Empirical Experiments on Financial Risk Management under Global Recession

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Abstract: With the volatility of financial market and the aggravation of system risk, financial market risk management has become the focus of financial industry. Markowitz in 1952, in his academic paper “portfolio selection”, for the first time application portfolio for the mean and variance of the two mathematical concepts, explicitly defines the mathematical formulation of the returns and risk of investors, to create the Markowitz asset pricing model, solved under some constraint conditions to solve the optimal ratio of investment. The Markowitz model is generally considered to have three insuperable shortcomings. The software used in this article is R language General Algebraic modeling system and Python which is used to calculate metrics such as the rate of return, expected return and so on.

1. Introduction

1.1 The Research Background

Since the creation of the securities market, risk has always been an important indicator that investors pay attention to. At the macro level, there are three broad trends affecting risk in financial markets. The three trends are the diversification of stock market, the expansion of international market and the popularization of electronic trading. Influenced by these three major trends, more and more types of financial risks with greater and greater deterrence appeared in the securities market. The diversification of securities market means that there are more and more new securities and the composition of investors is more and more complex, which leads to the rapid aggravation of the credit risk and legal risk of securities investment. The expansion of the international market means that the market size increases year by year and the internationalization degree of enterprises increases year by year, so the market risk, exchange rate risk, liquidation risk, liquidity risk and so on are more and more uncertain. The popularity of electronic trading means that electronic Internet trading, big data information service, automatic trading system and other innovations have become an important part of the securities market, so the risks of electronic operation and the security risks of information platform will become a major challenge for the securities market.

In 2007, the international subprime mortgage crisis broke out in the United States, and in the following for a long time to international investors brought huge losses. In mid-July 2008, the us real estate mortgage giants “Fannie and Freddie” suffered huge losses of 70 billion dollars and were finally taken over by the US government. Shares in General Motors, America's largest carmaker, have fallen to their lowest level in more than 50 years as bankruptcy looms. In mid-September 2008, Lehman Brothers, the fourth-largest INVESTMENT bank in the United States, fell into a severe financial crisis and filed for bankruptcy protection. Merrill Lynch was acquired by Bank of America.

Three of Wall Street's five biggest investment banks failed. In addition, the global stock market value of trillions of dollars was evaporated, resulting in many people can not afford to pay the mortgage, funds and banks and other institutions suffered heavy losses. Although the loss of investors in China's securities market in the crisis is relatively limited, but with the gradual increase of China's financial opening, RMB and China's securities market become more and more international, the risk of the securities market will become more and more unknown. In the situation of China's securities market with a short history and many problems, investors can take the American subprime mortgage crisis as a model case and learn strategies of risk management from it.

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In the middle of 2015, China's stock market suffered a “stock crash”. The Shanghai Composite Index reached 5,178.19 points at one time on June 12, 2015, and then plunged to the lowest 2,850 points, with a range amplitude of more than 2,300 points, a decline of 45%. Meanwhile, there are some defects in the ability of Chinese shareholders to predict market risks, and a large number of shareholders' hard-earned money is “trapped”. Different from the mature foreign securities markets, China's securities market is still in the development stage, with the major characteristics of high speculative and large fluctuation of emerging markets. Violent market shocks and speculative behavior have brought high risks as well as high returns, and vicious financial events have occurred continuously. In this environment, government agencies, pension funds and commercial banks are becoming more and more cautious when choosing their portfolios, and the stable operation of these investors will be further challenged by market risks. From the point of view of national and social stability, once these institutional investors suffer heavy losses, it will affect the stability of the country in all aspects, the consequences are unimaginable. Therefore, it is urgent to explore an effective model to quantify investment risk and return.

Risk is commonly defined as the degree of uncertainty about future net returns. As for risk measurement, people commonly use variance, VaR and CVaR, which are three common risk management models in the market: traditional Markowitz mean variance model, VaR model and CVaR model. Each of the three models has a number of complex technical indicators. How to select the most suitable model and index for risk management of China's securities market from many models and indicators has been one of the hot topics in academic circles. At present, some research achievements in this field have been accumulated in domestic and foreign academic circles. However, empirical research on portfolio risk management model based on high-order moment distribution of skewness coefficient and kurtosis coefficient has not been involved in the past. The academic community generally believes that it is difficult to test the model empirically due to the complexity of the model with high moment constraints and the huge volume of market data.

