An Empirical Study on Stock Market Portfolio

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***Abstract*—This paper takes the monthly stock data of four listed companies from January 2010 to October 2019 as the research data, takes mean variance model and Markowitz's portfolio theory as the research method and takes the planning solution as the research method. In the above sample stock range, the author finds out the feasible set and effective frontier of the sample. Through empirical analysis, the decision analysis process is explained, and the conclusion is that the securities portfolio constructed by Markowitz portfolio theory, mean variance analysis and planning solution by Excel is feasible. In addition, this paper proves that the decision-making of portfolio is enlightening for the investors to choose the combination of efficient income and risk and to optimize the portfolio of return and risk in the securities investment decision-making.**

***Index Terms*—Effective frontier, Markowitz, mean variance model, optimal portfolio, stock market.**

I. Introduction

The securities market plays an important role in improving China's economic structure adjustment, promoting the rapid development of economic market and promoting the reform of state-owned enterprises. Historically, the saying that "don't put all your eggs in one basket" was not accepted from the beginning, and even in some past years, it was advocated that people should make concentrated investment. It was not until the pioneers of modern finance, represented by Markowitz, that created the portfolio investment theory about risky assets in the 1950s, that is, the mean variance model. Only then did people realize the benefits of diversification and the way to disperse them. The market is changeable, there are many uncertain factors, and single asset investment often cannot meet the expectations of investors, so many investors began to choose to build portfolio for asset allocation. [1]

Based on the monthly data of four stocks from January 2010 to October 2019, this paper starts with the development of portfolio theory and combines the mean variance model of Markowitz with practice. [2] The author uses Excel as the research tool and takes planning solution as the research method. The feasible set and effective frontier of samples are found out within the scope of the sample stock. The decision analysis process is explained through empirical analysis, and relevant conclusions are drawn, which are enlightening for investors. To some extent, this paper is of great significance to investors in choosing efficient combination of income and risk and making optimal portfolio decision.

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II. Relevant Background and Data Selection

A. Portfolio

1) The basic concept of portfolio

As an important part of financial decision-making, the main research of portfolio is how to maximize the return or minimize the risk when the risk is certain [3].

2) Markowitz's mean variance model

Markowitz, an American economist, first put forward the portfolio theory in 1952. Using the quantitative method and taking the variance of securities return rate as the measurement index of portfolio risk, he first proposed the idea of determining the minimum variance to measure the risk of portfolio, and established the portfolio investment decision model. When investors invest the disposable assets in a certain period of time, their decision-making objectives are mainly two: as high as possible income and as small as possible uncertainty risk. The best goal is to seek a balance between the return and risk, thus establishing Mean-Variance (MV) Model.

B. Sample Data Selection

The author selects ZTE (000063), Xinyangfeng (000902), Jinyuan Shares (000546) and Tielong Logistics (600125) as samples to combine the four securities and observe their expected returns and standard deviations. The selected stocks belong to different industries, have different trading scales, have good liquidity, have certain representativeness, and the most important thing is that the data of each stock are relatively complete [4]. First of all, the data of the opening and closing prices of four stocks from January 2010 to October 2019 are exported through the stock trading software of Tonghuashun. In order to ensure that the data samples of the four stocks are the same, the data of some stock closing months are excluded.

III. Asset Return and Risk Estimation

A. Measurement of Expected Return and Risk of Single Security

Securities investment income refers to the value increment of initial investment. Generally speaking, it includes current income and capital gains. Usually, the short-term yield is measured by HPR (holding period return). When investors hold securities, they are more concerned about the future returns. Investors hope to obtain such information, and this indicator is the expected rate of return. The expected rate of return is the investor's rough estimate of the possible future return. Its calculation is based on the probability distribution of the future return [5].

The author selects Xinyangfeng (000902), a listed

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company, as an example. Firstly, the analysis period is selected as the monthly line in the stock analysis software, and then the stock prices over the calendar month are exported to excel table, and the monthly yield is obtained by using the opening price and closing price. Then in the expected return cell, average function is used to calculate the expected return rate, and VarP and StdevP are used to calculate the variance and standard deviation of Xinyangfeng stock return.

TABLE I: EXPECTED RETURN AND RISK OF SINGLE SECURITY

Expected rate of return	0.94%
Variance	1.88%
Standard deviation	13.70%

The results show that the expected monthly return of Xinyangfeng (000902) is 0.94%, and the standard deviation of risk is 13.70%.

