

Empirical Analysis on the Application of Markowitz Portfolio Investment Model in China's Stock Market

-- From the Perspective of Retail Investors

Wei Wang^{1, a}

¹School of Economics, Anyang Normal University, Anyang 455000, China.

^a814459094@qq.com

Abstract

Markowitz portfolio theory is based on portfolio as a whole and for the object, the individual characteristics of the risks and benefits of assets is not the focus of portfolio management, its portfolio management focuses on the relationship between assets and portfolio as a whole the trade-off between the benefits and risks. This paper mainly studies the feasibility and necessity of using markov model in retail. First, the theory of markowitz portfolio is introduced, and the feasibility and necessity of the markov model are preliminarily demonstrated. By constructing the investment portfolio, the effective frontier of the sample stock of the main board, medium and small version and gem board is obtained without the short selling condition, and the comparison is made as a reference to narrow the stock selection of retail investors. And combination of proportion index and corresponding with three tectonic plates, the empirical results show that according to markowitz model to build the effective combination of index is obviously better than the combination of proportion and the corresponding combination.

Keywords

Portfolio; stock market; efficient frontier; risk; returns.

1. Literature Review and Research Significance

1.1. Literature Review

Summary of Domestic Research Status: China's research on portfolio theory started in 1990 and the securities market started relatively late, which leads domestic scholars to study on markowitz's portfolio theory, which is still in the exploratory stage compared with western theorists. Relevant research mainly focuses on the analysis of the risk composition of China's stock market, while there are some deficiencies in the calculation and analysis of the effective frontier (based on effective combination) of China's stock market. However, Chinese scholars have also made many important and creative contributions in this field in a few short years. Due to the limited space and my knowledge, I will only make a brief review below.

Li Shanmin and Xu Pei made a comprehensive evaluation of markowitz's portfolio model and verified the feasibility of applying the theory to guide portfolio selection through empirical research, which is of great practical significance for diversification of portfolio risks. Ceng Yong and Tang Xiaowo studied the effective boundary of portfolio securities under the condition that short selling is not allowed; Zhou Sheng constructed a risk value model with or without risk assets, and found that the effective front of the new model and the effective front of the original mean-variance model are consistent under certain conditions, and obtained the effective front curves under different loan interest rates: Dai Yulin's research pointed out the shortcomings of markowitz's portfolio model, such as the lack of scientificity in taking variance as a measure of

risk, which should be corrected to semi-variance. Li Gang and Chen Zhiping put forward the problem of time incompatibility of optimal investment strategies of mean-variance model in random markets, and put forward effective correction strategies.

In the research of portfolio decision-making, Wang Dong proposed fuzzy stochastic method: Xu Dajiang proposed multi-objective decision-making method: Yan Biqing, Huang Debin, He Xiangfan and Lv Changhui proposed fuzzy multi-objective planning method: Fan Zhiping, Pan Dehui, Zheng Lihui and Liu Hailong etc. applied differential game method; Han Huijun, Yang Siyuan and Tang Liming proposed general game analysis method etc.

The derivative model of markowitz's portfolio theory is very large and mature. Scholars are committed to further improving the Markov model, including the improvement of estimation accuracy and the revision of the optimal investment strategy time, which has played a very good role in the study of this paper.

1.2. Research Significance

Although regulators have been pushing institutions to enter the market, up to now the active body of China's stock market is still dominated by retail investors. A considerable number of retail investors are focused on investment. With the increase of individual capital scale, some retail investors start to diversify their investments and hold portfolios of securities. Although it manages a portfolio of securities, its mode of thinking and focus are on individual securities, focusing on investment analysis of individual securities, which is a simple set of individual management. Markowitz's portfolio investment theory is based on the portfolio as a whole. The focus of the theory lies in the correlation between individuals and the trade-off between risks and returns of the portfolio as a whole. On the one hand, non-systematic risks are effectively reduced by increasing assets with low correlation. On the other hand, the method selects various asset combinations with different weights, which can reach the optimal state of maximum returns and minimum risks at a certain level of returns.

Although markowitz's portfolio investment model has theoretical advantages, it has not been paid much attention by retail investors. On the one hand, it is the inherent thinking of retail investors that portfolio investment management is a big fund that needs to be considered. On the other hand, the calculation process of markowitz model is too complicated, which also hinders the application of retail investors.

