

The Portfolio and Risk analysis of Pension fund in China based on the market-oriented operation

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Abstract. The pension fund investment operations in China are in a critical period of marketization and diversified investment. This article uses the bank deposit, treasury bond, stock as the investment tools and combines the theory of portfolio to build the portfolio model of pension fund. Under the income situation of maintaining value, slightly value-added, appreciation, we analyze the investment risk and put forward the countermeasures to reduce risk, and gives suggestions for perfecting the investment model of pension fund.

1. Introduction

The pension fund is a major social security, which involves people's livelihood. Based on the past policies, investment ways are limited to bank deposit and national debt. The yield is lower than the national consumer price (CPI), which is in a state of devaluation. Founded by Markowitz in the 1950s, the modern portfolio theory makes contributions to the quantitative risk analysis. William Sharp and Stephen Ross achieved further development [1]. David Neumark considered the advantages of age discrimination on social security reform, while Alisdair McKay[3]thought social security privatization is more beneficial to the improvement of the efficiency. In our country, Xiang Huaicheng [4] put forward that pension payment faces trouble and the investment efficiency was low. Since then, many scholars started their research on this issue. Li Yong [5] thought that investing to the stock market was a feasible way to improve the operational efficiency of investment; Tang Dapeng [6] got further study and proposed that the portfolio could effectively reduce the investment risk; Gu Mingshu [7] had done lots of work on broadening the investment channels and evaluating all kinds of investment risks on the basis of the optimal investment strategy. Nowadays, the national policies are relaxing pension investment channels, which makes it necessary to do the research on investment of pension funds based on the market-oriented operation both on theoretical and realistic aspects, and makes it meaningful to realize social steady and harmonious development[8].

2. The portfolio of pension fund

2.1 The choice of investment tool

In order to simplify the process, the article selects the bank deposit, treasury bond, stock as investment tools [9]. We usually choose bank deposit of 1 year as the main investment vehicle. As shown in table 1. On the selection of yields in the stock market, we use accumulative turnover of Shanghai stock market and Shenzhen stock market as weight to determine comprehensive index based on the data of Shanghai composite index and Shenzhen component index. In addition, the article selects the growth rates per month of Shanghai bond index as treasury month yield.

Table 1 Cumulative turnover of two major stock exchange markets

Market	From	To	Cumulative turnover (trillion)	weight
Shanghai stock exchange	1991-4	2014-12-31	243.17	0.57
Shenzhen stock exchange	1991-4	2014-12-31	182.90	0.43

Data sources: The Shanghai stock exchange, Shenzhen stock exchange's official website

2.2 The correlation analysis of return and risk of investment tools

Table 2 Different assets status of return and risk (monthly interest rate)

Items	N	Minimum	Maximum	Average	Standard deviation	Variance
Comprehensive	60	-0.089081204	0.208646594	0.00661162268	0.066700327704	0.004
The debt index	60	-0.002778304	0.008178760	0.00266068342	0.001765027604	0.000
Bank deposit	60	0.000167000	0.000417000	0.00031941667	0.000059291378	0.000

Data sources: Calculation form months yields (2010-2014)

Contrast returns-risk of different assets (table 2), yields of stock market are greater than treasury bonds and bank deposit interest rate, which are 0.66%, 0.27% and 0.03% respectively. But the yield range of stock market is bigger than the yield of treasury bond and bank deposit. It contradicts and the basic investment principle of pension fund, the security.

Table 3 Relevant information different assets

		Comprehensive	The debt index	Bank deposit
Comprehensive	Pearson correlation	1	-0.054	-0.067
	Significant (both sides)	-	0.680	0.610
	N	60	60	60
The debt index	Pearson correlation	-0.054	1	0.105
	Significant (both sides)	0.680	-	0.423
	N	60	60	60
Bank deposit	Pearson correlation	-0.067	0.105	1
	Significant (both sides)	0.610	0.423	-
	N	60	60	60

The article analyzes comprehensive monthly returns, the two major markets index monthly returns on debt and bank deposits on yield of our country by using SPSS19.0. The correlation coefficient between the deposit interest rate and bond yield $r = 0.105$; The correlation coefficient between bank deposit and stock yield $r = 0.067$; The correlation coefficient between the treasury bond and stock yield is $r = 0.054$. Bank deposit has the lowest correlation with stock, while it has the highest correlation with the treasury bond[10].

