Portfolio Analysis Based on 5 US Industries Assets

Jinping Yan*

School of Business, Nanjing University, Nanjing, China

*Corresponding author: 181098311@smail.nju.edu.cn

Abstract. Portfolio problem is the research direction of securities, finance and other markets. In order to study the situation of relevant markets and asset allocation, this paper selects the representatives of the Internet, medicine, finance, new energy vehicles and tobacco industries as the research objects. Based on the mean variance model, this paper uses CAPM model and FF model to calculate the optimal portfolio. The results show that the new energy automobile industry of the Internet is better under the CAPM model, while the financial industry performs well under the FF model. At the same time, the pharmaceutical industry can effectively reduce the risk while ensuring the income. At the same time, this paper discusses the portfolio under the condition of adding etf to further reduce risk. Under the condition of pursuing high Sharpe ratio and low risk, it can greatly affect the optimal portfolio. The research results are helpful to relevant investors.

Keywords: Mean-variance; CAPM; FF3F; portfolio optimization.

1. Introduction

Markowitz, an American economist, put forward the mean-variance model in 1952, and introduced mathematical statistics into asset allocation to obtain low risk and high return. Since it was proposed, this method has been concerned, and many researchers have conducted in-depth research on different directions of this model.

American scholars William Sharpe, John Lintner, Jack Treynor and Jan Mossin developed the Capital Asset Pricing Model (CAPM) on the basis of the mean-variance theory and the capital market theory in 1964. It was used to study the relationship between the expected rate of return and risk assets, and to seek the equilibrium price. This theory has become the pillar of financial market price theory. Banz found in 1981 that the value of stocks is related to their market value and size, and the price is affected by risk factors [1]. Fama and French studied and proposed the three-factor-model in 1993, which used market value and book value ratio as the main risk factor to study the impact on stock return [2]. And compared with the CAPM, the Fama-French three-factor-model is closer to the real market. On the basis of these models, more people have conducted relevant research on this aspect. Best and Grauer's 1991 paper proved that the weight of the positive weighted MV efficient portfolio is very sensitive to changes in the average value of assets, but the return of the portfolio is not [3]. He Chaolin introduced a random variable to measure the optimal portfolio selection problem under the mean variance model with general uncertainty in his research [4]. Based on the strength of the impact of stock market information and general uncertainty on the portfolio, it reflects the limited rationality of investors. Mishra and O'Brien studied and compared the relationship between CAPM model and Fama-French model under ex ante version and ex post version by using the observation of implied cost of equity in the United States [5]. Torre-Enciso, Oscar and Garcia's paper shows the practical usefulness of Markowitz-Tobin-Sharpe-Lintner (MTSL) model in the Spanish Stock Market to provide optimal portfolios that offer higher profitability and reduced risk than the IBEX35 Index portfolio [6]. W Fei and R Wu's paper studies the portfolio investment decision model under the standard of investors utility maximization and theoretically analyzes the investors behavior of investment when the stock prices and/or exchange rates fluctuations [7]. Luis and Guilermo examine whether the Fama-French model can be capable of incorporating variations of company characteristics in a more dynamic form [8]. And the paper shows that the adapted model is able to capture the behavior of a greater number of stocks than the original F&F model. Yang Zunhan test the CAPM Model and Fama French Three Factor Model in China's A-share Market. His empirical research results show that the CAPM model is effective in the Chinese market, but the Fama French

model is not obviously effective in the Chinese market, or that the Fama French three factor model is only effective in some industries [9]. Liao Li and Shen Chao use CAPM to calculate the capital cost of China's real estate industry and use the result to judge whether economic bubble exists in the market [10].

Based on these theoretical studies and some other application studies, this paper hopes to study the current market situation and make some reference for investors in the selection of investment portfolio on return and risk. Therefore, this paper selects the representative enterprises in the Internet, medicine, finance, new energy vehicle and tobacco industries from the market as the research object, and uses the CAPM and Fama-French three-factor model to analyze the changes in the market. This paper selects the data from October 2017 to October 2022 for analysis. After data processing, this paper calculates the optimal portfolio under the highest Sharpe ratio and the lowest risk respectively.

