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The Portfolio Analysis in Hong Kong Stocks

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Abstract: Maximizing returns is always people's investment goal. Stocks have some hedging capabilities, and their prices also fluctuate widely, making them popular investments for investors. As a result, Stock prices have fluctuated wildly, leading to uncertain investments and uncertain returns. To compute and analyze the maximum returns of stocks in Hong Kong stocks, this paper takes The Hang Seng index, an important indicator of Hong Kong stock market prices as the scene. We calculate the variance of these stocks using the Fama experiment. And We examined the normal distribution and i.i.d. of the data. To test whether the hypothesis of independence and the same distribution in the data is reasonable, and then conduct an ACF test on the five selected stocks to observe their time-series stability. Then, this paper uses Markowitz's effective frontier decision-making process to simulate stock trading and use the Sharp ratio risk analysis to select mid-risk and high-yield portfolios. The results show that: The weight of the five stocks shows an approximate trend with their average return rate. The larger the average value is, the larger the investment proportion will be. stock investment with low-risk accounts for a relatively high proportion, while stock investment with high-risk accounts for a relatively small proportion. Among the selected several representative stocks, Techtronic Industries and Long for Group have more investment value, while the investment value of bank stocks is on the low side.

Keywords: normal distribution and i.i.d.test, efficient frontier, portfolio, Sharpe ratio

1. Introduction

Market traders often buy and sell volatile assets with the goal of maximizing their total returns. There is usually a commission on every sale. One of those assets are stocks. There is volatile property in the market, and its value constantly fluctuates over time. Traders can maximize total returns by constantly buying and selling volatile property to continuously increase the total value of the holding property. But different investment projects require a different commission for each sale. Investing is not blind; the key issue of trading decision is to execute the right decision at the right time. When holding a variety of property such as stocks needs more strategy. Investors decide whether to buy the property or sell or continue to hold the property in the portfolio.

Currently, numerous investigations have been done regarding the portfolio management for financial asset. According to the classical financial theory, rational investors will choose the optimal investment portfolio in the whole market. However, in the real market, there is always a certain

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deviation between the investment portfolio held by investors and the ideal model. In the study on the portfolio analysis of Hong Kong stocks, funds showed a significant local preference to hold Chinese stocks, which is negatively correlated with price fluctuations in Chinese stocks and Shanghai markets and is positively associated with price fluctuations in Hong Kong cities, possibly due to the information advantage or familiarity with Chinese stocks [1]. The linkage effect and the risk spillover effect the Hong Kong stock market are both time-varying [2].

And other scholars studied the quantitative portfolio strategy for the AI industry [3]. The advantages and disadvantages of the mean-variance model and the capital asset pricing theoretical model [4]. The related strategies of the stock portfolio [5].

About Markowitz's research noted that: Even with a small number of portfolios, the portfolio sharp ratio has increased significantly. Therefore, a small number of portfolios can still avoid non-systemic risks and achieve relatively safe and stable returns [6]. Some researchers to the Shanghai A share stock yields, proved that under the Markowitz securities portfolio evaluation criteria, using the stock portfolio selection method, can get the same yield level, lower risk of stock portfolio, for investors to choose reasonable stock portfolio provides a new way to choose stock portfolio [7].

Combing past research found that: there is no clear analysis of portfolio in Hong Kong, is more for the research of investors investment tendency, and for fama experiment and Markowitz mean-variance theory research points out that these methods can be applied to the analysis of the portfolio and can be used to a smaller number of portfolios.

The empirical process is summarized as follows. First, replicate the Fama experiment using the given dataset, and assuming that existence of a risk-free asset which pays a yearly return of 1.94%. Check that assumptions of normal distribution, independence and identical distribution are reasonable in the data. Secondly, five stocks were selected for a normal distribution and ACF test. the mean and covariance of risky assets was calculated using RStudio. Third, Markowitz's Efficient Frontier is used to simulate stock trading based on the Portfolio Theory decision process of avoiding risk, using Sharpe ratio risk analysis, Markowitz's Efficient Frontier of portfolio management for comparison, select the portfolio with medium risk and high return. Finally, based on the above results, the quantile of the theoretical normal distribution with the same parameters as the sample is compared with the quantile of the sample distribution.