With the help of R language big data regression analysis programming software, this paper attempts to make an evaluation and comparative study on VaR model, CVaR model, mean-variance model, skewiness coefficient and kurtosis coefficient by combining with a large number of data of the mature S&P100 market in the United States in 10 years before and after the subprime mortgage crisis. Attempts to make a breakthrough in both quantifying and combining international experience. Finally, this paper will try to draw lessons from the experience of the American market, for the reasonable control of China's securities market portfolio risk, improve the comprehensive competitiveness of China's local financial system, and promote the leap-forward development of China's financial industry and risk control management.

1.2 Research Ideas and Paper Structure

This paper includes six parts: introduction, risk management of securities, risk management model, high order moment, empirical research on risk management based on high order moment, important conclusions and prospects. The first part of the introduction focuses on the background, significance and important domestic and foreign historical documents; In the second part, the risk management of securities market aims to compare the risks of domestic and foreign securities markets and introduce the methods of risk measurement of securities market. The third part of risk management model will introduce the traditional Markowitz theory, VaR model and CVaR model one by one, the process of solving and programming modeling; In the fourth part, the first to fourth order moments of the distribution function are introduced successively, and the meaning of skewness coefficient and kurtosis coefficient of the high order moments, the setting of constraint conditions and the programming modeling process are emphasized. In the fifth part, the empirical study of portfolio risk management based on high order moments will introduce the process of data selection, processing and model testing, and then compare the returns of each model in the span of five years. The sixth part of the important conclusions and prospects will state the empirical research results, put forward the domestic financial market risk management can be used for reference.

1.3 Main Innovation Points and Shortcomings

The innovation of this paper lies in the empirical comparison of VaR, CVaR and the traditional Markowitz mean-variance risk models with high-order moment constraints. The author closely analyzes and discusses the effect and robustness of risk control with the addition of high-order moment skewness and kurtosis coefficient constraints, aiming to find the portfolio ratio that enables investors to bear the minimum risk and obtain the maximum return with the help of big data statistical software R language. The authors used daily closing data for the S&P 100 quality stocks from 2004 to 2013, taking into account market conditions before and after the great crisis. In addition, the author has written the code of mean-Variance, VaR and CVaR models of R language regression analysis software.

There are several shortcomings in this paper which need to be improved.

Firstly, the data in this paper are only selected from well-known companies in S&P 100, which cannot represent the situation of the entire stock market. The sample size is small and there is survivor bias.

Second, the model in this paper still has the problem of long computing time, and the time for regression calculation of big data should be measured in hours, so the research efficiency needs to be improved.

Thirdly, the model in this paper does not take into account important risk factors such as macroeconomic indicators, so it cannot be directly used by rational investors, but can only be used as a reference for portfolio weight ratio.

Fourthly, this paper does not make the most comprehensive explanation of some results of empirical test of the model.

The authors have two short-term plans for further research. Firstly, the author hopes to find more suitable constraints of skewness and kurtosis coefficient. Taking kurtosis coefficient as an example, the constraint condition of kurtosis coefficient selected in this paper has no influence on the model results, perhaps because the constraint condition is not set properly. Secondly, the author hopes to explore a modeling method including rolling time window, so as to optimize the model to get a better portfolio weight ratio. The author's long-term plans for further research will focus on trying more empirical studies of this model, such as empirical studies based on the data of China's securities market.

2. Risk Management of Securities Market

2.1 Risk Analysis Based on Var Model

One shortcoming of the traditional Markowitz model is that it does not separate the “risk” of profit from the risk of loss. The failure of the traditional Markowitz model to address the tail distribution of losses becomes apparent when investors consider maximizing their returns. Since the VaR model only focuses on the probability of small probability loss value, it can better describe the asymmetric income distribution.