B. The Measurement of Expected Return and Risk of Portfolio

1) Return and risk of risk free securities and risky portfolio

In our country, bank deposit is often regarded as risk-free, and people usually regard it as the representative of risk-free securities. This kind of risk-free securities and risk securities together, is the capital allocation line. In this case, Xinyangfeng is selected as the representative of risk-free securities, and the annual deposit interest rate of bank is 3.5% as the return of risk-free assets. Since the return rate of risk assets selected in this experiment is the monthly rate of return, it is necessary to convert the annual return rate of risk-free assets into the monthly return rate of 0.29%, and the investment proportion of the two securities should be 1.

TABLE II: RETURN AND RISK OF RISK-FREE AND RISKY SECURITIES PORTFOLIO

	Xinyangfeng	**Risk-free**	
Expected rate of return	0.94%	0.29%	
Variance	13.70%	0	
Proportion of risk free assets	**Proportion of risk assets**	**Portfolio return**	**Portfolio SD**
0.00%	100.00%	0.94%	13.70%
5.00%	95.00%	0.91%	13.02%
10.00%	90.00%	0.88%	12.33%
15.00%	85.00%	0.84%	11.65%
20.00%	80.00%	0.81%	10.96%
25.00%	75.00%	0.78%	10.28%
30.00%	70.00%	0.75%	9.59%
35.00%	65.00%	0.71%	8.91%
40.00%	60.00%	0.68%	8.22%
45.00%	55.00%	0.65%	7.54%
50.00%	50.00%	0.62%	6.85%
55.00%	45.00%	0.58%	6.17%
60.00%	40.00%	0.55%	5.48%
65.00%	35.00%	0.52%	4.80%
70.00%	30.00%	0.49%	4.11%
75.00%	25.00%	0.45%	3.43%
80.00%	20.00%	0.42%	2.74%
85.00%	15.00%	0.39%	2.06%
90.00%	10.00%	0.36%	1.37%
95.00%	5.00%	0.32%	0.69%
100.00%	0.00%	0.29%	0.00%

In order to more intuitively reflect the change of expected return rate and standard deviation with the change of the proportion of risk securities in the portfolio, the author chooses to express the above relationship by the following scatter diagram.

It can be seen from Fig. 1 that after adding risk-free assets, and then adjusting the proportion of risk-free assets and risky assets in the whole asset portfolio, it is found that there is a linear relationship between the return rate of the portfolio and the standard deviation. The greater the proportion of risk assets, the greater the expected rate of return of the portfolio, in line with the principle of high risk and high return.

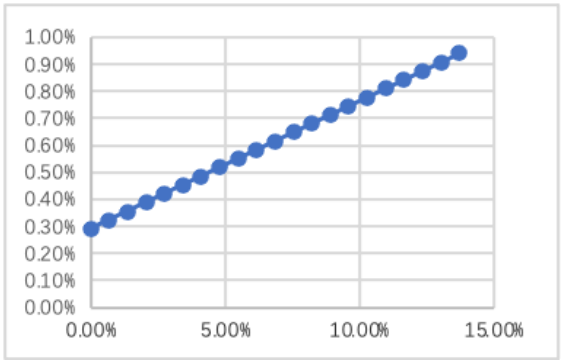

Fig. 1. Scatter diagram of return and risk of risk-free and risky securities portfolio.

TABLE III: EXPECTED RETURN AND RISK OF MULTIPLE SECURITIES

	ZTE Communications	**Xinyangfeng**	**Jinyuan Ep Co.**	**Tielong Logistics**
Expected rate of return	0.76%	1.19%	1.30%	0.17%
Variance	0.0192107	0.016882787	0.016084677	0.014314673
Standard deviation	0.138602671	0.12993378	0.126825381	0.119643942

2) Return and risk of multi risky portfolio

The author selects ZTE (000063), Xinyangfeng (000902), Jinyuan Shares (000546) and Tielong Logistics (600125) as samples to combine the four securities and observe their expected returns and standard deviations.

Using the covariance tool of data analysis in ECXEL software to calculate the covariance between any two securities, in order to observe the correlation between any two securities, it is necessary to calculate the correlation coefficient matrix.

