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Research on Asset Allocation of Insurance Companies Based on Mean-Variance Model

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Abstract. As a debt-based financial institution, the core work of insurance company management is asset allocation, and portfolio planning is one of the key links in the company's asset allocation. Starting from the Markowitz's Mean-Variance Model, combined with the regulatory requirements of China's insurance industry and the actual situation of the capital market, this paper improves the model by adding constraints, and establishes a nonlinear programming model suitable for asset allocation of insurance companies in China. The model strives to use the scientific quantitative model to select the optimal allocation plan that accords with the company's risk preference, and improve the efficiency of insurance funds. Furthermore, this paper takes the PING AN INSURANCE COMPANY as the background, solves the model through LINGO software, and conducts empirical analysis on the output. Finally, based on the empirical analysis, the feasibility and practical significance of the model are verified, and policy recommendations are proposed accordingly.

1. Introduction

The insurance industry has the functions of economic compensation, fund raising and social management. It is the basic means of risk management under the conditions of market economy and an important part of the financial and social security system. In recent years, along with the good momentum of China's insurance industry's sustained and healthy development, premium income has maintained rapid growth and the insurance system has become increasingly mature. However, compared with most developed countries, the scope of insurance coverage in China still needs to be further expanded, and the role of insurance companies in improving the social security system and promoting the development of the capital market remains to be tapped. With the increase in the scale of insurance, the market has put forward higher requirements for the allocation of insurance funds.

As the main body of the insurance industry, insurance companies collect premiums and invest the premiums in bonds, stocks, loans and other assets, thereby using the proceeds from these assets to pay for insurance claims as determined by the policy. Through the above-mentioned business, the insurance company obtains high returns in investment and provides appropriate insurance services to customers at a lower premium to realize its own profit. Therefore, asset allocation planning plays a vital role in the normal operation and healthy development of insurance companies.

Therefore, from the perspective of macroeconomic regulation and control, the efficient allocation of insurance funds is not only the key to perfecting the social security system, but also the favorable guarantee for regulating the capital market. Specific to micro-individuals, scientific and effective asset allocation programs have gradually become the core competitiveness of current insurance companies.

2. Literature review

Domestic and foreign scholars have in-depth research on portfolio theory and insurance fund management.

Portfolio theory: Modern portfolio theory is mainly composed of Portfolio Theory, Capital Asset Pricing Model, Arbitrage Pricing Theory, Efficient Markets Hypothesis. Their development has greatly changed the traditional investment management practices that relied mainly on basic analysis in the past, making modern investment management increasingly oriented towards systematization, scientization, and combination. In March 1952, the American economist Markowitz (1952) published the paper "Portfolio Selection", marking the beginning of modern portfolio theory. Through the analysis of the mean-variance model, he concludes that the portfolio can effectively reduce the risk, but because this method requires the calculation of the covariance matrix of all assets, it seriously restricts its application in practice. In 1963, William Sharp proposed Sharpe's One-way Analysis of Variance that can be used to simplify the estimation of covariance matrices, which greatly promoted the practical application of Portfolio Theory. In the 1960s, Sharp, Lint, and Mawson proposed the Capital Asset Pricing Model (CAPM) in 1964, 1965, and 1966, respectively. The model not only provides an operational framework for evaluating the characteristics of income-risk conversion, but also provides an important theoretical basis for portfolio analysis and fund performance evaluation. In 1976, in response to the shortcomings of CAPM, Rose proposed an alternative Capital Asset Pricing Model, namely Arbitrage Pricing Theory. This model directly promotes the wide application of multi-index portfolio analysis methods in investment practice.