2. Method

2.1. Markowitz portfolio theory

Risk and expected return are the two core issues that investors are most concerned about. Therefore, it is what every investor wants to achieve to determine the return and risk of an asset investment and to achieve the optimal asset allocation on the basis of balancing the two indicators. In this context, Markowitz published a work called Portfolio Selection in 1952, and mean-variance Model was formally introduced. In this paper, Markowitz proposed to use the mean value of risky assets to represent the expected return rate and variance (or standard deviation) to represent the risk level, and then explored the problem of asset portfolio and selection. The key role of the theory is to guide investors to invest their funds in various securities according to a certain proportion, so that the risk is minimum when the given expected return is realized, or the return is maximum when the given risk is achieved. In this paper, by referring to existing studies and using the data of 5 stocks in Hang Seng stocks from 2010 to 2021, the Markowitz mean-variance model is used to realize quadratic programming in R, and the weight and minimum standard deviation of each security corresponding to the set expected return rate are obtained, and the effective frontier is obtained [8].

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2.1.1. Mean-variance model.

Suppose that the investor invests in a portfolio composed of N risky assets in a single investment period, and Ri represents the expected return rate of the ith asset, then the expected return rate of the portfolio is:

$$E(r_p) = \sum_{i=1}^{n} x_i E(r_i) \tag{1}$$

x_i represents the proportion of investment in the first asset. σ_i^2 is used to represent the variance of the i asset, then the variance of the portfolio composed of n assets is

$$\sigma_i^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} x_i x_j cov(r_i, r_j) = \sum_{i=1}^{n} x_i^2 \sigma_i^2 + \sum_{j=1(j\neq i)}^{n} x_i x_j p_{ij} \sigma_i \sigma_j \tag{2}$$

According to the formula, the risk of portfolio mainly depends on the investment proportion of each asset, the correlation coefficient between different securities, and the standard deviation of each asset. Therefore, investors should preferentially choose assets with small variance and low correlation coefficient to construct their portfolios so as to reduce investment risks.

2.1.2. Effective boundary.

The idea of risk pricing expressed by Markowitz in this paper can be visually presented by means of mean-variance (or standard deviation) two-dimensional graphics. The line segment above the turning point in the figure is the effective frontier. It can be seen that risk (standard deviation) affects the expected return rate of assets. Specifically, the greater the risk, the higher the return rate, and vice versa. The relationship between risk and return rate presents a parabolic curve in the two-dimensional plane, and the above conclusion is based on the assumption of investors' risk aversion. Each point on the effective frontier line segment represents the mean-standard deviation combination. Compared with other points, the investment in the effective frontier part can ensure the maximization of return rate (mean) under a certain risk (standard deviation), or the minimization of risk at a given rate of return.

2.2. Sharpe Ratio

Sharpe simplified Markowitz's mean-variance model and proposed Sharpe ratio on the basis of capital Asset Pricing Model (CAPM), which takes the capital market line as the evaluation basis. When the Sharpe ratio of the portfolio is greater than that of the market benchmark portfolio, the portfolio is located above the capital market line. Outperform the market, otherwise the portfolio is below the capital market line and underperforms the market. Sharpe ratio is the risk-adjusted rate of return, which can simultaneously measure the return and risk of a portfolio. It has been widely used in the financial field, and Sharpe won the Nobel Prize in Economics for this reason [9]. while Sharpe ratio of the basic ideas for similar benefits selection risk level in smaller funds, when a similar level of risk selection higher-yielding fund, which can help investors out of high-yield must bear the risk of error, thus solved the funds under the condition of different risk and return performance ranking hard problem., and the calculation formula is:

$$s_p = \frac{E(r_p) - R_f}{\sigma_p} \tag{3}$$

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s_p represents Sharpe ratio, σ_p represents the overall standard deviation of the portfolio, and R_f is the risk-free interest rate. s_p represents how much excess return an asset portfolio can have for each additional unit of risk it takes. s_p considers both return and risk, and we will use this ratio to measure the portfolio's performance.

We use R to make sure all stocks prices are available over the entire period, and focus on complete time series, then team members figured out the returns on all the stocks available.

2.3. Normal distribution and i.i.d. test

The normal distribution and ACF test were carried out. Q plot is one of the methods to test whether the sample conforms to the normal distribution. Usually, the quantile of the theoretical normal distribution with the same parameters as the sample is compared with the quantile of the sample distribution. If the sample points are basically distributed on the line of the theoretical normal distribution, it can be shown that the sample conforms to the normal distribution.