In this paper, markowitz model is used to calculate the effective frontier of the main board, small and medium-sized board and GEM respectively and compare them, which can be used as a reference for retail investors to narrow the scope of stock selection. Then through the analysis of the investment of the selected stocks, according to the markowitz model for effective combination, and these combinations with equal proportion combination and the corresponding index comparison, to demonstrate the use value of the markowitz model.

Based on the perspective of retail investors, this paper starts with the necessity and feasibility of retail investors applying markowitz's portfolio theory, and makes an empirical analysis of Markov model in China's stock market.

2. Description of Relevant Sample Data

2.1. Selection of Sample Stocks

In this paper, 10 representative stocks are selected as samples from all stocks on the main board (code A), small and medium-sized board (code B) and gem (code C). These 30 stocks are selected according to the company's financial status (mainly referring to the return on net assets and profit year-on-year), price-to-book ratio, different industries, different regions and other indicators to fully meet the random correlation of stocks and the diversification characteristics of investment portfolios. Among them, in order to facilitate the comparison with

the Shanghai Stock Exchange, the main board selects stocks listed on the Shanghai Stock Exchange.

2.2. Determination of Sample Time Limit and Selection of Time Interval of Return Rate

The sample time limit selected in this article is from May 2014 to May 2017. The time limit we choose is long, with ups and downs during the period, and the economic situation is complicated. Therefore, it is of certain typical significance to conduct empirical research during this period.

The time interval of return rate is mainly divided into year, month, week and day. Since markowitz's portfolio model focuses on the comprehensive analysis of stock investment risks and returns, medium and long-term returns should be adopted, so this paper uses monthly returns to measure. A total of 36-month return rate within the sample time limit.

2.3. Collection of Sample Data

The closing price of the sample stocks, dividends and distribution of individual stocks are taken from china securities journal.

Due to suspension of trading or other reasons, there is no transaction price for the current day. In order to ensure the regularity of the data, the missing data are supplemented. This paper adopts the closing price of the first trading day after suspension as the missing closing price.

2.4. Description of Calculation Method

Calculate the monthly return $R_{j,t}$ of each sample stock within the sample time limit:

$$R_{j,t} = \frac{P_{j,t} - P_{j,(t-1)} + D_{j,t}}{P_{j,(t-1)}}$$

Among them $t=1, 2, 3, \dots, 36; j=1, 2, 3, \dots, 30;$

$P_{j,t}$:The closing price of security j in the t -month;

$D_{j,t}$:The sum of dividend per share and dividend income of securities j in the t -month;

If the sample shares show dividend distribution, stock delivery and share allotment within the sample time limit, then

$D_{j,t} = \text{Cash bonus per share} + P_{j,t} * (\text{conversion ratio} + \text{allotment ratio} + \text{allotment ratio}) - \text{allotment ratio per share} * \text{allotment ratio}.$

Calculate the average monthly return \bar{R}_j of each sample stock within the sample time limit:

$$\bar{R}_j = \frac{\sum_{t=1}^N R_{j,t}}{N}$$

Where N is the total number of months in the sample time limit, $N=36$.

Calculate the standard deviation σ_j of the monthly return rate of each sample stock within the sample time limit:

$$\sigma_j = \sqrt{\frac{\sum_{t=1}^N (R_{j,t} - \bar{R}_j)^2}{N - 1}}$$

The denominator of the formula is $N-1$, because we take the representative of the sample average as the unknown average, as compensation, the sample time limit minus 1 can produce unbiased estimation of variance.

The calculation results of the average monthly return rate and standard deviation within the sample time limit are obtained.

Calculate the covariance $Cov(R_i, R_j)$ of the monthly return rate between the main board, small and medium-sized board and gem respectively:

$$Cov(R_i, R_j) = \frac{\sum_{t=1}^N (R_{i,t} - \bar{R}_i)(R_{j,t} - \bar{R}_j)}{N - 1}$$

Where $R_{i,t}$: the monthly yield of securities i in t month;

$R_{j,t}$: The monthly rate of return of securities j in t month;

\bar{R}_i : The average monthly return rate of securities i within the sample time limit;

\bar{R}_j : Average monthly return rate of securities j within the sample time limit.

Calculate the return on the portfolio \bar{R}_p :

$$\bar{R}_p = \sum_{i=1}^n x_i \bar{R}_i$$

Among them x_i : The weight of securities i in the investment portfolio;

n: The number of securities in the portfolio.

