

# Research on Asset Allocation Based on Quantitative Investment

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**Abstract:** This paper discusses the application of quantitative investment models in asset allocation. The main model studied is the Markowitz model. The Markowitz model calculates the excess return, covariance and standard deviation to obtain the Sharpe ratio. Maximizing the Sharpe ratio under a certain risk level can have the optimal asset allocation weighted ratio. The purpose is to analyze how quantitative models can optimize investment portfolios and asset allocation by balancing the risk and return. By studying cases of asset allocation of different companies in the technology market, the application and effectiveness of the Markowitz model in different conditions are shown and factors that may affect research results and judgments are found. The results show that quantitative investment methods can improve portfolio performance more than traditional methods. Finally, the paper discusses the advantages and limitations of the Markowitz model, provides valuable insights to investors and proposes directions for future research in this field.


## 1 INTRODUCTION

With the advancement of data technology and the enhancement of computational power, quantitative investment had become an indispensable focal point in the financial sector. This method employs mathematical modeling and statistical algorithms to analyze market data, in order to effectively customize the asset allocation strategy for companies. This research discusses the application of the Markowitz model in optimizing asset allocation strategies. It conducts detailed analysis and comparisons of the model's effectiveness across various companies in the same field. Furthermore, this study identifies the potential strengths and limitations of the model, providing critical insights into its practical implications.

Alberg and Lipton found that listed companies need to analyze income, debt and other financial conditions through retrospective analysis, simulation and quantitative methods (Alberg and Lipton, 2018). What is more, quantitative investment has gradually replaced traditional investment methods. Li and Xu indicated that researchers increasingly try to apply machine learning and deep learning to quantitative investment (Li and Xu, 2023). Sharma and Kaushik pointed out that it is very significant to predict the

market value of a stock. Computers can be used as advanced and convenient tools to help researchers create investment models (Sharma and Kaushik, 2017). Ibbotson believed that in addition to the overall market trends that will affect changes in the time series returns for funds, asset allocation is very important in determining performance. The importance of asset allocation also reflects the necessity of quantitative investment (Ibbotson, 2010). Fabozzi and Markowitz pointed out that the three most important parts of an effective investment portfolio are expected returns, variance of asset return and correlation. Therefore, whether a quantitative investment portfolio is usable can be judged by observing whether the selected investment portfolio model contains these three data (Fabozzi and Markowitz, 2011). However, Farinelli et al. believed that the Sharpe ratio has weaknesses in quantitative investment construction. It is not as stable as the asymmetric parameter ratio (Farinelli et al., 2008).

In this study, the Markowitz model will be used as the research target. Parkinson believed that the Markowitz model provides strategies for investors who want to obtain high returns with low risk. Investors should identify an optimal allocation point to allocate asset portfolios (Parkinson, 2024). In addition, Maiti discussed the importance of

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systematic and unsystematic risk for risk and return. Maiti introduced the two important parameters of variance and covariance in detail and also plotted the optimization of Markowitz portfolio using R programming (Maiti, 2021). However, Markowitz's weaknesses have gradually been pointed out by many researchers. Lolic proposed an improvement method, which is to abandon some expected optimality to reduce the concentration of weights. Such an improvement better achieves risk-adjusted returns based on out-of-sample risks (Lolic, 2024). Ravipati also discussed further developments of the Markowitz model and the details that require attention, as the model becomes unstable when its mean and variance are replaced (Ravipati, 2012).

Therefore, the Markowitz model is a very important and mature quantitative investment tool in modern society.

## 2 METHODOLOGY

### 2.1 Data Source

In this research paper, the application of Markowitz model in the same field but different companies are mainly studied. The research subjects are Apple Inc., Alphabet Inc, Microsoft Corporation and Amazon.com Inc. Some of the data are discovered through the Yahoo Finance website. These data are the asset values of each company. Find the asset classification for each company. For example, Apple's assets include current assets and non-current assets. The data used in this article is current assets. To illustrate, Apple's current assets include cash, receivables, inventory and other current assets, so there are four optimal asset allocation categories studied. The risk-free rate that needs to be used in the calculation is found in Wharton Research Data Services. Find the return rate of zero-coupon bond U.S. Treasury bonds in the Fama-French Portfolios and Factors function. This is the basis for calculating annual risk-free rate.