Insurance fund management: The risk management theory of insurance companies needs to comprehensively identify and analyze the internal operation and the external capital market. When the company's operations and external environment are badly changed, the company's decision makers should assess the risks in a timely manner and make corresponding risk management decisions. Therefore, the risk management of insurance companies needs to be traced back from the academic development of risk management. The concept of risk management was first proposed by Dr. Solomon Shawner (1930) of the University of Pennsylvania in an insurance seminar in 1930. Gallagher (1956) introduced the theory of risk management from the academic perspective into the real management of the enterprise in his paper "Risk Management: A New Phase of Cost Control." Klock (1988), Lamm (1989), and Siegel (1992) proposed to control the systemic risk of insurance companies through asset-liability matching management. Bludgeon and Owen believe that insurance regulation is a measure to weaken market risks and a way to reflect positive externalities. Therefore, how to reduce risks is an important duty of insurance supervision. Phillippe Jorion (1998) extends VAR to credit risk: Promoting transparency of financial risk through the use of VAR in the marketplace.

3. Research summary

3.1 Research content

Unlike ordinary business enterprises, insurance companies are typical debt-based financial institutions. For premium income from the sale of different types of insurance products, the insurance company allocates funds to ensure that the investment income can generate sufficient yield and cash flow.

Therefore, this paper will start from the traditional Markowitz's Mean-Variance Model, based on the management requirements of insurance companies, further improve and optimize it, and strive to make the model more close to the requirements of current insurance fund management.

3.2 Research Methods

3.2.1 Technical Roadmap

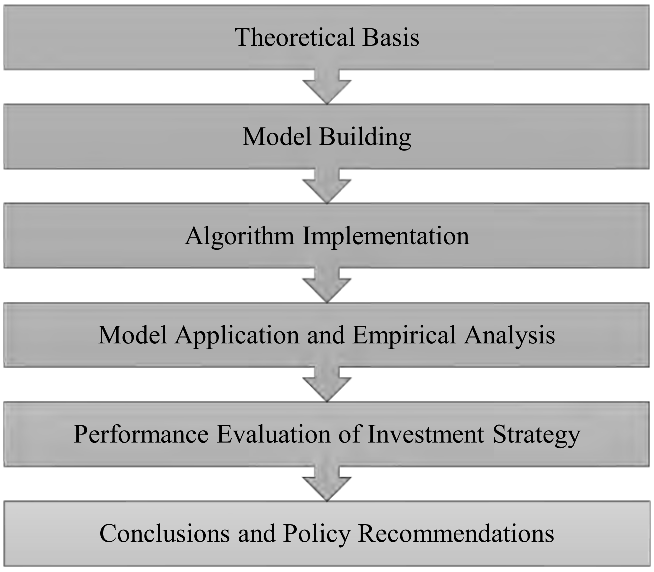

Fig. 1. Technical Roadmap

3.2.2 Innovation Points

Based on Markowitz's portfolio theory, this paper makes innovative optimizations for the actual situation of insurance companies, as follows:

1. According to Markowitz's portfolio theory, the edge of the portfolio umbrella is a collection of portfolios that meet the minimum variance, called the effective boundary. Due to the infinity of the set, the best combination of assets can be determined only by the cut-off point between the investor's indifference curve and the effective boundary. However, due to the incomprehensibility of risk appetite, traditional theory lacks practical operability. Based on the traditional model, this paper introduces a pair of convex combination coefficients $(\alpha, 1-\alpha)$. When $\alpha \in (0,1)$, $\frac{\alpha}{1-\alpha}$ will traverse all positive real numbers.

2. The Mean-Variance Combination Model proposed by Markowitz was established on the premise of many hypotheses. The actual situation and objective requirements of China's capital market were not considered, which greatly reduced the practicability of the model.

3. In order to verify the feasibility of the model and the effectiveness of the results, this paper introduces an empirical research method, which simulates the optimal portfolio plan for the company based on the investment of PING AN INSURANCE COMPANY in 2017. Furthermore, the results are compared with the actual investment ratio and the results are analyzed.