2.4. Fama experience

Fama randomly selected 50 securities listed on the New York Stock Exchange and calculated their standard deviations using monthly data from July 1963 to June 1968. Then a single security was selected randomly. Its standard deviation of return was around 11%. Next, this security was combined with another (also randomly selected) to form an equally weighted portfolio of two securities. The standard deviation fell to around 7.2%. Step by step more securities were randomly added to the portfolio until all 50securities were included. The portfolio standard deviation quickly approached a limit which is roughly equal to the average covariance of all securities, which means as we choose a large enough number of securities, the standard deviation of the portfolio tends to be fixed, so the risk of the portfolio is fixed [10].

3. Result

According to the above theoretical methods, R language is used to calculate and draw a conclusion. The study uses data from the monthly prices of 66 stocks in the Hang Seng Index over a 12-year period from December 2009 to December 2021 (http://www.hsindex.com). After removing all stocks with incomplete time series, there are still 50 stocks left, and the price is converted into the return.

3.1. Fama experiment

First of all, we know that investment risk can be divided into systemic risk and non-systemic risk. Choosing a portfolio of multiple stocks can diversify the investment risk of a single stock, specifically to reduce the non-systemic risk. According to the Fama experiment, the variance from selecting 1 to 50 stocks can be drawn, as well as the corresponding proportion of systemic risk and non-systemic risk.

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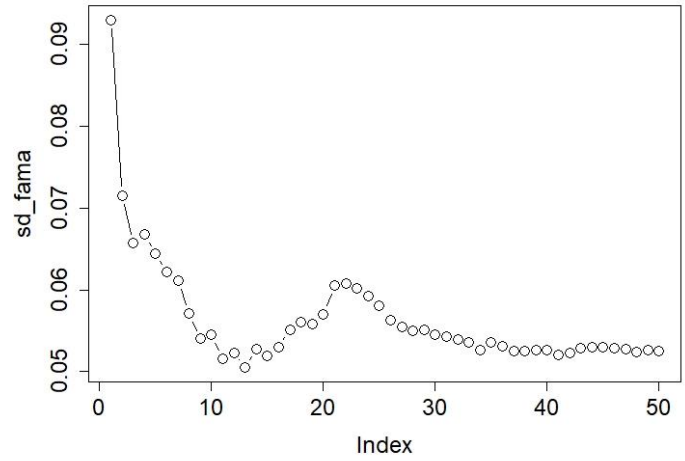

Figure 1: Result of FAMA experiment.

From the figure above, it can be found that when the number of stocks selected is large enough, the standard deviation tends to be a fixed value of about 0.053.

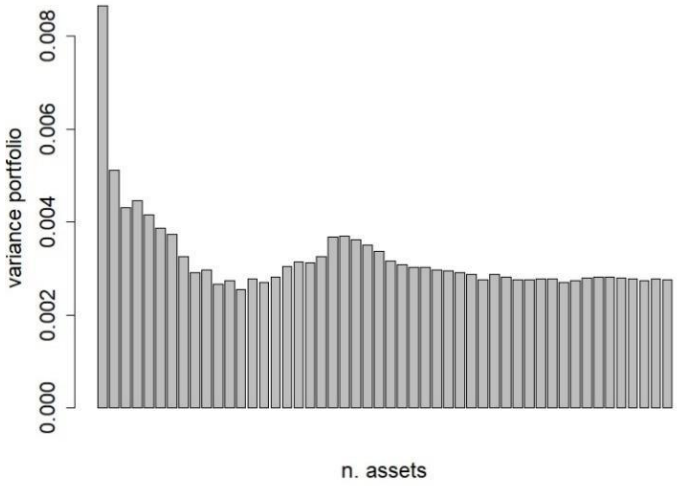

Figure 2: Variances of portfolios with a different number of stocks.

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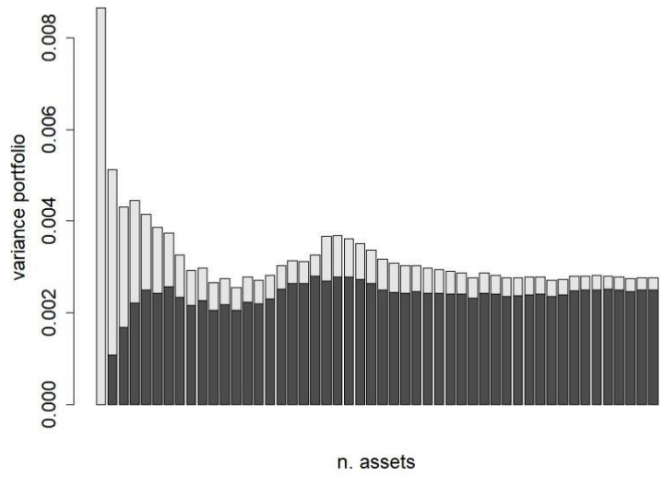

Figure 3: Systemic and non-systemic risk in different portfolios.