### 2.2 Variables Description

In order to analyze the Markowitz model, it is necessary to find out its research variables and indicators. The main indicators studied in this research paper are expected excess return, covariance, and Sharpe ratio. And the optimal asset allocation weight is determined based on changes in these data. A high expected excess return indicates a high rate of return for the company. Covariance

matrix is used to find the adjusted covariance matrix to calculate the variance of the combination, the standard deviation, which is the volatility and Sharpe ratio. The larger the Sharpe ratio, the higher the return of the portfolio under the given volatility.

The Table 1 below is some of the data that the model needs to use when studying four different companies, including expected excess returns, standard deviations, and the risk-free return rate.

Table 1: Variables needed in Markowitz model.

Variables	Apple	Google	Microsoft	Amazon
Expected excess return	0.051	0.264	0.140	0.277
Standard deviation	0	0.107	0	0.050
Risk-free rate	0	0	0	0

### 2.3 Model Introduction

The Markowitz model theory advocates that investors achieve portfolio optimization under given risks through reasonable asset allocation. It is based on the following assumptions. Firstly, investors are rational and they pursue maximizing expected returns. Secondly, investors are willing to take certain risks to obtain higher returns. Lastly, investors achieve risk diversification by constructing portfolios that consider the correlations between assets.

Analyzing the Markowitz model requires several steps. First, the expected excess return is calculated based on the collected data. To calculate the return rate in each year, return rate:

$$r_n = \frac{P_n - P_{n-1}}{P_{n-1}} \tag{1}$$

which is the difference between the current year's returns and the previous year's returns divided by the previous year's returns. After that, excess return is:

$$R_n = r_n - r_f \tag{2}$$

The expected excess return is the average excess return of this category in different years. The second step is to calculate the covariance matrix of the company's asset allocation through the data analysis function of excel. Find its adjusted covariance matrix by multiplying covariance by degree freedom.

The third step is to calculate the variance and standard deviation of the combination based on the adjusted covariance matrix that has been calculated. The standard deviation represents the volatility of the asset. The larger the standard deviation, the greater

the volatility and the greater the risk. The final step is to calculate the Sharpe ratio:

$$\text{Sharpe ratio} = \frac{R_p - r_f}{\sigma_p} \quad (3)$$

Find the proportional weight of different asset classes by maximizing the Sharpe ratio. This way can help investors ultimately choose the optimal portfolio and asset allocation.

### 3 RESULTS AND DISCUSSION

#### 3.1 Model Evaluation

The Table 2 is found on Yahoo Finance and shows the value of Apple's assets from September 30, 2020 to September 30, 2023. So Apple's annual return on assets, excess returns and expected excess return can be calculated. The calculation results are shown in the Table 3.

Table 2: Return on assets in each year.

	30/09/2020	30/09/2021	30/09/2022	30/09/2023
Cash	90,943,000	62,639,000	48,304,000	61,555,000
Receivables	37,445,000	51,506,000	60,932,000	60,985,000
Inventory	4,061,000	6,580,000	4,946,000	6,331,000
Other	11,264,000	14,111,000	21,223,000	14,695,000

Table 3: Apple's expected excess return.

	2021	2022	2023	expected
Cash	-0.311	-0.229	0.274	-0.089
Receivables	0.376	0.183	0.001	0.186
Inventory	0.620	-0.248	0.280	0.217
Other	0.253	0.504	-0.308	0.150

The Table 4 below shows the covariances of Apple's current assets in the past three years, which are calculated based on excess returns. The covariance can be used to find the adjusted covariance matrix in order to calculate the standard deviation, Sharpe ratio and weighted ratio.

Through the same operation process, the results of the Markowitz model in reallocating the asset ratios of the other three companies can also be calculated and be shown in the Table 5.

Table 4: Covariance of Apple's assets

	Cash	Receivables	Inventory	Other current assets
Cash	0.067	-0.036	0	-0.080
Receivables	-0.036	0.023	0.022	0.034
Inventory	0	0.022	0.128	-0.051
Other current assets	-0.080	0.034	-0.051	0.115

Table 5: Results of Markowitz model.