TABLE IV: COVARIANCE AND CORRELATION COEFFICIENT

Covariance				
	ZTE Communications	Xinyangfeng	Jinyuan Ep Co.	Tielong Logistics
ZTE Communications	0.018948461			
Xinyangfeng	0.003402174	0.002151021		
Jinyuan Ep Co.	0.001993263	0.000960816	0.001747804	
Tielong Logistics	0.005053916	0.001179485	0.000705082	0.002635085
Correlation coefficient				
	ZTE Communications	Xinyangfeng	Jinyuan Ep Co.	Tielong Logistics
ZTE Communications	1			
Xinyangfeng	0.532901963	1		
Jinyuan Ep Co.	0.346362721	0.495532075	1	
Tielong Logistics	0.715226708	0.495419375	0.328545829	1

Finally, with the above basic data, the author calculates the expected returns and standard deviations of the four kinds of securities. Assuming that the initial proportion of each security is 25%, the expected return of the portfolio can be calculated through the weighted average of the monthly expected return rate and proportion of each security. The calculation of portfolio variance can use the function of sumproduct, and the calculation of standard deviation of portfolio can be obtained by square root of variance with sqrt function on the basis of variance calculation.

TABLE V: PORTFOLIO RETURN AND SD

	ZTE Communications	**Xinyangfeng**	**Jinyuan Ep Co.**	**Tielong Logistics**
Investment proportion	25.00%	25.00%	25.00%	25.00%
Portfolio return	0.86%			
Portfolio variance	0.005531924			
Portfolio SD	0.074376903			

By calculating the return and risk of four kinds of risky portfolio, it is concluded that when the investment proportion of four kinds of risk assets is 25%, the monthly return rate of portfolio is 0.8566%, and the standard deviation of portfolio is 0.0744. In this case, the investment proportion is assumed by the author. In fact, the investment proportion can be changed at will, so that different mean variance points can be obtained. In theory, when all possible combinations are put together, it is the feasible set of four kinds of securities portfolio, which should be a region.

TABLE VI: EXPECTED RETURN AND STANDARD DEVIATION OF PORTFOLIO

	ZTE Communications	**Tielong Logistics**
Expected rate of return	0.76%	0.17%
Variance	0.0192107	0.014314673
Standard deviation	0.138602671	0.119643942
Covariance	0.003740986	
Correlation coefficient	0.225592036	

ZTE Investment proportion	**TL Investment proportion**	**Portfolio return**	**Portfolio variance**	**Portfolio SD**
0.00%	100.00%	0.17%	1.43%	11.96%
5.00%	95.00%	0.20%	1.33%	11.54%
10.00%	90.00%	0.23%	1.25%	11.16%
15.00%	85.00%	0.26%	1.17%	10.83%
20.00%	80.00%	0.29%	1.11%	10.55%

25.00%	75.00%	0.32%	1.07%	10.32%
30.00%	70.00%	0.35%	1.03%	10.16%
35.00%	65.00%	0.38%	1.01%	10.05%
40.00%	60.00%	0.41%	1.00%	10.01%
45.00%	55.00%	0.44%	1.01%	10.04%
50.00%	50.00%	0.47%	1.03%	10.13%
55.00%	45.00%	0.49%	1.06%	10.28%
60.00%	40.00%	0.52%	1.10%	10.49%
65.00%	35.00%	0.55%	1.16%	10.76%
70.00%	30.00%	0.58%	1.23%	11.08%
75.00%	25.00%	0.61%	1.31%	11.45%
80.00%	20.00%	0.64%	1.41%	11.86%
85.00%	15.00%	0.67%	1.52%	12.31%
90.00%	10.00%	0.70%	1.64%	12.80%
95.00%	5.00%	0.73%	1.77%	13.31%
100.00%	0.00%	0.76%	1.92%	13.86%

IV. Optimal Portfolio

A. Effective Frontier of Risky Assets

A feasible set is a set of securities composed of any K kinds of N tradable risky securities. Generally, they can be characterized in the mean standard deviation plane. If a combination is found to contain all the valid combinations, then the set is called the efficient frontier.[8] The function of the effective frontier is to select and eliminate the less excellent combinations among the numerous possible combinations, that is to say, the combination on the effective frontier is actually the combination with high cost performance.

1) *Feasible set and efficient frontier of two kinds of risky asset portfolio*

The author chooses ZTE and Tielong Logistics as examples to calculate the changing investment proportion, expected value and standard deviation of the two securities.