From the figure above, it can be clearly found that portfolio variance can be divided into systemic risk and non-systemic risk. When the number of choices is greater than 7, portfolio variance tends to be fixed, and the two risks also tend to be fixed. For the convenience of subsequent research, 5 stocks will be selected for investment in this paper.

3.2. Data

We have selected five representative stocks in these different sectors, including banking operations, telecom operations, Internet services, and tourism services, we aim to analyze the investment portfolio of Hong Kong stocks through multiple industries. i.e., China Merchants Bank, China Unicom Hong Kong, Tencent, Sands China, CK Hutchison Holdings for closing prices, from December 2009 to December 2021. Then, to implement further investigations, we do data cleaning to match the time. Finally, 730 data are collected. We transfer these closing prices to log-returns and some basic information is shown in Table 1.

Table 1: Descriptive statistics of the selected assets.

	China Merchants Bank	China Unicom Hong Kong	Tencent	Sands China	CK Hutchison Holdings
Mean	26.171	9.9401	214.32	32.721	73.448
Variance	196.90	9.7145	30160	131.90	344.45
Max	71.750	17.260	661.46	64.900	121.00
Min	11.707	3.9000	25.329	9.3348	46.600

3.3. Normal distribution and i.i.d. test

The normal distribution and independent identically distributed test were performed on the five stocks. Firstly, calculate the percentage of the five stocks in the range of $(\mu - \sigma, \mu + \sigma)$ and

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$(\mu - 2\sigma, \mu + 2\sigma)$ to the total data. The results of normal distribution test for these five stocks are shown in the following table:

Table 2: The results of normal distribution test for five chosen stocks.

	Mean	Standard deviation	Percentage between $(\mu - \sigma, \mu + \sigma)$	Percentage between $(\mu - 2\sigma, \mu + 2\sigma)$
China Merchants Bank	0.012	0.093	0.736	0.944
China Unicom Hong Kong	-0.003	0.086	0.694	0.958
Tencent	0.022	0.088	0.681	0.951
Sands China	0.011	0.110	0.674	0.951
CK Hutchison Holdings	0.002	0.073	0.736	0.958

The histograms of the five stocks are as follows:

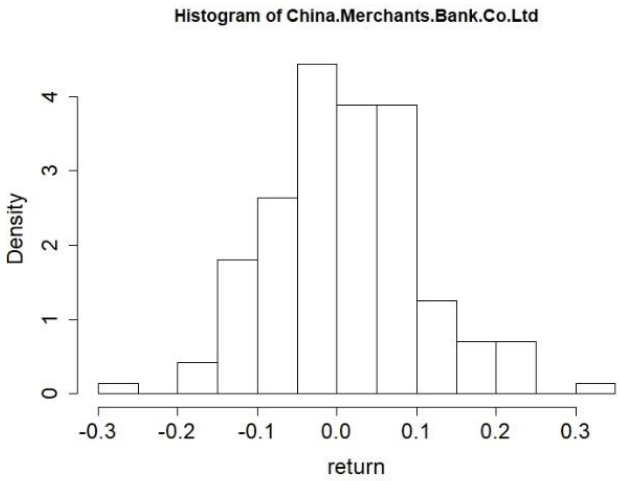

Figure 4: Histogram of China Merchants Bank.

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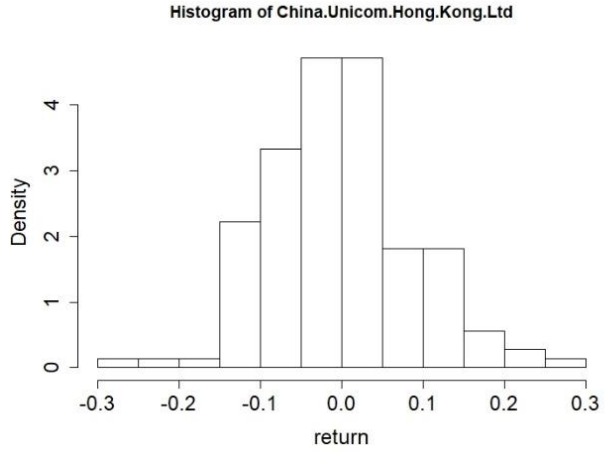

Figure 5: Histogram of China Unicom Hong Kong.