	Apple	Alphabet	Microsoft	Amazon
Cash	0.460	0	0.223	0.042
Receivables	0	0.365	0.281	0.958
Inventory	0.155	0	0.069	0
Hedging	None	None	0.003	None
Other current assets	0.386	0.635	0.423	None
Sharpe ratio	1,840,460	2,465	2055.886	5.523

The asset allocation of Google's parent company is very clear. It invests 0.365 in receivables and 0.635 in other current assets. This asset allocation also makes Google's Sharpe ratio very good, which is a feasible asset allocation ratio. Amazon's asset allocation is 0.042 for cash and 0.958 for receivables. Microsoft and Apple have the same problem. Their Sharpe ratios are too high to be realistic.

#### 3.2 Discussion

It can be found that the Sharpe ratios of Apple and Microsoft are too large. Such a large Sharpe ratio is impossible. The possible reason for this phenomenon is that both companies paid dividends not long ago. The distribution of dividends will have an indirect impact on the Sharpe ratio. Firstly, the distribution of dividends will affect the rate of return on assets. If an investor reinvests the dividends in the company's stock, the expected rate of return on the assets will increase due to the dividend income. Secondly, due to stock price adjustments and market feedback, there will be fluctuations in the short term. However, this fluctuation is short-lived and has little impact on the long-term standard deviation. The risk-free rate

calculation is based on the US Treasury bond. The dividend paid by a company will not have any impact on it. If paying dividends significantly increases the expected return but the standard deviation does not change much, the Sharpe ratio will rise.

Apple's most recent dividend was on May 10, 2024, when it paid 0.25 dividends. Microsoft's last dividend was on May 15, 2024, with a dividend of 0.75. The other two companies with relatively normal Sharpe ratios have no history of paying dividends. Therefore, this is one of the reasons why Apple and Microsoft get particularly large Sharpe ratios by using the Markowitz model for asset allocation.

### 3.3 Critical Thinking

The operation of the Markowitz model is not difficult, so its application is very wide. At the same time, it effectively diversifies risks by building a portfolio of multiple assets, thereby reducing the volatility brought by a single asset. This model also helps investors optimize their investment portfolios and quickly determine the weight of asset allocation in an intuitive and easy-to-understand way.

Markowitz has a wide range of applications and is highly applicable. However, this model still has limitations. This model relies on historical data, but historical data cannot fully represent future market performance and predict future returns and risks. Markets do not repeat. In addition, the model follows a normal distribution. However, assets may show non-normal distributions in the actual market. Thirdly, the model uses covariance matrix calculation, but the estimation of the covariance matrix is very difficult and cannot guarantee accuracy. Therefore, the estimation of the covariance matrix will also bring errors. Finally, the model is all based on rationality and data-based decisions. However, in real life, investors do not always remain rational. They may be affected by external factors such as emotions and preferences and so on.

This study only focuses on data from the past three years. A higher number of samples reduces the error of the model. In addition, This research only studies Markowitz's quantitative investment model. In fact, there are many types of quantitative investment models, such as the Black Littleman model, which combines investors' subjective views with historical data to better determine the optimal asset allocation. They also have different usage methods. Moreover, this research only studies the application of the Markowitz model for companies in the technology field. This is not comprehensive. It is essential to study the effects of using the model on

many different types of companies. Like the Financial sector with JPMorgan Chase, BlackRock and Morgan Stanley and the Food Industry with Coca-Cola, Nestle and PepsiCo.

## 4 CONCLUSION

In short, quantitative investment models are very helpful in the current market. These models provide absolutely rational and systematic methods and decisions to help investors improve the performance of their portfolios. However, despite the advantages of quantitative investment models, they also face many challenges and limitations. Models need to constantly adapt to market changes. At the same time, there are certain differences between the model and the actual market, and the calculation method of the model is also based on historical data, which may cause errors.

In conclusion, the application of quantitative investment models in asset allocation and portfolio construction is indispensable. It has become a powerful tool for modern investment portfolios. Models help investors achieve more optimized portfolios by utilizing data, accurate calculation methods and advanced analytical methods. However, in the face of market complexity and volatility, continuous innovation and development are necessary. Future developments in this field should lead to more precise and effective strategies.

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