After obtaining the set of expected return and standard deviation, these combinations can be described in the mean variance quadrant by using scatter plot:

From Fig. 2, it can be seen that the feasible set of two kinds of risk assets is a curve, which is convex to the left. On this curve, we can see that a point can bring the minimum risk, that is, the point above the point is the effective point, that is, the line above the minimum square error is our effective frontier.

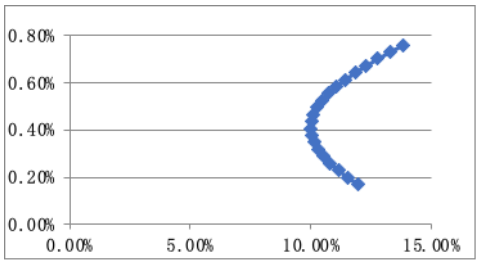

Fig. 2. Feasible set of two risky assets.

2) *Feasible sets and efficient frontier of three or more risky assets*

The author uses the method of programming solution to describe the minimum variance front, that is, the set of points with the minimum standard deviation at the same expected income level, and thus finds the effective frontier naturally.

It can be seen that when the correlation coefficient of various securities is not 1, the combination can play a role in dispersing risk, and there is a minimum variance point after the combination of these securities.

TABLE VII: Feasible Set and Efficient Frontier of Portfolio

No short selling		**Short selling**	
Portfolio return	Portfolio SD	Portfolio return	Portfolio SD
0.17%	11.964%	0.08%	12.775%
0.20%	11.595%	0.12%	12.331%
0.30%	10.458%	0.16%	11.896%
0.40%	9.533%	0.20%	11.595%
0.50%	8.725%	0.40%	9.533%
0.60%	8.069%	0.60%	8.069%
0.70%	7.605%	0.80%	7.368%
0.80%	7.368%	1.00%	7.642%
0.90%	7.381%	1.20%	8.863%
1.00%	7.642%	1.40%	10.558%
1.10%	8.128%	1.60%	12.665%
1.20%	8.863%	1.80%	14.977%
		2.00%	17.411%

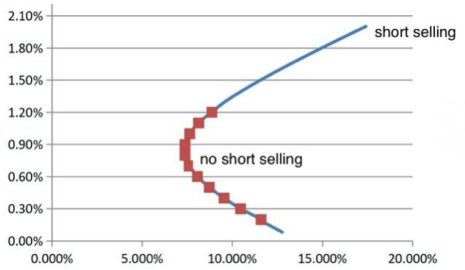

Fig. 3. Scattered diagram of efficient frontier.

B. Effective Frontier after Adding Risk-free Assets

1) Optimal portfolio of risky assets

If there is no risk-free asset, the effective frontier is certainly a curve. This curve is above the minimum variance point. Because people will allocate between risk-free assets and risky assets, after adding risk-free assets, the effective frontier will become a straight line, that is, the point where the risk-free rate of return is tangent to the effective frontier of risk-free assets, which is called the optimal portfolio. In this way, the effective frontier formed by the portfolio is better than that including only risk assets, which is the reason why asset allocation is needed.

According to the separation theorem, the optimal risk asset is the tangent point between the risk-free asset and the effective frontier of the risk asset, that is, the point with the maximum slope of the line with the risk-free asset, and that is the portfolio when $(E(r) - r_f)/\sigma_p$ is the greatest.

TABLE VIII: MINIMUM VARIANCE FRONTIER AND OPTIMAL PORTFOLIO

Minimum variance frontier of four risky assets		**Optimal risk portfolio**
Portfolio return	Portfolio SD	Slope after portfolio with risk-free assets
0.08%	12.775%	-1.6438%
0.12%	12.331%	-1.3786%
0.16%	11.896%	-1.0928%
0.20%	11.595%	-0.7762%
0.40%	9.533%	1.1539%
0.60%	8.069%	3.8419%
0.80%	7.368%	6.9218%
1.00%	7.642%	9.2908%
1.20%	8.863%	10.2674%
1.40%	10.558%	10.5134%
1.60%	12.665%	10.3435%
1.80%	14.977%	10.0821%
2.00%	17.411%	9.8214%

According to the calculation results, when the return rate of the risky asset portfolio is 1.4%, the slope is the largest. Therefore, the risky asset portfolio that everyone should hold is the proportion at this point. Through the solution of the planning, the cases that investors can hold ZTE, Xinyangfeng, Jinyuan Shares and Tielong Logistics are 0.179448, 0.467823, 0.573676 and-0.22095, respectively.