Calculate the variance σ_p^2 of the portfolio:

$$\sigma_p^2 = \sum_{i=1}^n \sum_{j=1}^n x_i x_j Cov(R_i, R_j)$$

The average monthly return rate and standard deviation of the sample stocks of the main board, small and medium-sized board and gem within the sample time limit are shown in Table 2:

Table 1. The calculation results of stock-related data of three plate samples

Numbering	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
Average Monthly Return Rate (%)	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Standard deviation (%)	9.26	9.26	9.26	9.26	9.26	9.26	9.26	9.26	9.26	9.26
Numbering	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
Average Monthly Return Rate (%)	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35
Standard deviation (%)	13.39	13.39	13.39	13.39	13.39	13.39	13.39	13.39	13.39	13.39
Numbering	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Average Monthly Return Rate (%)	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86
Standard deviation (%)	18.75	18.75	18.75	18.75	18.75	18.75	18.75	18.75	18.75	18.75

Carry out the operations shown in the attachment in Matlab R2017b, and obtain the effective combination of Shanghai main board under the condition that short selling is not allowed:

Table 2. Effective combination of the main board stock market (short selling is not allowed)

COMBINATION	1	2	3	4	5	6	7	8	9	10
Combined standard deviation (%)	6.21	6.27	6.45	6.73	7.51	9.53	12.1	14.94	17.97	21.18
Portfolio Return (%)	3.09	3.38	3.67	3.96	4.24	4.53	4.82	5.11	5.39	5.68
A1 (%)										
A2 (%)	27.16	31.86	36.56	41.26	43.70	40.78	37.87	34.95	18.66	
A3 (%)										
A4 (%)										
A5 (%)	1.36	1.76	2.16	2.57						
A6 (%)										
A7 (%)	23.30	32.25	41.20	50.15	48.64	33.19	17.75	2.31%		
A8 (%)										
A9 (%)	48.18	34.13	20.08	6.03						
A10 (%)					7.67	26.02	44.38	62.73	81.34	100.00

The effective combination of small and medium-sized boards under the condition that short selling is not allowed is obtained:

Table 3. Effective combination of small and medium-sized stock markets (short selling is not allowed)

COMBINATION	1	2	3	4	5	6	7	8	9	10
Combined standard deviation (%)	4.88	4.95	5.21	5.77	6.78	8.13	9.74	11.99	15.19	20.28
Portfolio Return (%)	1.93	2.42	2.90	3.38	3.86	4.34	4.82	5.31	5.79	6.27
B1 (%)	1.04	3.45	6.42	6.50	3.62	1.20				
B2 (%)	31.71	30.28	27.15	21.34	13.00	4.62				
B3 (%)	0.98	3.96	8.49	14.11	20.67	26.99	34.23	46.02	62.65	100.00
B4 (%)	17.41	15.11	5.31							
B5 (%)	22.69	20.63	19.09	17.33	15.27	13.30	5.80			
B6 (%)	6.78	11.00	12.67	19.19	30.85	37.38	39.79	23.64		
B7 (%)	10.61	11.05	9.21	5.76	0.92					
B8 (%)	8.20	0.73								
B9 (%)	0.58	3.78	11.64	15.77	15.67	16.51	20.18	30.34	37.35	
B10 (%)										

The effective combination of GEM under the condition that short selling is not allowed is obtained:

Table 4. The effective combination of GEM stock market (short selling is not allowed)

COMBINATION	1	2	3	4	5	6	7	8	9	10
Combined standard deviation (%)	6.10	6.22	6.45	6.78	7.23	8.02	9.09	10.36	12.69	18.57
Portfolio Return (%)	1.60	2.08	2.57	3.05	3.53	4.01	4.49	4.97	5.45	5.93
C1 (%)		0.86	3.40	5.93	5.59	2.35				
C2 (%)	35.68	34.42	33.25	32.08	27.12	18.33	9.32			
C3 (%)	1.75									
C4 (%)		1.25	3.83	6.41	10.22	15.26	20.56	26.63	33.61	
C5 (%)	35.28	36.94	35.68	34.43	33.37	32.51	31.15	27.93	1.99	
C6 (%)	27.29	20.39	12.24	4.09						
C7 (%)		1.41	2.31	3.21	3.82	4.12	4.36	4.26		
C8 (%)										
C9 (%)		4.73	9.28	13.83	19.88	27.44	34.61	41.18	64.40	100.00
C10 (%)										

According to the relevant data in Table 3, Table 4 and Table 5, the effective fronts of the three plates can be obtained as shown in Figure 3:

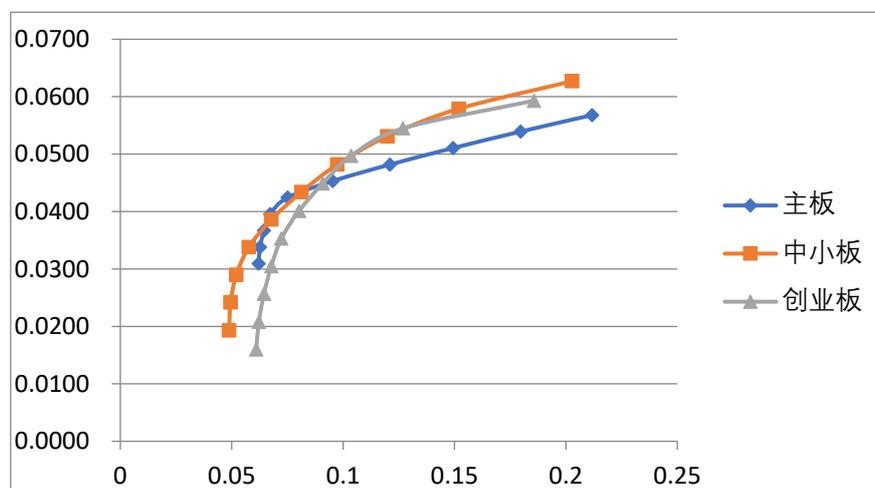


Figure 3. Comparison of the effective front of three plates (Markov model)

From the figure, it can be clearly found that when the rate of return is above 4.49%, the effective front curves of the small and medium-sized board and the growth enterprise board basically coincide with each other and are located above the main board as a whole. It indicates that when the expected return rate demanded by investors is greater than 4.49%, investors build an effective portfolio based on markowitz model. Under the same risk level, their returns on the SME board and GEM board are higher than those on the main board. At a given level of returns, investors build effective portfolios based on the markowitz model, and their risks in the small and medium-sized boards and the Growth Enterprise Market are lower than those in the main board.

When the rate of return is above 5.45%, the effective front curve of the small and medium-sized board starts to exceed that of the Growth Enterprise Market and lies above it. It indicates that when the expected return rate demanded by investors is greater than 5.45%, investors construct an effective portfolio based on markowitz model. At the same risk level, the expected return of SME board is higher than that of GEM board. At the established income level, the risk that investors bear in the small and medium-sized board is lower than that in the Growth Enterprise Market. The above conclusion only serves as a reference for retail investors to narrow the scope of stock selection.

3. Conclusion and Prospect

3.1. Some Summary and Discussion about Markowitz Portfolio Model

① Markowitz's portfolio model is superior to the equal proportion portfolio and corresponding index

Calculate the return rate and standard deviation of equal proportion combination of sample stocks of each plate within the sample time limit:

R=

Among them: The weight of each security in the investment portfolio is fixed at 0.1;

N: The number of securities in the portfolio is 10 (branches)

Collect the return rate and standard deviation of Shanghai Stock Exchange Index, Medium and Small Edition Index and Growth Enterprise Market Index respectively within the sample time limit

The yield and standard deviation of the equivalent proportion combination and corresponding index combination corresponding to the effective combination of the three plate sample stocks are shown in Table 6, Table 7 and Table 8:

Table 5. Return rate and standard deviation of main board index and equal proportion combination

Main board	Rate of return (%)	Standard deviation (%)
Equal proportion combination	2.99	9.33
Shanghai index	2.82	10.86

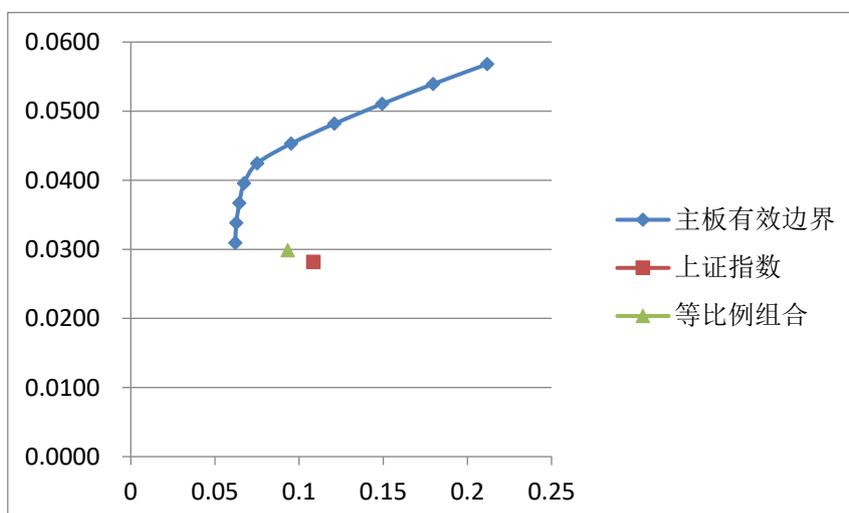


Figure 4.