The structure of this paper is as follows. The first part is introduction, the second part is method, the third part is data, the fourth part shows result, and the last part is conclusion and discussion.

2. Methods

2.1 Mean-variance Model

Mean variance theory is the base of portfolio theory, which can solve portfolio problems well and is an indispensable link in analyzing problems. If there are n assets in total:

$$\sum_{i=1}^{n} \omega_i = 1 \tag{1}$$

The ω_i is weight of different assets in portfolio. Then expected rate of return of the portfolio is:

$$E(r_p) = \sum_{i=1}^{n} \omega_i E(r_i) \tag{2}$$

The r_p is return of the portfolio, and the r_i is return of each asset. And variance is:

$$Var(r_p) = \sum_{i,j}^{n} \omega_i \omega_j Cov(r_i, r_j) \tag{3}$$

When $i = j$, it's the variance of the asset; when $i \neq j$, it's the covariance between two assets. This paper uses sharpe ratio to measure the return and risk:

$$\text{Sharpe ratio} = \frac{E(r_p) - r_f}{\sigma_p} \tag{4}$$

2.2 Capital Assets Pricing Model

CAPM is a very important method to make a great portfolio. It's used widely. It only considers about market and doesn't concern other factors. And the formula is:

$$E(r_i) = r_f + \beta_i E(r_m - r_f) \tag{5}$$

$E(r_i)$ is the expected rate of return, and r_f is the risk-free rate. β_i is the investment β value, which is the systematic risk of the asset. β measures the change rate between $E(r_m - r_f)$ and $E(r_i)$. $E(r_m - r_f)$ shows the expected return of the market minus risk-free rate.

2.3 Fama-French Three-Factor Model (FF3)

This model considers more factors than the CAPM, so it's more realistic than the CAPM. FF3 add size and book-value of a company to calculate. It's spread widely and it's easy to change the factors and get a new model, such as five-factor model. Thus, this paper uses it, here is the formula:

$$E(r_i - r_f) = \beta_i[E(r_m - r_f)] + s_i[E(SMB)] + h_i[E(HML)] \quad (6)$$

$E(r_i - r_f)$ means excess expected return of one asset and $E(r_m - r_f)$ is about the market. SMB and HML are the different types of companies, means size and book-to-market. s_i and h_i are the coefficient of these two factors.

3. Data

All data used in this paper are from Yahoo Finance (https://finance.yahoo.com/). The paper chooses 5 companies from different industries, which are Oracle Corporation (ORCL), Philip Morris International (PM), Johnson & Johnson (JNJ), Tesla (TSLA) and The Goldman Sachs Group (GS).

In this paper, time between October 2017 and October 2022 are selected. It is the newest data, and these 5 companies have a nice increase and all have good prospects for future development. And companies from different industries have a low correlation coefficient (See Table 1).

Table 1. Correlation coefficient among 5 companies

	ORCL	PM	JNJ	TSLA	GS
ORCL	1				
PM	0.335069372	1			
JNJ	0.446901027	0.503424858	1		
TSLA	0.304344497	0.185143051	0.348754384	1	
GS	0.600184501	0.554404519	0.463527623	0.416050941	1

As this paper shows in Table 1 that all the correlation coefficients are small enough. The highest coefficient is between ORCL and GS, up to 0.6, but it's acceptable. The two assets with greatest difference are TSLA and PM, which is 0.185. However, there is no doubt that using these 5 companies is meaningful.