2.1.1 The Var Model

There are three common algorithms of VaR model, namely historical simulation method, variance-covariance method and Monte Carlo simulation method. Due to the need of empirical research, historical simulation method is adopted in this paper. Historical simulation method is a calculation method that assumes that the future is the repetition of history. It will be introduced in detail in chapter 5. At the same time, the calculation amount of VaR model is the least among the three models, which is less than that of mean-variance model. Using the new concept of VaR model, scholars established the mean-risk portfolio optimization model on the basis of the original mean-variance model as follows:

Assuming that the confidence interval alpha is given, $VaR_{\alpha}(R) = min\{V; P(-R > V) \leq \alpha\}$

In the above equation, R stands for portfolio return. You can assume that the total value of the portfolio is $100, so that R is equal to the percentage return.

Suppose there are T periods:t=1…T

Suppose the weight vector of each stock is: $\omega \in R^N$

Suppose the expected expected earnings are: ρ

Then the portfolio problem based on VaR model can be expressed as:

Minimizing:$E\{-R|R \leq -VaR_\alpha(R)\}$

The constraint:$\underline{r}^T\omega = \rho\ 1^T\omega = 1\ \omega \geq 0$

In the above model expression, the weight can be solved by assuming the expected return ρ. Each unit in the weight should satisfy $\omega \geq 0$, that is, short selling is not allowed.

2.1.2 Disadvantages of Var Modeling

Although the VaR value at risk model mainly aims at the occurrence probability of small probability loss, the VaR model does not explain the specific shape of tail distribution. For example, suppose you have two portfolios with the same 5% VAR of the return distribution, but maybe one of them has a 1% VAR of -10% and the other has a -90% VAR. Valuing the two portfolios at 5 per cent value-at-risk wrongly treats the two portfolios as equivalent.

2.2 Risk Analysis Based on Cvar Model

CVaR model is defined on the basis of VaR model, and an expectation condition is added. According to the definition of CVaR, its expression is: $CVaR_\alpha(R) = E\{-R|R \leq -VaR_\alpha(R)\}$

In the above equation, R stands for portfolio return. So let's say the total value of the portfolio is $100,making R equal to the percentage of revenue.

2.2.1 Cvar Model

It is not difficult to find from the definition of CVaR:CVaR>= VaR

Suppose T periods: = 1,... , T

Suppose the weight vector of each stock is: : $\omega \in R^N$

Suppose the expected expected earnings are: ρ

In 2000, Uryasev and Rockafellar simplified the CVaR model construction and created a discrete valuation model to simplify the problem to a linear one, namely: $CVaR = V + \frac{1}{\alpha}\frac{1}{T}\sum_{t=1}^{T} \{v_t\}$

Then, the portfolio problem based on CVaR model can be expressed as

Minimizing: $V + \frac{1}{\alpha}\frac{1}{T}\sum_{t=1}^{T} \{v_t\}$

The constraint: $\underline{r}^T\omega = \rho\ 1^T\omega = 1\ \omega \geq 0$

In the above model expression, the weight can be solved by assuming the expected return. Each unit in this weight must satisfy $\omega \geq 0$, that is, it cannot be sold short. Using the above model, VaR can be simultaneously estimated:VaR=V

2.2.2 Expression of Var/Cvar Model in r Language Program

According to the VaR/CVaR model, the author constructs the above model expression in the programming language in R language program, and the process is carried out according to the following steps.

Import data:

$include “SP100.MODEL.inc”

Assuming stock I branch, and t time periods in units of weeks, r is the return:

* set i stocks * set t time; * parameter r(t,i) returns of stock i on week t

Assuming the confidence interval α, expected return, w(I) is stock I with weight between 0 and 1:

Rho = 10.0; Alpha = 0.05; w.lo(i) = 0; W.u p (I) = 1.0; w.l(i) = 1/card(i);

Based on the model theory of Uryasev and Rockafellar, the CVaR/VaR model and constraint conditions are obtained as follows:

cvar =e= VAR + 1/alpha/card(t)*sum(t,v(t)); sum(i, w(i)) =e= 1; sum(i, rbar(i)*x(i))*52 =g= rho; v(t) + sum(i,r(t,i)*w(i)) + VAR =g= 0;

The calculation is as follows:

model portfolio /all/; solve portfolio using nlp minimizing cvar; display VAR.l , cvar.l , w.l;

The above R language programming language can be used to match the portfolio of a given investment option based on VaR and CVaR models according to the database information.