4. Research on Insurance Fund Allocation Based on Mean-Variance Model

4.1 Theoretical basis

The first thing that needs to be addressed in the investment of securities and other assets is two core issues: expected returns and risks. Then, how to determine the risks and benefits of portfolio investment and how to balance these two indicators for asset allocation are urgent problems for market investors. It is in this context that the Markowitz's theory came into being.

The theory is based on the following assumptions:

(1) When considering each investment choice, investors are based on the probability distribution of securities returns within a certain holding time.

(2) When considering each investment choice, investors are based on the probability distribution of securities returns within a certain holding time.

(3) The investor's decision is based solely on the risks and benefits of the securities.

(4) At a certain level of risk, investors expect the maximum return; correspondingly, at a certain level of return, investors want the minimum risk.
Based on the above assumptions, Markowitz established the calculation method of the expected return and risk of the portfolio and the effective boundary theory, thus establishing the mean-variance model of the asset optimization configuration:

Minimize

$$\sigma^2(rp) = \sum_{i=1}^{n}\sum_{j=1}^{n} x_i x_j \sigma_{ij} \tag{1}$$

Subject to

$$rp = \sum x_i r_i \tag{2}$$

$$\sum x_i = 1 \tag{3}$$

$$x_i \geq 0 \tag{4}$$

Among them: rp is the portfolio income; $\sigma^2(rp)$ is the combined investment variance, representing the combined risk; r_i is the income of the i-th investment; x_i and x_j are the proportion of the i-th and j-th investments respectively; σ_{ij} is the covariance between two securities.

In this model, investors can predetermine a desired return, and then determine the investor's investment ratio on each investment project by the above formula to minimize the total investment risk. Different expected returns have different combinations of minimum variances, thus forming a minimum variance set.

4.2 Model construction

4.2.1 Model assumptions

Based on the assumptions made by the traditional Markowitz's model, the following assumptions are added to the specific needs of the new model:

(1) Assume that the company does not frequently buy or sell an asset within one year, that is, only increase or decrease in years, and not short-term arbitrage.

(2) It is assumed that the company judges its expected rate of return and risk based on the actual conditions of each asset in the past ten years, and uses it as the decision information of this year, and the impact factor of each year is the same.

4.2.2 Model preparation

According to the Insurance Law and related regulations, insurance company investment assets are divided into five categories of assets: Liquid Assets, Fixed Income Assets, Equity Assets, Real Estate and other financial assets.

In order to simplify the model, we select the larger and most representative asset categories of each major asset category into the portfolio analysis:

Table 1. Optional asset type

Category	Segmentation Category	Numbering
Fixed Income Assets	Time Deposit	1
	Bond Investment	2
Equity Assets	Stock and Equity Funds	3
Real Estate	Investment Real Estate	4
Liquid Assets	Cash and Cash Equivalents	5

4.2.3 Model Building

Since in reality, investors tend to consider both revenue maximization and risk minimization, and there may not be a given expected rate of return, which makes Hypothesis 2 too strict. Therefore, we introduce a pair of convex combination coefficients (α, 1-α): when α∈(0,1), α/(1-α) will traverse all positive real numbers. Furthermore, αμ-(1-α)σ is used as an objective function to maximize it, thereby quantifying the equilibrium condition between risk and benefit. In this way, the risk-return preference is considered in the portfolio optimization process.

Thus, the traditional Markowitz's Mean-Variance Model can be modified to a linear programming problem with the risk preference coefficient α as a parameter:

Model I：

Maximize

$$\alpha\mu-(1-\alpha)\sigma^2,\ \alpha\epsilon[0,1] \tag{5}$$

Subject to

$$\sum_{i=1}^{5} x_i = 1 \tag{6}$$

$$x_i \geq 0,\ i=1,2,\dots,5 \tag{7}$$

Where

$$\mu=\sum_{i=1}^{5} x_i r_i \tag{8}$$

$$\sigma^2=\sum_{i=1}^{5}\sum_{j=1}^{5} x_i x_j \sigma_{ij}=\boldsymbol{X}^T\boldsymbol{\Omega}\boldsymbol{X} \tag{9}$$

$$\sigma_{ij}=\boldsymbol{cov}(r_i,r_j),\ i,j=1,2,\dots,5 \tag{10}$$

Among them: μ is the expected return rate of the portfolio, and σ^2 is the portfolio risk; α is the risk preference coefficient, and the larger α indicates the more preferred risk; x_i is the investment ratio of the i-th investment in the portfolio, and r_i is the expected rate of return of the i-th investment; n is the number of alternative investment projects; σ_{ij} is the covariance between the expected yields of the i-th and j-th investments.

In order to further promote the market-oriented reform of the insurance fund utilization system and strengthen and improve the supervision of the use of insurance funds, the China Insurance Regulatory Commission issued the "Notice of the China Insurance Regulatory Commission on Strengthening and Improving the Supervision of the Use of Insurance Funds" on February 19, 2014. Based on this, we set the following constraints:

(1) Proportion of insurance fund supervision ratio: The book balance of equity assets and investment real estate shall not exceed 30% of the total assets of the company at the end of the previous period:

$$A*x_i \leq A_0*LM_i,\ i=3,4 \tag{11}$$

$$LM_3=30\% \tag{12}$$

$$LM_4=30\% \tag{13}$$

Among them: A_0 is the total assets of the company at the end of last quarter, LM_i is the upper limit of the use of insurance funds for the i-th asset, and A is the total investment assets.

(2) Liquidity ratio limitation: The total liquid assets of the investment accounted for not less than 5% of the total assets of the company at the end of last quarter:

$$A*x_5 \geq A_0*5\% \tag{14}$$

(3) The proportion of the balance of funds used does not change significantly every year, and the change usually does not exceed 25% of the original proportion:

$$75\%*x_i' \leq x_i \leq 125\%*x_i' \tag{15}$$

Among them: x_i' is the proportion of investment in the i-th asset last year.

In practical problems, transaction costs can also become an important factor affecting the portfolio. So, we set the following constraints to make the model more realistic:

Among the five assets, there are transaction costs for stocks and investment properties. Among them, the stock transaction fee includes brokerage commission and stamp duty, and the stamp duty is only charged at the time of sale; the house transaction tax includes stamp duty and notary fee, and the notary fee is only paid by the buyer. which is:

$$c_i=\frac{k_i*|A*x_i-A'*x_i'|}{A},\ i=3,4 \tag{16}$$

$$k_i=0,\ i=1,2,\dots,n \tag{17}$$

$$k_3 = \begin{cases} 0.2\%, & A * x_3 - A' * x_3' \geq 0 \\ 0.3\%, & A * x_3 - A' * x_3' \leq 0 \end{cases} \tag{18}$$

$$k_4 = \begin{cases} 3.5‰, & A * x_4 - A' * x_4' \geq 0 \\ 0.5‰, & A * x_4 - A' * x_4' \leq 0 \end{cases} \tag{19}$$

Among them, A' is the total investment assets of the previous period, c_i is the transaction cost rate of the i-th asset, and k_i is the proportion of the handling fee for the i-th asset.

Model I is optimized in conjunction with regulatory proportional constraints and transaction cost constraints:

Model Ⅱ：

Maximize

$$\alpha\mu - (1-\alpha)\sigma^2, \ \alpha\epsilon[0,1] \tag{20}$$

Subject to

$$\sum_{i=1}^{5} x_i = 1 \tag{21}$$

$$x_i \geq 0, \ i = 1,2,\dots,5 \tag{22}$$

$$A * x_i \leq A_0 * LM_i, \ i = 3,4 \tag{23}$$

$$A * x_5 \geq A_0 * 5\% \tag{24}$$

$$75\% * x_i' \leq x_i \leq 125\% * x_i', \ i = 1,2,\dots,5 \tag{25}$$

Where

$$\mu = \sum_{i=1}^{5} x_i * (r_i - c_i) \tag{26}$$

$$c_i = \frac{k_i * |A * x_i - A' * x_i'|}{A}, \ i = 3,4 \tag{27}$$

$$k_i = 0, \ i = 1,2,5 \tag{28}$$

$$k_3 = \begin{cases} 0.2\%, & A * x_3 - A' * x_3' \geq 0 \\ 0.3\%, & A * x_3 - A' * x_3' \leq 0 \end{cases} \tag{29}$$