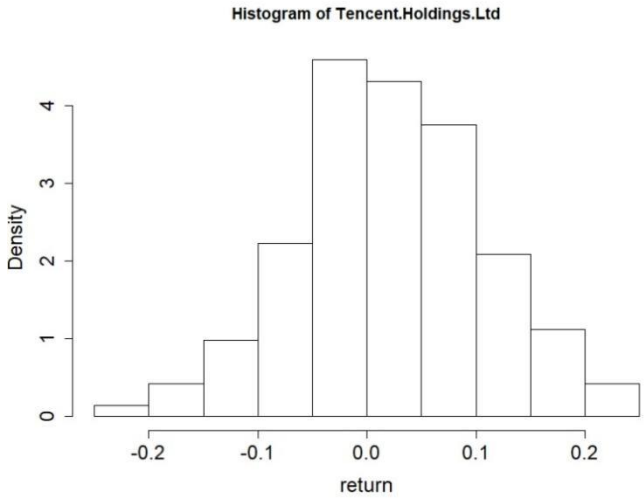

Figure 6: Histogram of Tencent.

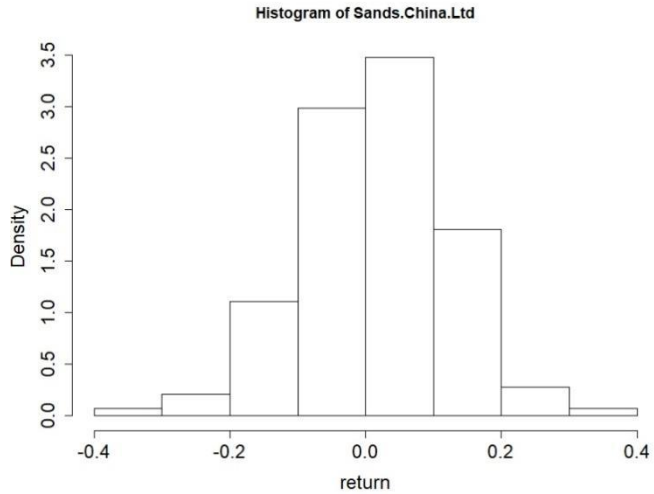

Figure 7: Histogram of Sands China.

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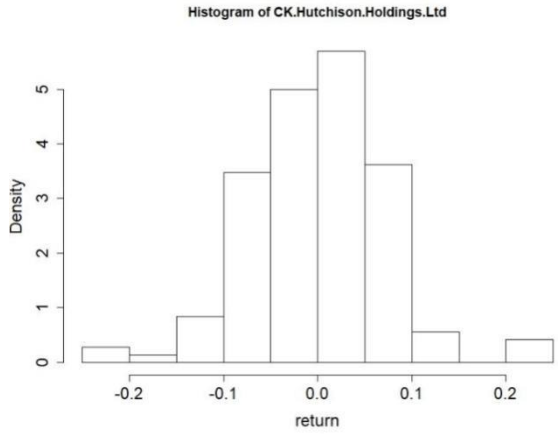

Figure 8: Histogram of CK Hutchison holding.

Then the Q-Q plot of five stocks can be made for normal distribution test. The results are as follows:

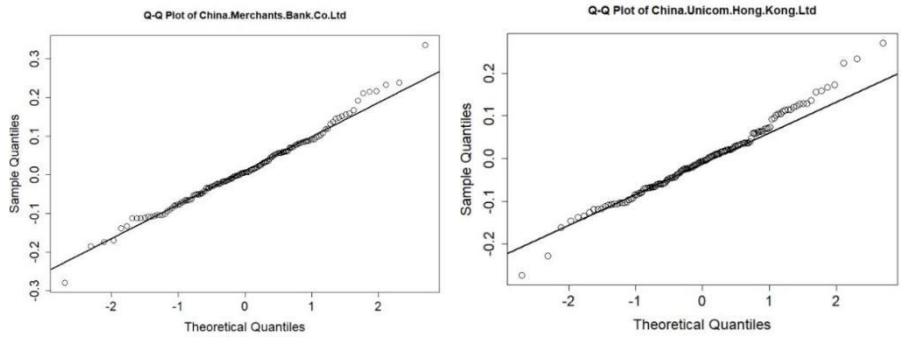

Figure 9: Q-Q plots of China Merchants Bank and China Unicom Hong Kong.