2) Effective frontier after adding risk-free assets

Everyone should allocate the assets to the risk-free assets and the optimal risk portfolio. The combination of these two kinds of assets is the effective frontier that the investors finally have to face.

TABLE IX: EFFECTIVE FRONTIER AFTER ADDING RISK-FREE ASSET

Effective frontier after adding risk-free asset			
risk-free asset	risky asset	Portfolio return	Portfolio SD
100.00%	0.00%	0.292%	0.000%
96.00%	4.00%	0.336%	0.422%
92.00%	8.00%	0.380%	0.845%
88.00%	12.00%	0.425%	1.267%
84.00%	16.00%	0.469%	1.689%
80.00%	20.00%	0.513%	2.112%
76.00%	24.00%	0.558%	2.534%
72.00%	28.00%	0.602%	2.956%
68.00%	32.00%	0.646%	3.379%
64.00%	36.00%	0.691%	3.801%
60.00%	40.00%	0.735%	4.223%
56.00%	44.00%	0.779%	4.646%
52.00%	48.00%	0.824%	5.068%
48.00%	52.00%	0.868%	5.490%
44.00%	56.00%	0.912%	5.912%
40.00%	60.00%	0.957%	6.335%
36.00%	64.00%	1.001%	6.757%
32.00%	68.00%	1.045%	7.179%
28.00%	72.00%	1.090%	7.602%

24.00%	76.00%	1.134%	8.024%
20.00%	80.00%	1.178%	8.446%
16.00%	84.00%	1.223%	8.869%
12.00%	88.00%	1.267%	9.291%
8.00%	92.00%	1.311%	9.713%
4.00%	96.00%	1.356%	10.136%
0.00%	100.00%	1.400%	10.558%

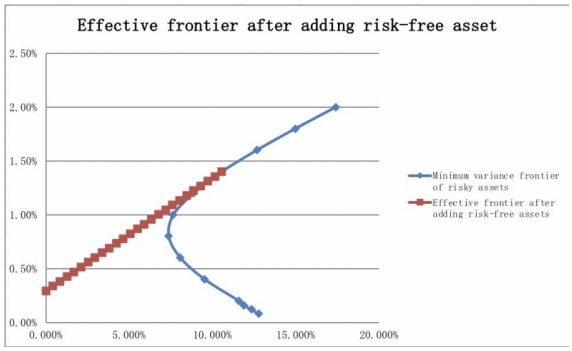

Fig. 4. Scattered diagram of both effective frontier.

As shown in Fig. 4, when the risk-free assets are added, the effective frontier becomes a straight line. The optimal risk asset portfolio point can be obtained by the point with the maximum slope of the point tangent to the risk-free return rate and the effective frontier of risk assets.

C. The Choice of Optimal Portfolio (Utility Function)

Efficient set is an option for one portfolio. For each investor, which portfolio to choose is a personalized matter. Because each investor's preference is different, the expected return and the risk that the investor can bear are different. The cut-off point between utility function and efficient frontier is the optimal portfolio of investors, which is the most suitable portfolio for investors with the highest cost performance ratio of return and risk.

TABLE X: CHANGE OF INVESTOR UTILITY

The change of investor utility level with risk aversion degree of 200				
risk-free asset	risky asset	Portfolio return	Portfolio SD	Utility u
100.00%	0.00%	0.29%	0.00%	0.2920%
96.00%	4.00%	0.34%	0.42%	0.3333%
92.00%	8.00%	0.38%	0.84%	0.3693%
88.00%	12.00%	0.43%	1.27%	0.4009%
84.00%	16.00%	0.47%	1.69%	0.4262%
80.00%	20.00%	0.51%	2.11%	0.4461%
76.00%	24.00%	0.56%	2.53%	0.4617%
72.00%	28.00%	0.60%	2.96%	0.4709%
68.00%	32.00%	0.65%	3.38%	0.4748%
64.00%	36.00%	0.69%	3.80%	0.4743%
60.00%	40.00%	0.74%	4.22%	0.4675%
56.00%	44.00%	0.78%	4.65%	0.4553%
52.00%	48.00%	0.82%	5.07%	0.4388%
48.00%	52.00%	0.87%	5.49%	0.4159%
44.00%	56.00%	0.91%	5.91%	0.3876%
40.00%	60.00%	0.96%	6.33%	0.3551%
36.00%	64.00%	1.00%	6.76%	0.3161%
32.00%	68.00%	1.05%	7.18%	0.2718%
28.00%	72.00%	1.09%	7.60%	0.2232%
24.00%	76.00%	1.13%	8.02%	0.1682%
20.00%	80.00%	1.18%	8.45%	0.1079%
16.00%	84.00%	1.22%	8.87%	0.0432%
12.00%	88.00%	1.27%	9.29%	-0.0279%
8.00%	92.00%	1.31%	9.71%	-0.1042%
4.00%	96.00%	1.36%	10.14%	-0.1850%
0.00%	100.00%	1.40%	10.56%	-0.2721%

