employee and the contribution proportion of employees is 4%. The later part is accumulated in real personal account, while the former part is in an empty account for temporary. For better management of occupational annuity, both contributions of employers and employees are accumulated to real personal account in Beijing.

(2) Suppose employees choose to get benefits of occupational annuity monthly.

(3) Since occupational annuity applies the account accumulation system, the amount in the account is distributed completely. Suppose the number of occupational annuity distribution years regulated by policies is the average life span of employees minus the average retirement age of employees. The annual pension of an employee after retirement could be calculated according to this time span.

- (4) The amount of occupational annuity that retired employees get is adjusted annually according to rate of inflation and changes of rate of interest.
 (5) Annual wage of employees increases stably at a fixed rate.
 (6) Occupational annuity involves no taxes and management cost.

2.2. Relevant Variables

S: total contribution of occupational annuity
 F: total distributions of occupational annuity
 x: working years of employees
 y: retirement age of employees
 w: initial annual wage of employees
 c: contribution rate of occupational annuity
 r: rate of return on fund investment
 g: growth rate of annual average wage
 j: annual distribution of occupational annuity of employees at the retirement age of y
 i: annual interest rate
 f: rate of inflation
 n: number of years of occupational annuity distribution to employees

2.3. Deduction of Estimation Formula of Replacement Rate

(1) At retirement of employees, S can be expressed as:

$$S = cw(1+r)^{y-x} + cw(1+g)(1+r)^{y-x-1} + \dots + cw(1+g)^{y-x-1}(1+r) \\ = \sum_{t=1}^{y-x} cw(1+g)^{t-1}(1+r)^{y-x-t+1} \quad (1)$$

(2) After retirement, F can be expressed as:

$$F = j + j(1+f)\frac{1}{1+i} + \dots + j\left(\frac{1+f}{1+i}\right)^{n-1} \\ = j\sum_{k=0}^{n-1} \left(\frac{1+f}{1+i}\right)^k \quad (2)$$

(3) Replacement rate of occupational annuity

Since occupational annuity adopts the accumulation system, total contribution and total distribution in an account of employee are equal, that is, S=F:

$$cw\sum_{t=1}^{y-x} (1+g)^{t-1}(1+r)^{y-x-t+1} = j\sum_{k=0}^{n-1} \left(\frac{1+f}{1+i}\right)^k \quad (3)$$

$$\text{And } j = T \bullet w(1+g)^{y-x-1} \quad (4)$$

The Eq.(4) is brought into the Eq.(3), so T can be deduced:

$$T = \frac{c\sum_{t=1}^{y-x} (1+g)^{t-1}(1+r)^{y-x-t+1}}{(1+g)^{y-x-1}\sum_{k=0}^{n-1} \left(\frac{1+f}{1+i}\right)^k} \quad (5)$$

It can be seen from the Eq.(5) that the replacement rate of occupational annuity (T) is related with rate of return on fund investment (r), working years of employees (x), retirement age of employees (y),

number of years of occupational annuity distribution to employees (n), annual interest rate (i), contribution rate of occupational annuity (c), growth rate of annual average wage (g) and rate of inflation (f).

3. Parameter Setting for Estimation of Replacement Rate of Occupational Annuity

Due to great regional differences in personnel structure, average retirement age, average life span, actual contribution of personal account in government departments and public institutions in China, the quantitative estimation in the present study is based on relevant data in Beijing with considerations to data accessibility.

3.1. Working Years and Retirement Age of Employees

Government departments and public institutions in Beijing mainly concentrate in Education, Science, Culture, Health and Sports industries. Compared with employees of enterprises, employees in government departments and public institutions have higher education background and take jobs at an older age. For these reasons, the average age for employees in government departments and public institutions participating in job is set $x=25$.

According to China's retirement policy, male employees of government departments and public institutions retire at 60 years old, while female employees retire at 50 years old, female cadres retire at 55 years old, and female director of departments or female employees with senior title retire at 60 years old. Male employees engaged in heavy physical labor or jobs bad for physical health retire at 55 years old, and female employees retire at 45 years old. Special regulations are provided to disabled employees for diseases or non-job reasons. Zhang Yizhen, the undersecretary of Ministry of Human Resources and Social Security of the People's Republic of China, once revealed that the average retirement age in China was about 54 years old. With the continuous reform in personnel system in government departments and public institutions in Beijing, auxiliary logistics in government departments and public institutions are mainly replaced by government purchased social services or socialized employment system, thus reducing logistics posts. Generally speaking, the average retirement age of civil servant and employees in public institutions is relatively higher than that of enterprise employees. For the convenience of calculation, the average retirement age is set $y=57$ for temporary.

