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Design and Explanation of Portfolio Optimization Model Using Similarity and TOPSIS Methods

Sohrab Biglari[1], Zadollah Fathi[2*], Mir Feiz Fallahshams Layalestani[3]

[1] Department of Financial Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran.
[2] Department of Financial Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran (Corresponding Author).
[3] Department of Financial Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran.

*** Corresponding author email address**: z_fathi46@yahoo.com

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Abstract

This study examines and optimizes investment portfolios using Similarity and TOPSIS methods. The aim of this study is to identify and rank assets in order to create a diversified and low-risk portfolio that can provide the best possible returns. The Similarity method is used to identify the correlation between assets and find more diversified combinations, while the TOPSIS method ranks assets based on their proximity to the positive ideal by evaluating multiple criteria. This research is applied in nature and is classified as descriptive-survey research in terms of data collection method. The statistical population of the study includes companies listed on the stock exchange during the period from 2011 to 2020. A judgmental sampling method is employed in this research. The results indicate that the combination of these two methods with the Markowitz model can lead to improved portfolio performance and offer better results under different market conditions. This practical approach enables investors to create an optimized portfolio resistant to market fluctuations through detailed analysis based on multiple data points.

Keywords: *Portfolio Optimization, Similarity Methods, TOPSIS*

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1. Introduction

The issue of selecting an optimal set of assets is one of the core theories in capital markets, which holds significant importance in both micro and macroeconomic discussions. In macroeconomics, investment is considered one of the key indicators and plays a decisive role in economic growth and development. In microeconomics, the importance of investment decisions stems from the fact that an investor postpones current consumption in the hope of greater consumption in the future, aiming to improve their current and future well-being [1]. In essence, the optimal investment decision maximizes the investor's expected utility from future consumption. Risk and return are the criteria that determine an investor's utility from selecting a set of investment assets [2]. The composition of each investor's asset portfolio varies according to their conditions, time horizon, risk, and expected cash flow. In portfolio management, the goal is to select a set of stocks in such a way that minimizes risk and maximizes return [3].

The issue of portfolio selection was first introduced by Harry Markowitz, whose proposed model used the mean to measure portfolio return and variance to assess risk. The most important assumption in Markowitz's mean-variance model is the assumption of a normal distribution of stock returns. However, numerous studies have been conducted, and the assumption of normality in returns has been largely rejected. Early research by Fama (1992) and Mandelbrot (1963) indicated skewness in the distribution of returns [4].

Every rational individual seeks to meet their needs, and every investor seeks an investment that will increase their wealth. Some investors choose the stock market for their investments. As a result, the investor must select a portfolio of companies to invest in their stocks [3]. The first and best source of information is the company's past performance. The second source is the belief, attitude, and analysis of the investor regarding the company's future performance. A simple but comprehensive definition of investment is the postponement of current consumption to achieve more consumption in the future, with pension funds being an example of such delayed consumption [5, 6].

Ranking companies for decision-making purposes is conducted to compare and select the best companies. As a result of the ranking, priorities and advantages are identified, allowing for the selection of the most successful company and thus making sound investment decisions. However, the main problem for today's investors is dealing with and responding to environmental changes. In this context, information dissemination institutions play a crucial role by providing timely, accurate, appropriate, and relevant information to decision-makers. Company ranking institutions are among such institutions, playing a vital role in the industry environment [5]. These institutions identify the competitive positions of leading companies in the industry based on various indicators or variables. In Iran, due to the non-issuance of bonds, there is no institution responsible for grading companies [7]. Although in 2016, rating agencies were registered as financial institutions under the supervision of the Stock Exchange Organization, their effectiveness is limited compared to companies operating in other countries under different conditions, given the current situation and lack of complete transparency and efficiency in the capital market. However, the ranking of Tehran Stock Exchange companies is currently conducted by the stock exchange itself in two ways: the first method is based on a single variable, typically sales, and the second is based on the "harmonic mean." Although single-variable ranking benefits from ease of calculation, it offers limited reliability, as it focuses on one aspect of the company's activity, while company rankings should encompass multiple dimensions [3].

Stock evaluation techniques are typically divided into two categories: fundamental analysis and technical analysis [8-13]. The two fundamental topics in investment discussions are risk and return, and there are two significant perspectives: first, investors only bear risk when they expect additional returns, and second, risk can be reduced through diversification. Extensive efforts have been made among investment researchers to propose methods for analyzing and improving stock analysis in financial markets. These efforts have led to the development of new methods that, alongside traditional ones, aim to maximize investors' utility in financial markets. The main issue in this research, considering the uncertainty prevailing in the stock market and portfolio selection models, is the use of a new tool for selecting an investment portfolio. Moreover, given that a large body of research has been conducted in recent years on portfolio optimization, since Markowitz first introduced his mean-variance model, other diverse models have been presented based on fundamental and technical indicators. According to the author of this research, the TOPSIS and Similarity methods, which are recognized under credit assessment and credit risk in financial management science, can offer high efficiency in selecting an optimal portfolio, a subject that has not yet been researched or modeled. Therefore, in this research, we aim to model optimal stock

portfolios using these two methods and compare them with the traditional Markowitz model.

2. Methodology

This study is applied research in terms of its objective and is categorized as descriptive-survey research based on its data collection method. The statistical population consists of companies listed on the stock exchange during the period from 2011 to 2020. A judgmental sampling method is employed in this research. For this purpose, companies related to the industries of banks and financial institutions, investment companies, financial intermediaries, conglomerates, and insurance companies were excluded from the population due to structural differences in their financial reporting. From the remaining companies, manufacturing companies that meet the following criteria were selected as the statistical sample, while the rest were excluded. The criteria are as follows:

The company must not have incurred losses in the three years leading up to March 19, 2021.