Table 2. Descriptive statistics of the selected assets

	ORCL	PM	JNJ	TSLA	GS
Mean	0.009850736	0.005874401	0.005992061	0.062907752	0.01083951
Variance	0.003922281	0.00575031	0.002545441	0.043485565	0.007749463
max return	0.125889298	0.166887627	0.144207962	0.741452118	0.21974189
min return	-0.112776511	-0.228475539	-0.115916716	-0.2242658	-0.225306585

In Table 2, the TSLA has the highest arithmetic average return of 0.063, and it also has highest variance, which means it has high return and high risk. The JNJ has the lowest variance of 0.0025.

4. Results

4.1 Results of CAPM Model

Using the CAPM model, to get the sharpe ratio and use Solver to get the final portfolio considering the highest sharpe ratio situation.

Table 3. Result for highest sharpe ratio using CAPM model

	ORCL	PM	JNJ	TSLA	GS
weight	0.81626	0.252115	-0.38591	0.760371	-0.44284
Expected return		0.041640447			
Variance		0.018021368			
Standard deviation		0.13424369			
Sharpe Ratio		0.303951756			
weight without short selling	0.400839	0	0	0.599161	0
Expected return		0.05024248			
Variance		0.025443472			
Standard deviation		0.1595101			
Sharpe Ratio		0.309733602			

As the Table 3 shows, when short selling is allowed, investors should take ORCL most, the weight is 0.816. And they may give GS a lot of short selling, 0.443 of their whole capital. The reason is probably ORCL always has a positive trend, especially when the COVID-19 came, internet companies met a great chance to develop and it's nice to invest. Considering GS, it may be because GS has excessive fluctuation around a price and it's easier to predict than others. When investors ignore short selling, they may choose TSLA more and ORCL less, no other assets. Because TSLA has the highest means and the maximum return. The sharpe ratio and the variance between these two portfolios are close.

Table 4. Result for lowest variance under CAPM model

	ORCL	PM	JNJ	TSLA	GS
Weight without short selling	0.298163	0.101581	0.600257	0	0
Expected return	0.007131				
Variance	0.002204				
Standard deviation	0.046942				
Sharpe Ratio	0.134076				
weight	0.347652	0.122592	0.626893	-0.03623	-0.06091
Expected return	0.004962				
Variance	0.002124				
Standard deviation	0.046088				
Sharpe Ratio	0.089502				

In the Table 4, the portfolio between not considering and considering short selling is almost the same. The largest weight of portfolio is JNJ. Respectively, 0.600 and 0.627. The variance of JNJ is lowest and JNJ smoothly developed in the last five years with no big losses. Because pharmaceutical companies' stock is always stable, it's not sensitive to the market. Except GS and TSLA, the weight of PM is also low, it may be because PM had the minimum return in these 5 years and was deeply influenced by the COVID-19.

4.2 Results of FF 3-factor Model

When using Fama-French three-factor model, this paper replaces expected return with excess expected return and use regression to calculate the β value and recalculate the means, variance, covariance and risk premium of size and book value.

Table 5. Result of the regression and the risk premium of each factor

	ORCL	PM	JNJ	TSLA	GS
FF Mkt beta(β_i)	0.891172	0.701879	0.588615	2.25156	1.288238
FF SMB beta(s_i)	-0.5074	-0.50034	-0.38232	-0.42147	0.201951
FF HML beta(h_i)	-0.16082	0.579483	0.089031	-0.87609	0.444068
	ORCL	PM	JNJ	TSLA	GS
P-value of β_i	$6.54e^{-10}$	0.000116	$2.28e^{-6}$	$1.03e^{-5}$	$2.92e^{-13}$
Standard error of β_i	0.118487	0.168559	0.111025	0.4619	0.133552
MKT RP	0.006768				
SMB RP	0.00193				
HML RP	0.003527				
RF RP	0.002664				

Table 5 shows the results of the regression and the risk premium of each factor in the market. The coefficient of each asset, β_i, s_i and h_i. And from the P-value of β_i, it's certain that β_i is meaningful and our results are effective.

Here is the portfolio based on the Fama-French Three-Factor model with short selling and with not when requiring the highest sharpe ratio.