3.2. Contribution Rate

According to regulations in *Measures on Occupational Annuity in Government Departments and Public Institutions*, employees in government departments and public institutions have to pay occupational annuity in addition to basic pension. Specifically, employers contribute 8% of employee's wage and employees contribute 4%. Contribution rates of employers and employees are consistent with those of basic pension. Moreover, China will adjust contribution rates of employers and employees annually according to actual needs. In this study, replacement rate of occupational annuity when the total contribution rate ranges between 8% and 16% was calculated.

3.3. Growth Rate of Annual Average Wage

Occupational annuity is calculated based on wage of employees. Hence, fluctuation of wage can influence contribution and accumulation of occupational annuity directly. The estimated total contribution of occupational annuity must consider wage growth. According to national statistical data, the actual average wage growth in government departments and public institutions in China was 8.22% from 2009 to 2016. Considering the slowing down economic development in China recently, the growth rate of GDP decelerated, but the growth of per capital income accelerated. Hence, the variable g was set 8%.

3.4. Annual Rate of Inflation

Rate of inflation refers to the ratio of super currency and actual needed currency of the whole society. It is mainly used to reflect degree of currency devaluation. Economically, rate of inflation can be

understood as the average rise in commodity price in the whole society. It can be seen from inquiry on National CPI Index that China's CPI index curve tended to be stable in recent years and rate of inflation changed slightly. With references to average rate of inflation in recent years, the rate of inflation was set 3% in this study.

3.5. Rate of Return on Fund Investment

Occupational annuity is an important institutional design to promote combination of pension insurance and it is related with welfare of all civil servants after retirement. Hence, occupational annuity must realize preserve or increase of values, same with social insurance funds. According to policy regulations, occupational annuity is managed by individual account. Personal contribution is accumulated in a real account, whereas contribution of employers is recorded an empty account, plus annual interests according to the account interest rate issued regularly by the country. The real account forms the annuity fund which is managed by market-oriented investment of investment organizations to gain relevant benefits according to regulations of *Measures on Occupational Annuity in Government Departments and Public Institutions*. Interest rate of account determines the value-added ratio of annuity fund to a large extent.

To manage occupational annuity better and protect benefits of employees, contributions of both employers and employees are accumulated in personal account in Beijing. In this way, rate of return on investment is equal to value-added ratio. Since the occupational annuity system is just set up in China and there's no information of investment with occupational annuity disclosed, the average rate of return on occupational annuity investment was estimated based on social insurance fund and annuity management of enterprises in this study.

China founded the social insurance fund in 2000. According to the annual work report of social insurance fund in 2016 which was issued by China Securities Journal recently, the annual average rate of return on social insurance fund investment since 2016 reached 8.37%. According to management report of enterprise annuity in 2016 which was published by Ministry of Human Resources and Social Security of the People's Republic of China, the average rate of return on enterprise annuity investment from 2007 to 2016 was 7.57%.

Due to violent fluctuation of stock market in China and decelerated economic growth in recent years, the lower limit of annual rate of return on annuity fund investment was set 6 for temporary. With economic and social development as well as gradual improvement of fund operation and investment, investment policy is perfecting increasingly and investment strategy is optimizing continuously, accompanied with gradual diversification of investment channel. The rate of return on annuity fund investment is expected to grow at a stable rate. Hence, the upper limit was set 10% in this study.

3.6. Annual Interest Rate

Interest rate plays an extremely important role in modern economy. Generally, it can be understood as the price of capital. In China, benchmark interest rate is issued by People's Bank of China. Combining with the historical deposit interest rate in China, interest rate was set 3% for temporary.

3.7. Number of Years of Occupational Annuity Distribution to Employees

According to previous deduction, the average retirement age of employees in government departments and public institutions in Beijing is about 57. In 2016, the National Health and Family Planning Commission of China reported that the average life span of urban residents in Beijing was 82. Therefore, n was set 25 years according to the hypothesis that number of years of occupational annuity distribution to employees = average life span of employees – average retirement age of employees.