$$k_4 = \begin{cases} 3.5‰, & A * x_4 - A' * x_4' \geq 0 \\ 0.5‰, & A * x_4 - A' * x_4' \leq 0 \end{cases} \tag{30}$$

$$\sigma^2 = \sum_{i=1}^{5}\sum_{j=1}^{5} x_i x_j \sigma_{ij} = \boldsymbol{X}^T \boldsymbol{\Omega} \boldsymbol{X} \tag{31}$$

$$\boldsymbol{X} = (x_1, x_2, x_3, \cdots, x_5)^T \tag{32}$$

$$\boldsymbol{\Omega} = \begin{pmatrix} \sigma_{11} & \cdots & \sigma_{15} \\ \vdots & \ddots & \vdots \\ \sigma_{51} & \cdots & \sigma_{55} \end{pmatrix} \tag{33}$$

$$\sigma_{ij} = \boldsymbol{cov}(r_i, r_j), \ i,j = 1,2,\dots,5 \tag{34}$$

$$LM_3 = 30\% \tag{35}$$

$$LM_4 = 30\% \tag{36}$$

Where x_i is the investment ratio of the i-th asset in the portfolio as a decision variable; μ is the expected return rate of the portfolio, and σ^2 is the risk of the portfolio; α is the risk preference coefficient, and the larger α indicates the more preferred risk; r_i is the expected rate of return for the i-th asset; σ_{ij} is the covariance of the expected rate of return for the i-th and j-th assets; A_0 is the total assets of the company at the end of last quarter, LM_i is the upper limit of the use of insurance funds for the i-type assets, and A is the total investment assets for the current period; x_i' is the proportion of investment in the i-type assets in the previous year; c_i is the transaction cost rate of the i-th asset, and k_i is the proportion of the commission for the i-th asset.

4.3 Algorithm Implementation

First, since the objective function of model II contains a nonlinear function, this model belongs to the nonlinear programming problem. We use LINGO to find its optimal solution.

Secondly, due to the uncertainty of the insurance company's risk preference coefficient, we will try to dynamically solve the model with different values of α, and compare the output with the actual situation of PING AN INSURANCE COMPANY's insurance fund investment portfolio in 2017.

4.4 Empirical Analysis – Based on PING AN INSURANCE COMPANY's Insurance Fund Portfolio in 2017

In order to verify the role of the above model in the asset allocation of insurance companies, we use PING AN INSURANCE COMPANY's insurance fund investment portfolio in 2017 as an example to apply and solve the model, and scientifically use the quantitative model to select the optimal allocation plan that accords with the company's risk preference.

(1) According to the 2007-2016 historical database, find the raw data needed by the model.

For time deposits, the insurance company's deposit amount is huge, and relatively high interest rates can be obtained. Therefore, the one-year savings deposit interest rate is taken as the model parameter; For bond investments and other fixed-income assets, the annual index return rate of the Shanghai Stock Exchange's national debt index (full price) is used as its annualized rate of return on the bond market; For cash, cash equivalents and others, due to lower interest rates on demand deposits and taking into account inflation rates, we simplify their yields to zero each year.