2.3 The determination of target yield

Considering the investment objectives of pension fund, the target yield is divided into three conditions: (1) Maintaining value. Safety is the primary purpose of pension fund investment, therefore, its investment return shall not be less than the consumer price level (CPI) in the process of actual investment. (2) Slightly value-added. To ensure the basic purchasing power of the pension fund, the investment rate shall not be less than urban residents disposable income growth across the country. (3) Appreciation. The ultimate goal of pension fund investment is to realize the value of the fund. Therefore, the pension fund should enjoy the dividends of high-speed economic development, while its investment yield should synchronize with economic development. In this article, we use gross domestic product (GDP) to determine the highest investment objectives.

3. The portfolio construction of pension fund

(1) The construction of portfolio returns-risk model

This article assumes that the overall yield of pension fund portfolio is P . K_1, K_2, K_3 represent stock, treasury bond and bank deposit respectively. And the proportion of investment is w_1, w_2, w_3 . $w_1 + w_2 + w_3 = 1$. Assuming that r_i was the expected yield of K_i , $i = 1, 2, 3$. So the expected yield of the portfolio P is:

$$E(r_p) = \sum_{i=1}^n w_i E(r_i) = w_1 E(r_1) + w_2 E(r_2) + (1 - w_1 - w_2) E(r_3) \quad (1)$$

We can reach the point that the variance of the portfolio P is:

$$\sigma_p^2 = \sum_{i=1}^n \sum_{j=1}^n w_i w_j \sigma_i \sigma_j \rho_{ij} = w_1^2 \sigma_1^2 + w_2^2 \sigma_2^2 + w_3^2 \sigma_3^2 + \rho_{12} w_1 w_2 \sigma_1^2 \sigma_2^2 + \rho_{13} w_1 w_3 \sigma_1^2 \sigma_3^2 + \rho_{23} w_2 w_3 \sigma_2^2 \sigma_3^2 \quad (2)$$

(2) Use CPI monthly growth rate as expected yield

This article selects 2008-2014 CPI monthly growth. After calculation, the CPI average annual growth rate is 2.57%, and the average monthly growth rate is 0.214286%. Due to $E(r_1) = 0.006611623$, $E(r_2) = 0.002660683$, $E(r_3) = 0.000319417$, $\sigma_1^2 = 0.004448934$, $\sigma_2^2 = 0.000003115$, $\sigma_3^2 = 0.000000004$, $\rho_{12} = -0.054$, $\rho_{13} = -0.067$, $\rho_{23} = 0.105$. We can draw: $0.00214286 = w_1 \times 0.006611623 + w_2 \times 0.002660683 + (1 - w_1 - w_2) \times 0.000319417$

Based on the Lagrange multiplier method:

$$L(w_1, w_2, \lambda) = w_1^2 \times 0.004448934 + w_2^2 \times 0.000003115 + (1 - w_1 - w_2)^2 \times 0.000000004 - 0.054 \times w_1 w_2 \times 0.000000014 - 0.067 \times w_1 \times (1 - w_1 - w_2) \times 0.000000000156 + 0.105 \times w_2 \times (1 - w_1 - w_2) \times 0.00000000000011 + \lambda \times (w_1 \times 0.006611623 + w_2 \times 0.002660683 + (1 - w_1 - w_2) \times 0.000319417 - 0.00214286)$$

Then we take the derivative, when the formula equals 0:

$$w_1 = 0.0293, w_2 = 0.0927, w_3 = 1 - 0.0293 - 0.0927 = 0.878 \text{ and } \sigma^2 = 0.000000564.$$