3. Empirical Research

3.1 Sample Data Selection

In the empirical analysis, we choose 8 risky assets for investment analysis. Among them, 8 risk assets are “PG”, “GS”, “WMT”, “AAPL”, “TSLA”, “BA”, “F” and “CAT”. The closing price data of these 8 stocks from July 20, 2020 to July 16, 2021 are selected for analysis. First, the cumulative daily returns of these 8 stocks are given, as shown in Figure 1. It can be seen that the return rate of different stocks is different. The cumulative return rate of PG and WMT keeps at a low level with small fluctuation, while the cumulative return rate of TSLA stock is higher with large fluctuation.

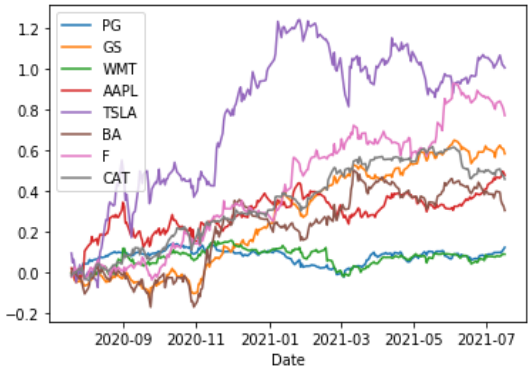


Fig.1 Daily Cumulative Returns of 8 Stocks

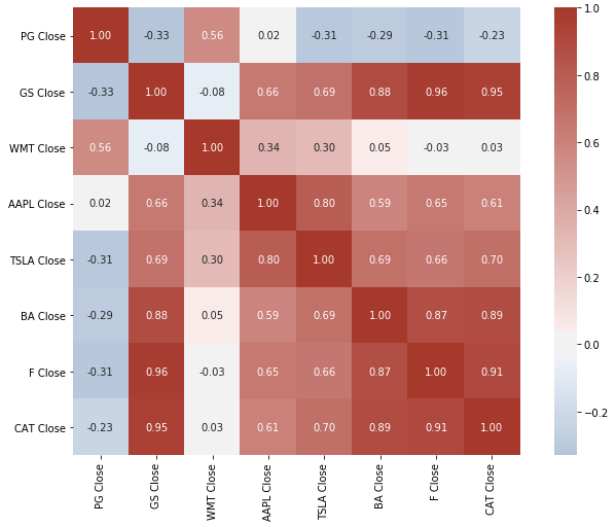


Fig.2 Chart of the Closing Prices of the 8 Stocks

Then we analyzed the correlation graph of the eight assets, as shown in Figure 2. It can be seen that “PG” and “WMT” have a high correlation. It can also be clearly seen from Figure 1 that these two assets are low-risk assets, while the other six assets have a high correlation. Combined with Figure 1, it can be seen that “GS”, “BA”, “F” and “CAT” have similar trend curve of daily cumulative return with high correlation, and the risk and return of these assets are at a medium level. The other two assets “TSLA” and “AAPL” have high correlation, and the trend curve of their daily cumulative

return is similar as shown in Figure 1. “TSLA” assets are riskier. The following paper will use the above 8 assets to make empirical analysis.

3.2 Empirical Simulation of Mean-Variance Model

By selecting the expected return between 10% and 50%, we calculate the optimal risk-return curve of the traditional Markowitz model for the period From July 2020 to July 2021 using Python software when considering the investment proportion of eight stocks. The results are shown in FIG. 3. The basic shape of the curve is basically similar to the optimal investment frontier in Markowitz model theory. Under the same risk, investors always choose the portfolio with higher return, so only the upper half of the curve has practical significance, which is called the efficient boundary, as shown in the green curve in the figure. The efficient boundary is essentially, every point above it is the point of the portfolio that has the minimum volatility for a given return. Therefore, the calculation of the point on the effective boundary can be described as: given the return rate of this point, the weight combination is calculated to minimize the volatility of this point, which is obtained in this paper. At the same time, it can be seen that with the increase of variance, the growth of expected return shows a diminishing trend, and this curve perfectly presents the marginal diminishing effect of investment portfolio.