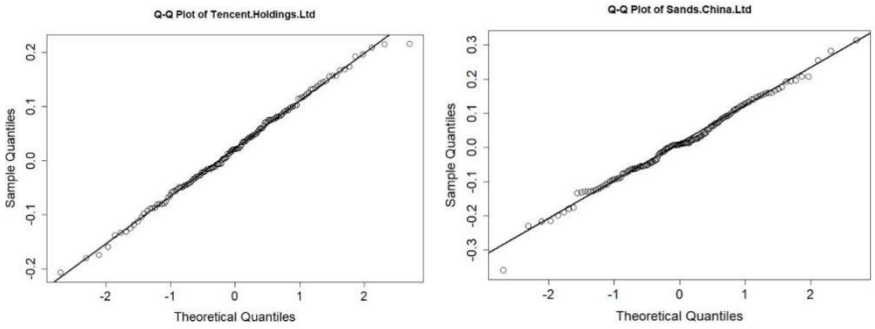

Figure 10: Q-Q plots of Tencent and Sands China.

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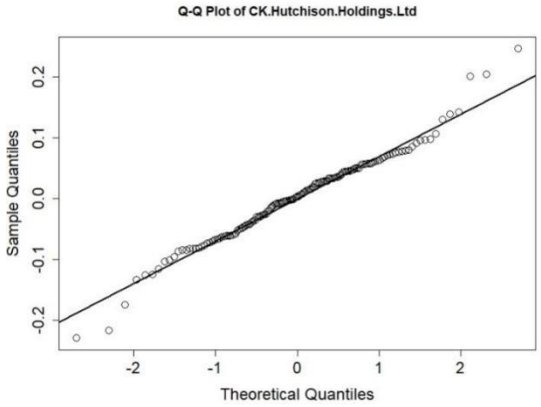

Figure 11: Q-Q plots of CK Hutchison holding.

From result above, it can be found that Tencent and Sands China are relatively in line with normal distribution, while the other three stocks are not.

ACF test was conducted, and the results of the five stocks were shown in the figure below:

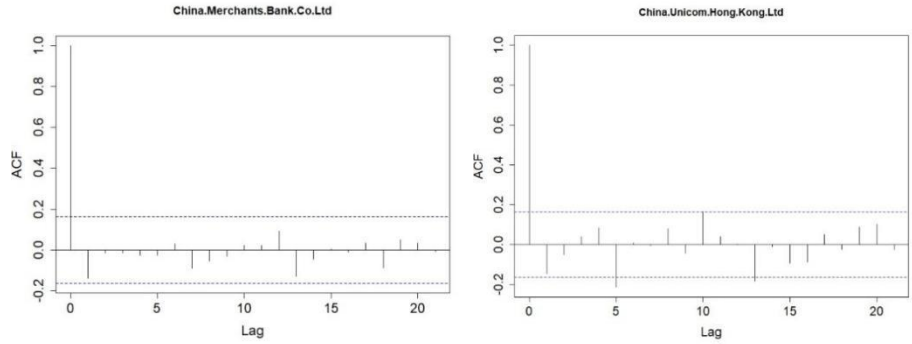

Figure 12: Results of ACF test of China Merchants Bank and China Unicom Hong Kong.

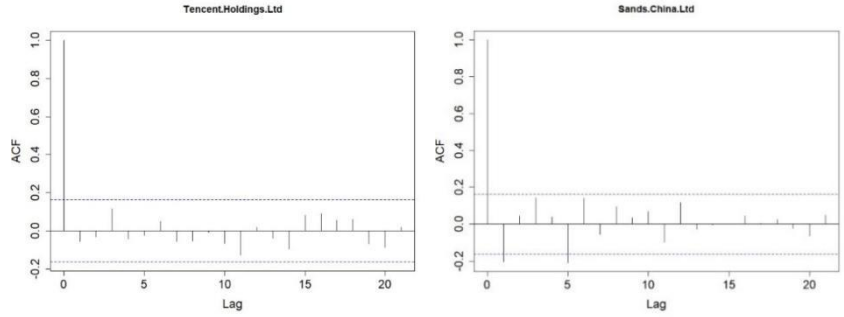

Figure 13: Results of ACF test of Tencent and Sands China.