(3) Use national urban residents disposable income growth as the target yield

This article selects the annual urban residents disposable income growth from 2008 to 2014. By calculating, the annual growth rate is 8.26%, average monthly growth rate is 0.688095%. Due to $E(CPI) = 0.00688095$. We can infer: $w_1 = 0.2013$, $w_2 = 0.4214$, $w_3 = 1 - 0.2013 - 0.4214 = 0.3773$. So, if makes the guarantee fund of primary endowment insurance is slightly surplus, the proportions of investing are 20.13%, 42.14%, 37.73%, respectively. And $\sigma^2 = 0.0000664$.

(4) Use GDP growth rate as expected yield

The average annual GDP growth rate is 8.59%, the average monthly growth rate is 0.72%. Due to $E(CPI) = 0.0072$, we can calculate the proportion of investing is 24.3%, 47.8%, 27.9%, respectively. And $\sigma^2 = 0.0001262$.

4. Risk analysis of pension fund portfolio

The diversified operation of China's pension fund investment operation faces various risks, such as policy risk, purchasing power risk, credit risk and interest rate risk and so on. We should be prudent in risk analysis within the safe scope of the pension fund investment.

4.1 Establish the range of the risk

Table 4 Pension fund investment risk analysis

Signal	Condition	Range
Green	Safe	$\sigma^2 \leq 0.000000004$
Light blue	Basic security	$0.000000004 \leq \sigma^2 \leq 0.000000564$
Yellow	Low risk	$0.000000564 \leq \sigma^2 \leq 0.0000664$
Double yellow	Moderate risk	$0.0000664 \leq \sigma^2 \leq 0.0001262$
Red	High risk	$0.0001262 \leq \sigma^2 \leq 0.004448934$
Double red	Crisis risk	$0.004448934 \leq \sigma^2$

4.2 The handling of the investment risk of pension fund

Table 5 Different allocation of stock, treasury debt, bank deposit

Stock w_1	Treasury debt w_2	Bank deposit w_3	Average monthly yield	Variance	Standard deviation
0%	10%	90%	0.000553543	0.000000315	0.000229865
5%	10%	85%	0.000868154	0.000222761	0.003561917
10%	10%	80%	0.001182764	0.000445208	0.006893969
15%	10%	75%	0.001497374	0.000667654	0.010226020
15%	15%	70%	0.001614438	0.000667810	0.010311307
15%	20%	65%	0.001731501	0.000667965	0.010396594
20%	20%	60%	0.002046111	0.000890412	0.013728646
20%	25%	55%	0.002163175	0.000890568	0.013813933
25%	25%	50%	0.002477785	0.001113014	0.017145984
25%	30%	45%	0.002594848	0.001113170	0.017231271
25%	35%	40%	0.002711912	0.001113325	0.017316558
25%	40%	35%	0.002828975	0.001113481	0.017401845

Data sources: Oriental wealth network, the website of People's Bank of China

Once the target yields are determined, then the proportions of the portfolio calculated according to the Markowitz portfolio theory can keep the risk smallest. From table 5, while investing in stock share, the greater the average monthly income, the greater variance it has, namely, the greater risk it has been through. Therefore, adjusting the investment share can change benefits, and it can also adjust the risk. When the risk is under control, we can adjust investment share to keep the expected yield.

5. Summary

In view of the present crisis, we discuss pension fund operation mechanism and evaluate and explore the pension fund investment operation. For the contemporary study of pension fund. We use the theory of portfolio, take CPI, the urban residents disposable income growth rate, GDP as the target rate and calculate the matching portfolio proportion. Also, we explored three investment strategies, calculate their matching portfolio and analyze the risk conditions. Pension fund need to be reformed, which needs the encourage of national policy, the perfection of market mechanism, relaxation of investment mode, etc. Only by the scientific and effective investment, can we truly realize the value of pension fund, and promote social harmony and orderly development.

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