In addition, there are two special points in the figure, one is the point with the smallest variance, the other is the point with the largest Sharpe rate, where the red five-pointed star is the portfolio point with the largest Sharpe rate, the corresponding yield is 0.481, the variance is 0.188, and the Sharpe ratio is 2.559. The portfolio weight is shown in Table 1. The yellow five-pointed star is the portfolio point with the minimum variance, the corresponding return rate is 0.207, the variance is 0.129, and the Sharpe ratio is 1.608. The weights of the eight stocks are shown in Table 3. It can be seen that stocks with low volatility have a larger proportion of the weight, such as PG and WMT, while those with high volatility have a smaller proportion of the weight.

When an investment strategy with the same weighting of eight stocks is used, the corresponding return is 0.406 and the variance is 0.202, which is lower and riskier than the maximum Sharpe rate portfolio strategy.

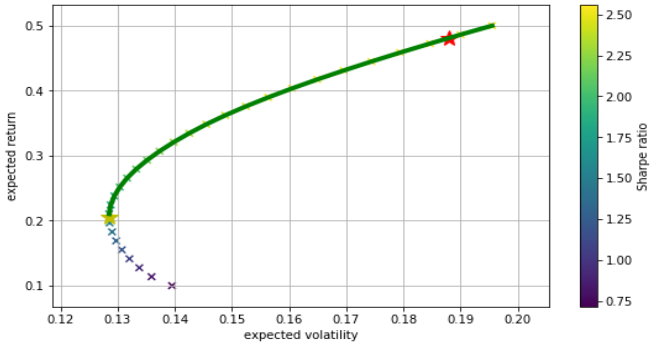


Fig.3 The Optimal Curve of the Traditional Markowitz Model for Venture Capital Returns between July 2020 and July 2021

Table 1 Minimum Variance Portfolio of Each Asset Investment Weight

Investment Asset Type	Portfolio weighting ratio
PG	0.5718
GS	0.1337
WMP	0.1892
AAPL	0.0259
TSLA	0.0
BA	0.0
F	0.041
CAT	0.0384

Table 2 Maximum Sharpe Ratio the Weighting of Each Asset in a Portfolio

Investment Asset Type	Portfolio weighting ratio
PG	0.5718
GS	0.1337
WMP	0.1892
AAPL	0.0259
TSLA	0.0
BA	0.0
F	0.041
CAT	0.0384

3.3 Empirical Simulation of Portfolio under Different Investment Preferences

When making investment, some investors can accept higher risks, while others prefer capital preservation investment, hoping to obtain greater returns with as little risk as possible. This section will study the optimal risk portfolio according to different investment preferences. The value of Tau is the measure of risk preference. The larger the value of Tau, the more inclined to higher returns, and the smaller the value of tau, the more inclined to lower risks. 0.05 to discuss the return on investment. As shown in figure 3.

As shown in Figure 3, when tau value is 0.05, the daily return rate from October 2020 to July 2021 fluctuates greatly, reaching a maximum of plus or minus 7.5%. In this case, there are both high returns and high risks. Each day's weighting is determined by the average daily return of the previous 50 days and the variance of the daily return. According to the empirical analysis, when the investment is biased to low risk, the overall fluctuation of the investment return rate is small, and the average return rate is 0.057%. The investment weight here allows negative value, which means that short selling is allowed in this investment strategy. The orange curve shows the return on each risky asset with the same proportion of investment. The average daily return is 0.1888%. (b),(c),(d),(e) and (f) respectively represent the time sequence diagram of return rate when tau value is 0.01, 0.02, 0.03, 0.04 and 0.05. It is not difficult to see that the average daily return rate decreases with the increase of Tau value, indicating that when the tau value is inclined to high return, Using the 50-day average rate of return to determine the weight of the day does not necessarily yield high returns.