4. Estimation Results of Replacement Rate of Occupational Annuity and Analysis

4.1. Effects of Contribution Rate and Rate of Return on Replacement Rate

The above parameters were brought into the formula according to set values to calculate replacement rates of occupational annuity when the contribute rate ranged within 8%-16% and the rate of return ranged within 6%-10% (Table 1).

It can be seen from Table 1 that the replacement rate of occupational annuity is 7.6349% when the contribution rate is 8% and the rate of return is 6%. Under this circumstance, the replacement rate is far from the target replacement rate of occupational annuity. The replacement rate reaches 15.36% when the contribution rate is 12% and the rate of return is 8%. In this case, values of r and c are the closest to values regulated in present policy. However, the replacement rate of 15.36% differs significantly from the target displacement rate. When the contribution rate is 14% and the rate of return is 9%, the replacement rate of occupational annuity further increases to 20.9389%, which meets the preset goal of existing policies. The replacement rate further increases to 28.1211% when the contribution rate is 16% and the rate of return is 10%.

Table 1. Replacement rate of occupational annuity (unit:%)

rates of return \ contribution rates	6	7	8	9	10
8	7.6349	8.8154	10.2400	11.9651	14.0605
10	9.5436	11.0192	12.8000	14.9564	17.5757
12	11.4524	13.2231	15.3600	17.9477	21.0908
14	13.3611	15.4269	17.9200	20.9389	24.6060
16	15.2698	17.6308	20.4800	23.9302	28.1211

In addition, it can be estimated based on above data that given a fixed rate of return at 8%, the replacement rate is increased by about 1.25% when the contribution rate is increased by 2%. When the contribution rate is fixed at 12%, the replacement rate can be increased by about 2% when the rate of return is increased by 1%. Therefore, it concludes that increasing rate of return on occupational annuity investment can increase replacement rate more significantly. Therefore, the management level and profitability of occupational annuity have important significance to actual effect of annuity.

4.2. Effects of Delayed Retirement Age on Replacement Rate

Replacement rate of occupational annuity under different retirement ages when the contribution rate is 12% and the rate of return is 8% is calculated. It can be concluded from Table 2 that increasing the retirement age can increase replacement rate of occupational annuity significantly. Moreover, the replacement rate is increased more with the increase of retirement age. Currently, delaying the retirement is an irresistible trend in China due to the intensifying aging problem. According to Table 2, the replacement rate of occupational annuity is increased by 1.6% in average by delaying retirement for 1 year according to contribution rate and rate of return regulated in existing policy. The replacement rate can reach 20.57% when the average retirement age is delayed to 61 years old.

Table 2. Replacement rate of occupational annuity under different retirement ages (unit:%)

Average retirement age	Replacement rate (T)	Growth of T
57	15.3600	*
59	17.7391	2.3791
61	20.5714	2.8323
63	24.0000	3.4286
65	28.2353	4.2353

5. Summary

An estimation formula of replacement rate of occupational annuity is established in this study. Based on a quantitative estimation of actual value in Beijing, some conclusions could be drawn:

(1) The replacement rate of occupational annuity which is estimated according to different indexes in Beijing is too low and it is lower than 20% of the ideal value. This replacement rate cannot offset reduction of pension to employees of government departments and public institutions. The relevant policy has to be further perfected.

(2) Replacement rate of occupational annuity is positively correlated with rate of return on annuity investment, number of contribution years and contribution rate. The replacement rate of occupational annuity can be increased by increasing rate of return on annuity investment, number of contribution years and contribution rate.

(3) The calculation formula is simplified by estimation of replacement rate of occupational annuity. Based on sensitivity analysis of main variables that influence replacement rate of annuity, the replacement rate can be increased by 0.63% for every 1% increase of contribution rate and it can be increased by 2% for every 1% increase of rate of return under current situations. Moreover, the replacement rate can be increased by 1.6% when the retirement age is delayed by 1 year. Delaying retirement age produces quick effect, but it has great controversy. Although it can increase rate of return more significantly, it proposes high requirements on management institutions of annuity.

6. References

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