Table 2. Yields of various assets in 2007-2016

Numbering / Years	1	2	3	4	5
2007	4.14%	-0.47%	164.53%	2.36%	0.00%
2008	2.25%	9.41%	-62.60%	4.81%	0.00%
2009	2.25%	0.87%	102.89%	-10.38%	0.00%
2010	2.75%	3.21%	-11.16%	6.15%	0.00%
2011	3.50%	4.05%	-17.89%	2.90%	0.00%
2012	3.00%	3.35%	6.06%	-5.16%	0.00%
2013	3.00%	2.75%	-4.97%	-0.79%	0.00%
2014	2.75%	4.42%	58.14%	0.20%	0.00%
2015	1.50%	6.09%	9.62%	-2.29%	0.00%
2016	1.50%	3.39%	-8.40%	1.22%	0.00%
Mean	2.66%	3.71%	23.62%	-0.10%	0.00%

Source: CSMAR database, National Bureau of Statistics

According to the annual report of the listed company, other raw data (RMB million) is collected as follows:

$$A_0 = 5576903 \tag{37}$$

$$A' = 2004780 \tag{38}$$

$$A = 2449474 \tag{39}$$

$$\boldsymbol{X}' = (X_1', X_2', X_3', X_4', X_5', X_6')^T = (10.3\%, 63.1\%, 18.2\%, 2.2\%, 6.2\%)^T \tag{40}$$

（2）Based on the original data for ten years, the initial data is calculated as follows:

Expected rate of return:

$$\boldsymbol{R} = [r_1, r_2, r_3, r_4, r_5]^T = [2.66\%, 3.71\%, 23.62\%, -0.10\%, 0.00\%] \tag{41}$$

Covariance matrix：

$$\boldsymbol{\Omega} = \begin{pmatrix} 6.171 & -9.887 & 214.192 & 8.002 & 0.000 \\ -9.887 & 65.663 & -1266.556 & 41.916 & 0.000 \\ 214.192 & -1266.556 & 40042.674 & -1125.273 & 0.000 \\ 8.002 & 41.916 & -1125.273 & 216.521 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \end{pmatrix} * 10^{-5} \tag{42}$$

（3）Input this nonlinear programming problem into LINGO, and output the optimal result as follows:

When $\alpha \to 0$:

$$\boldsymbol{X} = (x_1, x_2, x_3, \cdots, x_5)^T = (7.7\%, 65.6\%, 13.7\%, 1.7\%, 11.4\%)^T \tag{43}$$

$$r = 5.86\% \tag{44}$$

When $\alpha \to 1$:

$$\boldsymbol{X} = (x_1, x_2, x_3, \cdots, x_5)^T = (7.7\%, 56.5\%, 22.8\%, 1.7\%, 11.4\%)^T \tag{45}$$

$$r = 7.67\% \tag{46}$$

Where: r is the yield of the portfolio.

4.5 Discussion of results

It can be seen from the model output:

First, when α is low, the company is risk-averse, increasing its holdings of bonds and reducing its holdings to avoid risks. When α is high, the company is risk-averse, increasing its holdings of bonds and reducing its holdings to obtain excess returns. When risk-reward preferences change, insurers usually make trade-offs between fixed-income and equity-based investments, while the other types of assets are designed to diversify assets and spread risk.

Secondly, for highly indebted insurance companies, bonds and other fixed-income assets have stable returns, strong liquidity and relatively low risks, which are in line with the profitability, safety and liquidity requirements of insurance funds. Therefore, it has the highest proportion of all asset classes. For investment properties with high risks and low expected yields, insurance companies tend to minimize their holdings.

Finally, in order to discuss the feasibility and limitations of the model, we compare the output of the model in 4.3 with the actual situation of PING AN INSURANCE COMPANY's insurance fund investment portfolio in 2017, as shown in Table 3:

Table 3. Comparison of actual portfolio and model solution results

Numbering	Actual portfolio（%）		Optimal combination of model solutions（%）	
	2016	2017	$\alpha \to 0$	$\alpha \to 1$
1	10.3	6.6	7.7	7.7
2	63.1	61.9	65.6	56.5
3	18.2	23.7	13.7	22.8
4	2.2	2.0	1.7	1.7
5	6.2	5.8	11.4	11.4
Rate of return	5.3	6.0	5.9	7.7

Source: PING AN INSURANCE COMPANY, 2017 Annual Report.