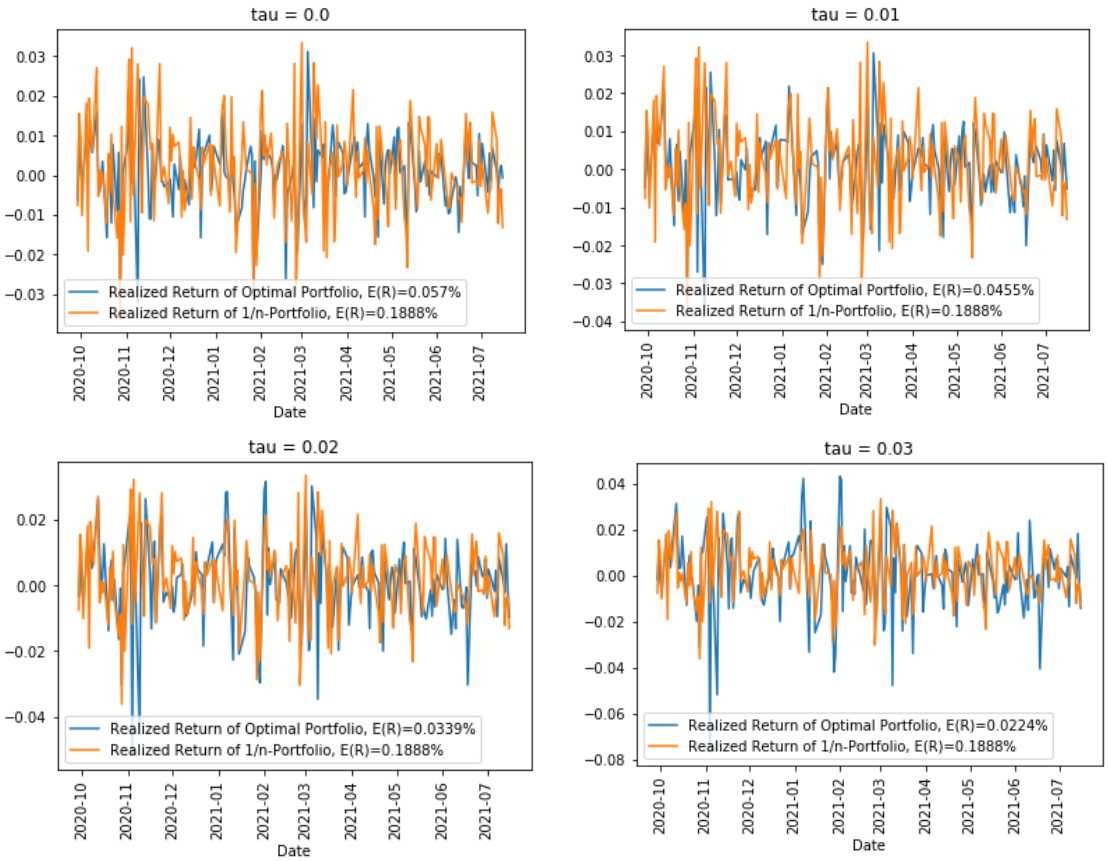
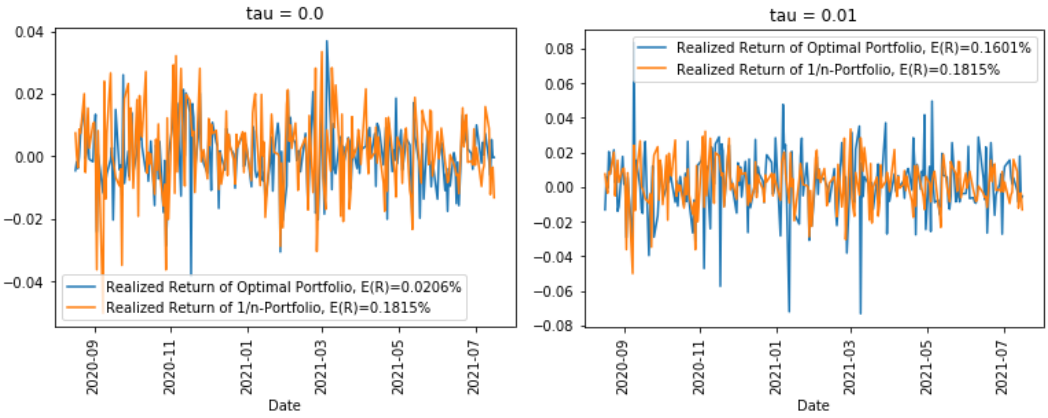


Fig.4 The Average Daily Return Rate of Different Tau Values When n is 50 Days

If the average daily return rate of 20 days in history is taken as the reference for the investment weight of the day, the results are different from those of 50 days in history. The results are shown in Figure 4. It can be seen that when the weight ratio of each investment asset is the same, the average return on investment is 0.1815%. With the increase of tau value, the average return rate keeps increasing, and when tau value is equal to 0.02 to 0.05, The weight is determined according to the daily average return rate of the first 20 days, so that the average return rate of investment is higher than the average return rate of each investment asset with the same weight proportion. Figure 5 shows the change of average return rate and variance under different tau values. At this time, with the increase of tau value, the average return on investment also increases, and even exceeds the return on investment under the same investment weight.