Table 6. Returns and standard deviations of small and medium-sized indexes and proportional combinations

Small and medium plate	Rate of return (%)	Standard deviation (%)
Equal proportion combination	2.98	7.17
Small and medium board index	1.44	9.40

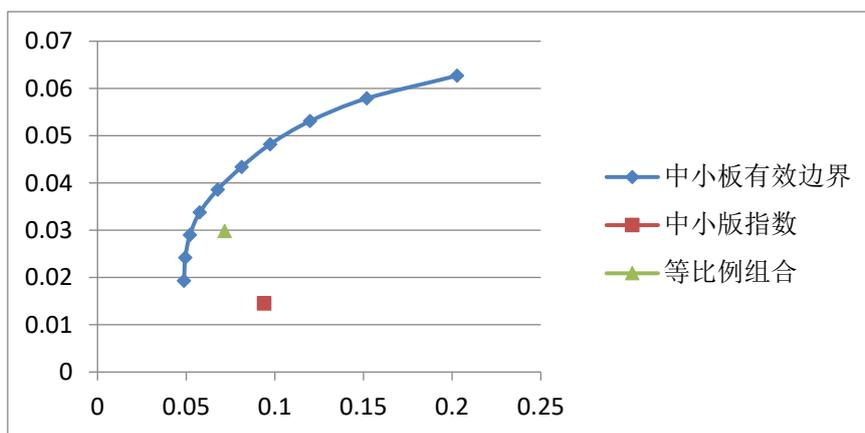


Figure 5.

Table 7. The return rate and standard deviation of GEM index and equal proportion combination.

Gem	Rate of return (%)	Standard deviation (%)
Equal proportion combination	2.91	9.03
GEM Index	1.69	11.50

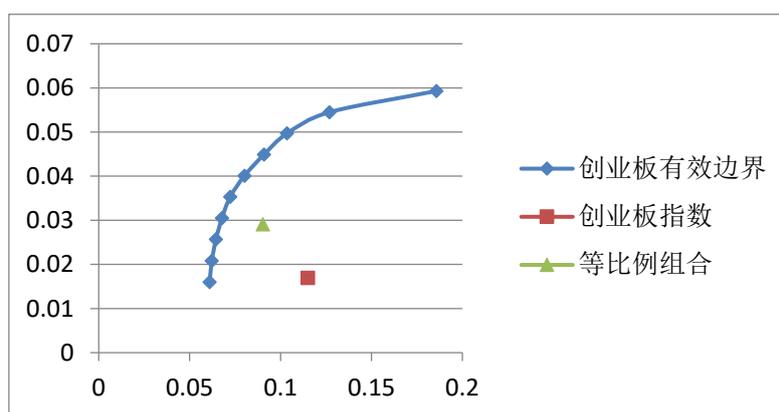


Figure 6.

From Figure 4, Figure 5 and Figure 6, we can clearly observe that the points represented by the corresponding indexes and equal proportion combinations of the three plates are all below the effective boundary and far away, which indicates that under the same risk level, the effective combination constructed by using markowitz model obtains significantly better returns than the equal proportion combination investment and index investment. At the same income level, the risk of the effective portfolio constructed by markowitz model is obviously lower than that of equal proportion portfolio investment and index investment. This further demonstrates the feasibility of the markowitz model.

Point A in the three charts is all at the lower right of point B, indicating that the return rate of each plate index is lower than the corresponding proportional combination within the sample time limit, and the standard deviation is higher than the corresponding proportional combination. Compared with selecting ten well-run securities to invest in equal proportion, index investment can achieve lower returns even though it takes on higher risks.

Among them, the distance between point a and point b in fig. 6 indicates that the expected return rate of gem index is far lower than the corresponding proportional combination within the sample time limit, and the standard deviation is far higher than the corresponding proportional combination. Compared with the selection of ten well-run securities in GEM for equal proportion investment, GEM index investment is obviously worse, and it is far from the application of markowitz model to construct effective portfolio investment.