Table 6. Result for highest sharpe ratio using FF 3-Factor model

	ORCL	PM	JNJ	TSLA	GS
weight	0.096708	0.088916	0.368679	0	0.445697
Expected return	0.009686				
Variance	0.003495				
Standard deviation	0.059118				
Sharpe Ratio	0.118782				
Weight with short selling	-0.0654	0.06651	0.200809	0.007168	0.790911
Expected return	0.011997				
Variance	0.005817				
Standard deviation	0.076267				
Sharpe Ratio	0.122375				

From the Table 6, GS has the largest weight in both situations, but the smallest assets are very different. When short selling is not concluded, GS has weight of 0.446, and TSLA has no weight. But when short selling is allowed, GS has weight of 0.791 and TSLA has little weight of 0.00717, and ORCL has weight of 0.0644 short selling. Because from Table 5, all β value of GS are positive. ORCL and TSLA have a positive β_i but they have negative s_i and h_i, Considering all three factors, ORCL and TSLA have low weight. Then this paper calculates the portfolio of lowest variance.

Table 7. Result for lowest variance under FF 3-Factor model

	ORCL	PM	JNJ	TSLA	GS
weight	0.292247	0.086388	0.621365	0	0
Expected return	0.00669				
Variance	0.002171				
Standard deviation	0.04659				
Sharpe Ratio	0.086416				
Weight with short selling	0.34813	0.113093	0.646508	-0.03371	-0.07402
Expected return	0.006013				
Variance	0.002088				
Standard deviation	0.04569				
Sharpe Ratio	0.073314				

In Table 7, the largest weight of lowest variance portfolio is JNJ. With no short selling, JNJ has 0.621 of whole capital, while TSLA and GS are both 0. With short selling, JNJ has weight of 0.647 and GS has the lowest weight of 0.0740 short selling. This result is similar to the CAPM model, because the size relation of variance of these five companies doesn't change. The weight changes only because of the two new factors.

4.3 Reducing the Risk of Portfolio

Considering the changing market, reducing risk is absolutely significant. So, this paper chooses Invesco QQQ Trust (QQQ) to reduce the risk and use Fama-French Three-Factor model to analyse how the portfolio changes.

Table 8. Result for highest sharpe ratio under FF 3-Factor model, QQQ added

	ORCL	PM	JNJ	TSLA	GS	QQQ
Weight with short selling	-0.218472	0.089263	0.149067	-0.0427	0.56263	0.460213
Expected return	0.011026					
Variance	0.004445					
Standard deviation	0.066674					
Sharpe Ratio	0.125419					
weight	0	0.09573	0.09483	0	0.54622	0.26321
Expected return	0.010974					
Variance	0.0045					
Standard deviation	0.067082					
Sharpe Ratio	0.123881					

After QQQ is added, when short selling exists, GS still has highest weight among all assets, with 0.563, even higher than the weight in Table 6. JNJ weight decrease a lot and QQQ also has a high weight of 0.460, which means market goes better than some assets. And the highest sharpe ratio increase a little, from 0.119 to 0.125. When there is no short selling, GS has highest weight of 0.546 and QQQ still has the second place with 0.263 weight. The situation is close to the result ahead, what changes is that TSLA and ORCL weight is 0.

Table 9. Result for lowest variance under FF 3-Factor model, QQQ added

	ORCL	PM	JNJ	TSLA	GS	QQQ
weight with short selling	0.094056	0.132001	0.507171	-0.085818	-0.194185	0.546775
Expected return	0.005905					
Variance	0.001723					
Standard deviation	0.041509					
Sharpe Ratio	0.078082					
weight	0.151497	0.07627	0.548323	0	0	0.223909
Expected return	0.007087					
Variance	0.002075					
Standard deviation	0.045552					
Sharpe Ratio	0.097104					

In the Table 9, QQQ has highest weight of 0.547 considering short selling and GS has the lowest weight of 0.194 short selling. But when there is no short selling, JNJ cover most of the capital, with weight of 0.548, and QQQ only has 0.224. Compared with Table 7, ORCL decreases a lot and others change a little, which means ORCL has a low risk but it's still higher than QQQ. However, JNJ has very low risk, which is close to the QQQ.