From the above analysis, it can be seen that in the historical forecast period, the value of risk preference will affect the average investment yield. When tau value increases, investors are more inclined to high return, which will bring high risk and thus affect the investment yield. From the empirical analysis, the average investment return when the historical period is 20 days is higher than that when the historical period is 50 days. So is the smaller the historical cycle, the better? The tau value is 0.05, and the results of subsequent research and analysis show that when the historical forecast period is less than 10 days, the return rate obtained is contrary to the actual. When n=13 days, the average daily return rate reaches the maximum value of about 0.019, and then decreases with the increase of the period. See Figure 6.



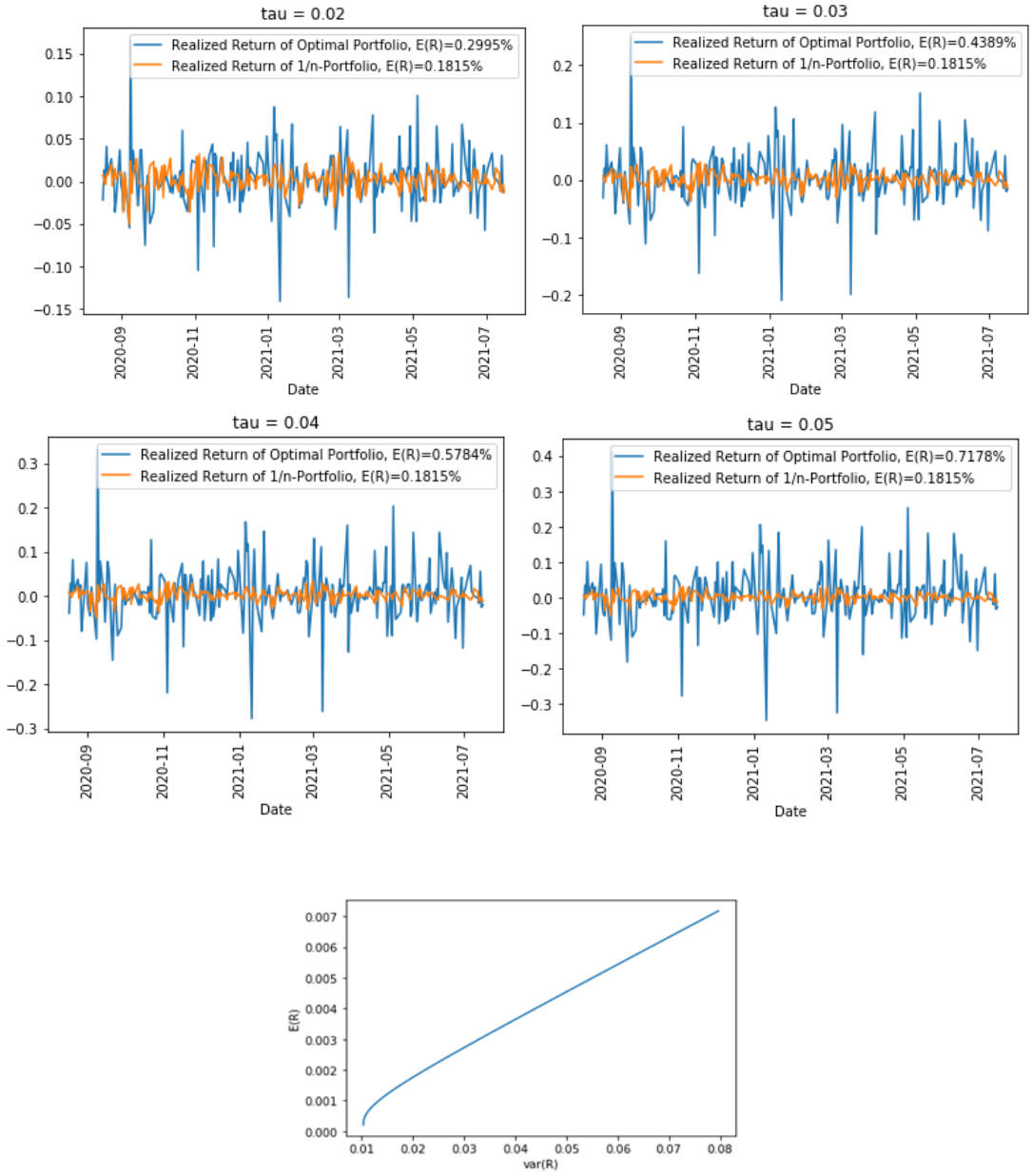


Fig.5 When Tau Value Increases, the Change Curve of Daily Average Return Rate and Average Variance

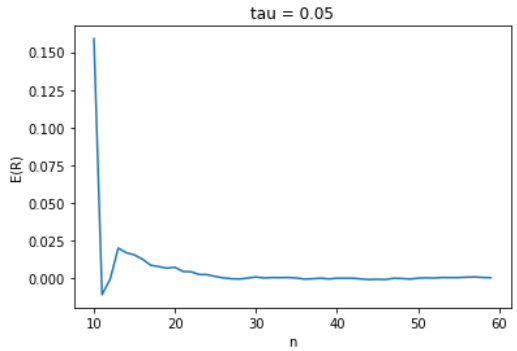


Fig.6 The Change Curve of the Daily Average Return on Investment as the Historical Forecast Period Increases

4. Conclusions and Prospects

In this paper, eight risky assets are selected for empirical analysis of risk portfolio, including two low-risk assets, four risky assets, and two high-risk assets. The closing price data from July 2020 to July 2021 are selected to conduct empirical simulation of mean-variance model and portfolio empirical simulation under different investment preferences. The conclusions are as follows:

In the empirical simulation of the mean-variance model, this paper obtains the optimal risk-return curve of the traditional Markowitz model from July 2020 to July 2021. The basic shape of the curve is basically similar to the optimal investment frontier in Markowitz model theory. Under the same risk, Investors will always choose a higher yield portfolio. In addition, with the increase of variance, the growth of expected return shows a diminishing trend, and this curve perfectly presents the marginal diminishing effect of the portfolio. In addition, this paper also solved two kinds of classical portfolio, one is the portfolio with the minimum variance, the other is the portfolio with the maximum Sharpe rate, the corresponding yield is 0.207 and 0.481, the variance is 0.129 and 0.188, and the Sharpe rate is 1.608 and 2.559, respectively. From the perspective of the two different portfolios, the