From the actual investment situation of PING AN INSURANCE COMPANY, during the period of 2016-2017, the company reduced the fixed-risk assets, investment real estate and cash-based assets with lower risks, and increased the proportion of risk-based investment. This is precisely because China's financial market is maturing, the capital market is gradually picking up in 2017, and the economy is steadily improving. The investment portfolio of insurance companies is in line with the macroeconomic environment of China.

By comparison, we find that the reduction of low-risk assets in the model is much smaller than in the actual situation. This is because, in order to quantify the regulatory requirements for the proportion of the balance of funds used, the model sets it as a constraint of 25%, and actually the China Insurance Regulatory Commission does not give clear criteria. At the same time, according to the actual yield of each asset in 2017, the rate of return on venture capital is higher than the average of the past decade, while the yield on low-risk assets is relatively low. In actual decision-making, within a year, companies can adjust their portfolios at any time according to the macro environment of the current market, rather than making a decision solely based on historical data.

It can be seen from the table that as the macro economy continues to improve, the risk appetite of PING AN INSURANCE COMPANY also maintains a relatively high growth rate. While the return on investment of enterprises has increased, it has also raised the risk level of the portfolio.

4.6 Model limitations

(1) Measuring the risk of assets with variance is only applicable to assets with a symmetric distribution of returns, which is not general.

(2) The model assumes that the initial investment amount is a fixed value, excluding the impact of expenditure on investment, and does not consider the portfolio adjustment within one year, so it does not apply to the dynamic multi-stage situation.

(3) The selection of risk preference coefficient α is subjective, which is suitable for trend change analysis and not applicable to specific numerical analysis.

5. Conclusions and recommendations

Starting from Markowitz's Mean-Variance Model, combined with China's insurance industry regulatory requirements and the actual situation of the capital market, this paper improves the model and adds constraints, establishing a nonlinear programming model suitable for the asset allocation of insurance companies in China. Furthermore, we use LINGO software to solve the model and conduct empirical analysis in the context of PING AN INSURANCE COMPANY in 2017. From the results of the operation, this model is effective and realistic.

For the results of empirical analysis, the following policy recommendations are proposed for the insurance industry:

(1) Carefully increase the risk assets. Because insurance companies are highly indebted and their risk tolerance is weak, they should carefully assess their risk tolerance and not excessively pursue profit maximization.

(2) Increase the diversification of investment portfolios. Due to the particularity of the industry, the MCRC has imposed strict restrictions on the investment scope of insurance companies. Despite the limited types of investments, insurers can make reasonable plans for the subdivision of securities, such as: increasing different types of bonds, stocks, funds; diversifying investment in underlying assets, investing in different sectors and industries.

(3) Reasonably control the ratio of financial investment to cash assets.

Because portfolio theory can only disperse and reduce non-systemic risks, it cannot eliminate systemic risks. Even if the portfolio is absolutely effective, the total risk remains.

Therefore, insurance companies should maintain a certain percentage of monetary funds to counter the fluctuations in the capital market.

References

[1] J. Wang and D. Wang, Research on the Portfolio and Optimal Investment Ratio of Insurance Companies, *Insurance Research*, vol. 12, pp. 60-67, 2010.

[2] H. Yu and L. Li, The Markowitz's Model and Empirical Research Based on China's Securities Market, *Journal of Gansu Science*, vol. 25(03), pp. 146-149, 2013.

[3] Q. Nan, The status quo and trend of insurance fund allocation from three dimensions of assets, liabilities and policies, *Zhejiang University*, 2018.

[4] Y. Feng, On the Asset and Liability Matching Management of Insurance Companies, *Financial Economy*, vol. 16, pp. 75-78, 2018.