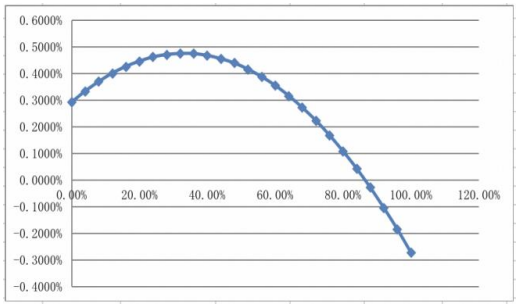

Fig. 5. Diagram with risk aversion degree of 200.

Every point on the efficient frontier is efficient. Each investor chooses his own portfolio on the basis of utility function, that is U=E(r)-0.005Aσ^2, investors should choose the portfolio that can bring him the most efficient use. Because the monthly data is selected, it is found that the effect is not ideal in the analysis. Therefore, in order to ensure the obvious effect, investors with risk aversion degree of 200 are selected for analysis.

Rational investors should choose the most efficient portfolio. Through observation, it is found that 31.05% of risky assets and 68.95% of risk-free assets are the optimal portfolio for investors with a degree of aversion of 200.

If the investor has 1 million capital, he should invest 689500 in risk-free assets and 310500 in risky assets. The proportion of risk assets invested in four kinds of stocks are 16.85%, 16.73%, 18.58% and 47.84%, that is, ZTE with 52300 yuan, Xinyangfeng with 51900 yuan, Jinyuan Shares with 57700 yuan and Tielong Logistics with 148500 yuan.

TABLE XI: OPTIMAL PORTFOLIO FOR INVESTORS

Optimal portfolio for investors					
Bank deposit	ZTE Communications	Xinyangfeng	Jinyuan Ep Co.	Tielong Logistics	
68.95222795	5.231528698	5.193098175	5.769352821	14.85379236	100

V. CONCLUSION

According to Markowitz's portfolio theory, using Excel to analyze the mean variance and solve the programming problem is feasible and has a certain reference value. China's stock market has the feature that systemic risk accounts for a large proportion of the total risk, which makes the diversification effect of various portfolio strategies on the unsystematic risk is not ideal.

As investors, they should have a clear understanding of the operating conditions and solvency of the enterprise, like reducing the liquidity risk and the value of standard deviation. The risk of securities investment is derived from the time-space difference and income difference in investment activities, and also due to the limited understanding of investment and financial products and the defects of the products themselves [6], as well as the information asymmetry and mistakes in the process of investment, the investment deviates from the expected results, and the value of standard deviation increases. Investors can properly use the mean variance theory to participate in the portfolio decision.

As the investment and financial products are becoming increasingly diversified, investors should pay attention to the correlation when choosing investment projects or products for portfolio investment, and try to choose a variety of securities portfolio with less correlation or negative correlation. The risk factors of securities market exist objectively, so the risk of securities investment is also objective. In the securities investment activities, investors should improve the risk awareness, do a good job in risk prevention, and try to avoid and reduce the investment risk in the investment. The risk of securities investment is uncertain. Investors should compare the risks and returns of different securities, and make the right investment decisions according to their own investment preferences and income expectations, so as to effectively avoid risks.

Due to the limited selection of variables in this paper, and that the daily trading volume of each exchange is different, the follow-up research needs to be further improved. In addition, time combination can be considered (when investing, don't invest in one product at a time, but invest in stages and batches [7]), especially for the financial assets with high volatility and high risk, it is of great importance to take timing into consideration. Although the strategy is relatively passive, it actually plays an objective role in dispersing investment risks. The follow-up research can focus on the combination of time and space to reduce the risk of investment as a whole.

CONFLICT OF INTEREST

The author declares no conflict of interest.

AUTHOR CONTRIBUTION

The author independently completed this paper.

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