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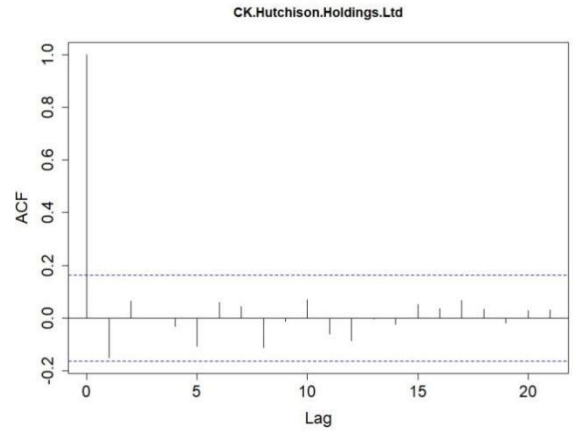

Figure 14: Results of ACF test of CK Hutchison holding.

From the figure above, the time series of China Unicom Hong Kong and Sands China are not stable.

3.4. Portfolio under different conditions

In this paper, one-year yield of National debt is selected as the risk-free rate, and its return is 1.94%. In this paper, the R language portfolio package is used to construct the best portfolio by using the stocks selected above and the risk-free interest rate. The effective boundary can be drawn as follows:

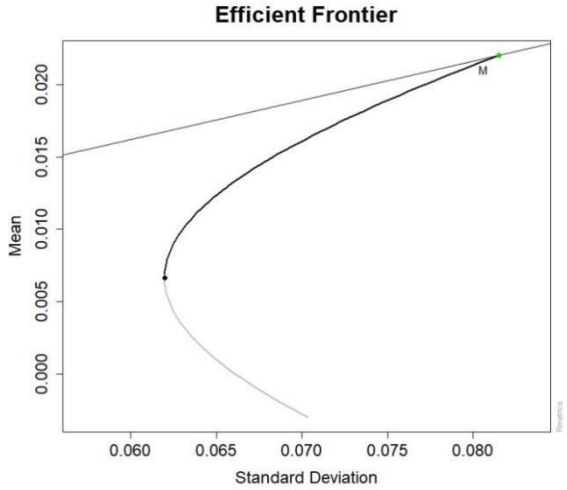

Figure 15: The efficient frontier of the portfolio.

3.4.1. Minimum risk portfolio

According to the figure above, its effective frontier is a part of the hyperbola, and the minimum variance portfolio results can be obtained from the figure as shown in the following table:

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Table 3: The result of minimum risk portfolio.

	China Merchants Bank	China Unicom Hong Kong	Tencent	Sands China	CK Hutchison Holdings
Mean	0.012	-0.003	0.022	0.011	0.002
Standard deviation	0.093	0.086	0.088	0.110	0.073
Weight	0.157	0.267	0.211	0.012	0.353
Portfolio					
Target return	0.007				
Target Risk	0.062				
Sharpe Ratio	0.082				

As can be seen from the above table, CK Hutchison Holdings has the highest weighting, possibly because it has the smallest standard deviation, while Sands China has the smallest investment, possibly because it has the largest standard deviation. stock investment with low-risk accounts for a relatively high proportion, while stock investment with high risk accounts for a relatively small proportion, which is in line with expected cognition.

3.4.2. A portfolio with the highest expected return at expected risk

In order to obtain the highest expected return, it is necessary to determine the expected risk, which is assumed to be 0.07. The results are shown in the following table:

Table 4: The result of the portfolio with the highest expected return at expected risk.

	China Merchants Bank	China Unicom Hong Kong	Tencent	Sands China	CK Hutchison Holdings
Mean	0.012	-0.003	0.022	0.011	0.002
Standard deviation	0.093	0.086	0.088	0.110	0.073
Weight	0.276	0.067	0.541	0.082	0.033
Portfolio					
Target return	0.016				
Target Risk	0.070				
Sharpe Ratio	0.205				

As can be seen from the above table, when the specified risk is 0.07, the expected return rate is 0.016. Tencent has the largest weight (0.541), and its mean value is the largest. CK Hutchison Holdings has the lowest weighting at 0.033. The weight of the five stocks shows an approximate trend with their average return rate. The larger the average value is, the larger the investment proportion will be. China Unicom Hong Kong and CK Hutchison Holdings are on the contrary, but their average values are close to 0.

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3.4.3. Maximum Sharpe ratio portfolio.

According to the results, the optimal Sharpe ratio portfolio can be obtained in the following table:

Table 5: The result of the maximum Sharpe ratio portfolio.