5. Conclusion

At this stage, more research on investment portfolio is aimed at a large amount of data in a certain market to draw conclusions on the applicability of relevant models, or in-depth analysis of the market. This paper selects the representative enterprises in the Internet, medicine, finance, new energy vehicle industry and tobacco industries as the research object, hoping to explore the best investment decisions in the current market, and consider what changes will occur under lower risks. At the same time, consider and compare the difference between short selling and no short selling.

In this paper, based on the mean variance model, CAPM and FF 3-Factor model are mainly used as analysis tools, and the maximum Sharpe ratio and minimum variance are used as demand for portfolio. In the CAPM model, this paper finds that the new energy vehicle and Internet industries account for a high proportion in the portfolio pursuing high Sharp ratio, while the pharmaceutical industry accounts for a high proportion in the portfolio pursuing low risk. In the FF 3-Factor model, the pharmaceutical industry still accounts for the majority of low-risk investment portfolio, while the financial industry accounts for the highest proportion in the case of high Sharpe ratio. The results of short selling and no short selling under these two models are relatively similar. Only when pursuing high Sharp ratio in FF 3-Factor model, Internet companies change from short selling to investment.

Under the natural pursuit of low risk in the market, in order to reduce risk, considering the relevant changes of portfolio under low risk, this paper add QQQ to asset selection. At this time, under the FF 3-Factor model, when pursuing a high Sharpe ratio, the financial industry accounts for the highest proportion, and QQQ can also account for a large proportion; When pursuing low risk, the proportion of QQQ is the highest in the case of short selling, more than half. When short selling is not considered, the proportion of QQQ decreases, and the pharmaceutical industry has become the highest proportion.

However, the deficiencies are inevitable. There are five-Factor model and many other factors will influence the results. There are also other industries worth studying.

References

[1] Banz R. W. The Relationship between Return and Market Value of Common Stocks. Journal of Financial Economics, 1981, 9: 3 - 18.

[2] Fama E.F., French K.R. Common Risk Factors in the Returns on Stocks and Bonds. Journal of Financial Economics, 1993, 33: 3 - 56.

[3] Michael J. Best, Robert R. Grauer. On the Sensitivity of Mean-Variance-Efficient Portfolios to Changes in Asset Means: Some Analytical and Computational Results, The Review of Financial Studies, 1991, 4 (2): 315 – 342.

[4] Chao-Lin H E. Optimal Portfolio Choice under the Mean-Variance Model with General Uncertainty. Chinese Journal of Management Science, 2015, ,23 (12): 63 - 70.

[5] DEV R., MISHRA, THOMAS J. O'BRIEN. Fama-French, CAPM, and implied cost of equity. Journal of economics and business, 2019, 101: 73 - 85.

[6] Martinez Torre-Enciso I, VDLTT Oscar, Bilbao Garcia J. Theoretical Review to the Definition of the IBEX35 Stock Index as the Market Portfolio in Spain. International conference on risk and reliability management, 2010.

[7] Fei W, Wu R. A STUDY ON THE MODEL OF THE INTERNATIONAL INVESTORS PORTFOLIO INVESTMENT DECISION. MATHEMATICS IN ECONOMICS, 1999.

[8] FERRUZ LUIS, BADIA GUILLERMO. Adapting and testing the Fama and French model, with some variations of company characteristics. Applied economics letters, 2017, 24 (4/6): 342 - 345.

[9] Yang Zunhan. Test of CAPM Model and Fama French Three Factor Model in China's A-share Market. Economic Research Guide, 2022, (8): 117 - 119.

[10] Liao Li, Shen Chao. Using CAPM to calculate the capital cost of China's real estate industry. Chinese Journal of Management Science, 2004, 12 (4): 37 - 42.