portfolio with the smallest variance assigns more weight to low-risk assets, for example, PG and WMT account for 0.5718 and 0.1892 respectively. The largest Sharpe ratio portfolio comprehensively considers the assets of various risk levels, and mainly assigns the weight to the medium and low risk assets: “GS”, “F”, “PG” and “AAPL”, accounting for 0.3451, 0.2052, 0.1928 and 0.1465, respectively.

In risk investment, considering investors' different acceptance of investment risks, this paper adds the risk preference factor Tau value. The greater the value, the higher the risk can be borne. History on this basis, the selected 50 days of daily average yields 20 day average yields with history to determine the weight of the portfolio, the results show that the selected historical 20 day average daily yield average daily yields higher weights to get, at the same time, when the tau value reached 0.02, which is able to bear the risk of can achieve a certain degree, According to this method, the average investment yield is higher than that given the same weight. In order to further study the influence of the historical forecasting period on the investment return, this paper selects more historical forecasting periods to test the change of the investment return. The results show that when the historical forecasting period is 13 days, the average investment return is the largest, and then with the increase of the period, the average investment return gradually decreases.

At present, China's securities market is not so mature, from policy to supervision, from information technology to supporting industries, our level and professional level are far from the level of western markets. On the other hand, most domestic investors lack a rational understanding of the market, and they are more likely to follow their feelings, blindly listen to others' opinions, and invest with a speculative attitude, which will inevitably lead to large fluctuations in the price of financial products and very low risk resistance. There are also political disasters and human factors that have unknown effects on the prices of financial products. Therefore, the existing venture investment portfolio model may not bring the corresponding income as expected, so more venture investment portfolio models can be considered in the future, so as to be more close to the trading characteristics of the domestic market.

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