Two points A and B, which respectively represent the returns and risks of equal proportion portfolios and corresponding index portfolios, are below the effective boundary of the investment portfolio composed of 10 alternative stocks, which indicates that the effective portfolio bears lower risks on the given expected returns. Under the given risk, the expected return rate of effective portfolio is higher. To sum up, this shows that the effective combination of markowitz is obviously better than the equal proportion combination and the corresponding index combination. The effect of individual investors using Markov model to construct effective portfolio investment is better than simply dispersing investment and some passive index investment.

② Within the sample time limit selected in this article, ten securities with good operating conditions are selected for equal proportion investment. Compared with index investment, they have obtained higher returns with less risks, and equal proportion portfolio investment is completely superior to index investment. This can't help but make us question and think about index investment (i.e passive investment).

③ The effective combination of markowitz has effectively reduced non-systematic risks. Under the condition that short selling is not allowed, the higher the correlation of assets, the greater the risk of asset portfolio. Mahalanobis model effectively reduces non-systematic risks by selecting assets that are not correlated with each other or have low correlation coefficients. Compared with simple stock analysis, the stability of the same return rate is greatly increased. Although China's securities market is still not standardized and the examination and supervision are not perfect, leading to greater systemic risks, markowitz's portfolio theory still has good results.

④ Markowitz's effective portfolio contains a small number of securities, and individual securities account for a considerable proportion in the effective portfolio. For example, in this paper, under the same risk level, when the size of equal proportion portfolio is 10 kinds, the effective portfolio size of markowitz in the main board stock market is only 3 kinds, while the effective portfolio size of markowitz in the small and medium board stock market is 6 kinds, and the effective portfolio size of markowitz in the GEM stock market is 6 kinds. Many retail investors have inherent thinking that the portfolio they have built is full of securities and they do not have enough energy and ability to carry out practical operations. In fact, retail investors can build an effective portfolio of markowitz, instead of focusing on a few securities with a large investment weight, instead of being too tied and scattered in management resources. This further demonstrates the feasibility of markowitz's portfolio theory.

The above results show that in China's stock market, where retail investors are increasing, modern portfolio theory, markowitz, has significant application value. It is of great practical significance to guide the rational investment behavior of retail investors, promote the stable and healthy development of China's stock market, and respond to the requirements of the new era of socialism in China on the capital market.

3.2. The Effect of Applying Markowitz's Portfolio Theory to Retail Investors

In the summary and discussion on Markowitz's portfolio model, it has been proved that within the sample time limit, the application of Markowitz model to select 10 stocks to construct an effective boundary is better than investing the same weight in these 10 stocks, and is also better than investing funds in passive investments such as Shanghai Stock Exchange Index.

However, retail investors are also limited by the limited capital scale and cannot fully diversify their investments. In this paper, 10 representative stocks from different industries are selected. The sample size is small, but the number of stocks selected is enough for retail investors. In fact, the larger the number of stocks in the portfolio and the smaller the correlation coefficient between stocks, the smaller the non-systematic risk of the portfolio and the better the effect of applying Markowitz's portfolio theory. Moreover, retail investors do not have the conditions to exhaust the effective combination of all high-quality stocks in the stock market, and it is very difficult to find the optimal combination from the huge stock market.

To sum up, the application of Markowitz model by retail investors has certain and limited effects. Markowitz and modern portfolio theory have their own limitations. First of all, compared with the improved theory developed later, this theory relies entirely on past data to infer the future rate of return and risk level, which many scholars have raised reasonable doubts. Secondly, the theory is based on a series of strict assumptions. If the standard deviation of the combination is regarded as a measure of the risk level, in fact, the mean-semi-variance and mean-absolute deviation models proposed by scholars are more reasonable for measuring the risk level. Moreover, the selection of sample time limit has a great influence on the calculation results, and the time limit should be selected by scientific methods. This paper selects a relatively complete stock index period as the time limit, which is of representative significance.

Due to the limitations of the theory itself, retail investors should make effective adjustments according to the actual situation in the actual application process, instead of blindly applying mechanically and avoiding risks through decentralized investment, which is the core content brought to investors by Markowitz and modern portfolio theory.

Finally, it should be pointed out that the empirical research on the construction of effective combination of Markowitz model is a research on specific time and specific samples, which belongs to case study. Due to the existence of sampling error, there is a certain deviation from the actual situation.

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