	China Merchants Bank	China Unicom Hong Kong	Tencent	Sands China	CK Hutchison Holdings
Mean	0.012	-0.003	0.022	0.011	0.002
Standard deviation	0.093	0.086	0.088	0.110	0.073
Sharpe Ratio	0.112	-0.054	0.232	0.085	0.005
Weight	0.351	-0.058	0.749	0.126	-0.167
	Portfolio				
Target return	0.022				
Target Risk	0.082				
Sharpe Ratio	0.250				

As can be seen from the above table, Tencent and China Merchants Bank accounted for a relatively large proportion of investment, are 0.749 and 0.351 respectively. It can be found that the stock with a high Sharpe ratio account for a high proportion of investment in the portfolio, while the stock with a negative Sharpe ratio has a negative weight. The weight of each stock in the portfolio with the best Sharpe ratio is positively correlated with its own Sharpe ratio.

3.4.4. Minimum variance and optimal Sharpe ratio portfolio under complete data set

The effective boundary can be drawn as follows:

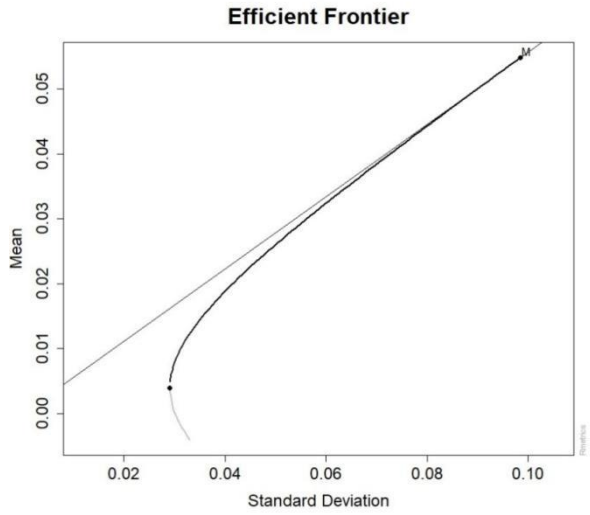

Figure 16: The efficient frontier of the portfolio with the complete data.

With the complete data set, the portfolio results of minimum variance and optimal Sharpe ratio are shown in the following table:

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Table 6: The minimum risk and optimal Sharpe ratio portfolio with the complete data.

	Min risk portfolio	Tangency portfolio
Mean	0.004	0.055
Risk	0.029	0.098
Sharpe ratio	0.082	0.541

The investment proportion of the top three stocks under the optimal Sharpe ratio are shown in the following table:

Table 7: The weights of the top three stocks.

	China Merchants Bank	Techtronic Industries	Longfor Group Holdings
Weight	0.459	0.346	0.308

When we select any of the five stocks for the maximum Sharpe ratio portfolio analysis, the investment proportion of China Merchants Bank is 0.351, which is not the highest among the five stocks. However, when we use all stocks for the maximum Sharpe ratio portfolio analysis, the investment proportion of China Merchants Bank is 0.459, which is the highest among all stocks. Therefore, it can be found that when the range of available stocks is different, the investment proportion of the same stock may also be different.

The three stocks with the lowest proportion are as follows:

Table 8: The weights of the last three stocks.

	Industrial and Commercial Bank of China	Bank of China	China Construction Bank
Weight	-0.576	-0.542	-0.471

It can be seen from the above figure that, according to the historical situation, it is not recommended to buy stocks from the three banks, but to buy the stocks of enterprises such as Techtronic Industries and Longfor Group.

4. Conclusion

Based on the data of the Hang Seng Index from December 2009 to December 2021, this paper studies 5 representative stocks in different industries, and finds that: The five stocks are weighted similarly to their average return. The larger the average value, the greater the proportion of the investment. Low-risk stock investment accounted for a high proportion, while high-risk stock investment accounted for a small proportion. Among the selected representatives, tech Industries and Longfor Group had higher investment value, while bank stocks had lower investment value.

However, there are still some shortcomings in this study, such as the lack of more rigorous reference and theoretical basis for the selection of risk-free return and the reasons for the selection of 5 stocks, and the lack of classification discussion under different circumstances. In future studies, we can also conduct indepth analysis from the following aspects. For example, the conclusions and suggestions

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of this portfolio analysis can be compared with the stock trading situation in 2022 to verify whether the conclusions have certain accuracy.

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