The company must have a fiscal year ending on March 19.

The company's shares must have been traded on more than 70% of the trading days in the three years leading up to March 19, 2021.

After reviewing the available data and considering the above limitations, 30 companies from various industries that meet the criteria will be selected as the sample for this research. Then, using the Markowitz model as well as Similarity and TOPSIS techniques, three portfolios will be selected for the year 2021 based on 10 years of data (from 2011 to 2020). Finally, by comparing the selected portfolios with the actual figures for the mentioned year, the optimal portfolio will provide answers to the research hypotheses and questions.

The following tools were used to collect data in this research:

a) Library studies (including foreign and domestic books and publications, databases, websites, etc.).

b) Referring to information databases such as the CODAL website, the Technology Company of the Securities and Exchange Organization, the Iranian Financial Data Processing Center, the Rahavard Novin 365 website, and the Rahavard 365 software, among others.

The information used consists of company data, which will be collected using Excel software. To determine the importance of each factor influencing portfolio selection, expert opinions were employed. For portfolio optimization modeling, Markowitz, TOPSIS, and Similarity methods were used with MATLAB and Excel software.

3. Findings

In this section, first, descriptive statistics are examined, followed by inferential analysis and interpretation. The descriptive statistics demonstrate the data related to the variables used in the research. These descriptive statistics pertain to 30 companies listed on the Tehran Stock Exchange over a 10-year period (2011-2020). The primary central indicator is the mean, which represents the balance point and center of the distribution, and serves as a good indicator of the centrality of the data. The descriptive statistics table shows the mean stock return, which is calculated in this study for presenting the Markowitz model. The average stock return of the companies equals 0.19206, with a maximum of 0.409787 and a minimum of -0.07765. Additionally, the average return on assets (ROA) of the companies under study equals 13.7693.

In general, dispersion parameters are used to determine the degree of variability between data points or their deviation from the mean. The most important dispersion parameter is the standard deviation. The lowest dispersion is related to the quick ratio variable, while the highest dispersion pertains to earnings per share (EPS).

Skewness shows the asymmetry of the frequency distribution curve. If the skewness coefficient is zero, the distribution is perfectly symmetrical. A positive skewness coefficient indicates right skewness, while a negative skewness coefficient indicates left skewness. By examining the skewness values, it is observed that the debt ratio variable has negative skewness, while other variables have positive skewness.

Kurtosis indicates the peakedness or flatness of the frequency distribution curve relative to a normal curve. If kurtosis is around zero, the distribution is balanced and normal in terms of peakedness. A positive kurtosis suggests a peaked curve, whereas a negative value suggests a flat curve. The kurtosis of all variables in this model is positive.

Table 1. Descriptive Statistics of Research Variables

Variables	ROA	Gross Profit Ratio	Quick Ratio	P/E	Net Profit Margin	EPS	Debt Ratio
Mean	13.7693	23.7385	0.9973	18.9561	30.7356	1221.1681	56.1221
Median	12.3950	22.4725	0.9370	16.0926	15.1215	671.9650	54.7665
Maximum	46.21	64.77	2.18	100.61	394.12	10097.00	91.63
Minimum	9.40	-4.53	0.38	4.66	-10.66	-314.00	23.01
Standard Deviation	13.29	16.99	0.45	17.33	70.39	1918.23	17.99
Skewness	0.56	0.45	1.10	3.66	4.80	3.68	0.16
Kurtosis	0.63	-0.24	1.02	16.42	24.84	15.45	-0.75
Observations	300	300	300	300	300	300	300

For applying the Markowitz model, the following data are required:

- The expected return of stock *i*, denoted as $E(R_i)$.
- The standard deviation of the expected return of stock *i*, which serves as a measure of each stock's risk.
- Variance, representing the correlation and co-movement between the returns of different stocks, denoted as δ(ij).

The reason a company's stock is considered a risky asset is due to the fluctuating (random) nature of its total return (weekly, monthly, annually). Since these rates change over time, a probability distribution can be formed for them, from which the necessary criteria for the Markowitz model, such as mean, standard deviation, variance, etc., can be derived. Table 2 shows the mean, variance, and standard deviation of stock returns, and the results are presented below:

Table 2. Statistical Measures of Data

Company	Mean Stock Return	Variance of Stock Return	Standard Deviation of Stock Return
National Copper	0.101185921	0.569504782	0.754655420
Kashan Steel	0.295521541	0.299833570	0.547579938
Mobarakeh Steel	0.080639918	0.215474074	0.46419185
Khorasan Steel	0.148740559	0.316436176	0.562526601
Bahonar Copper	0.293777526	0.556948979	0.746290144
Zamyad	0.111236429	0.542772607	0.736731027
Bahman Group	0.149982408	0.491297477	0.700926156
Nirou Moharekeh	0.189852265	0.551192858	0.742423638
Pars Khodro	0.178828327	0.934544446	0.96671839
Saipa	0.001317616	0.218142308	0.467057071
Tractor Engine Co.	0.144950949	0.165269817	0.406533906
Iran Khodro	0.341896879	1.121897222	1.059196498
Pars Oil	0.409878247	2.255366152	1.501787652
Chadormalu	-0.066887347	0.230228832	0.479821667
Golgohar	-0.077657063	0.180257722	0.424567689

The Markowitz model is based on the following assumptions: investors are risk-averse and have increasing expected utility, with diminishing marginal utility of wealth. Investors choose their portfolio based on the mean-variance of expected returns. Therefore, their indifference curves are a function of the expected return and variance. Each investment option is infinitely divisible, and investors share the same one-period time horizon. At a specific level of risk, investors prefer higher returns, and vice versa. Investors consider two factors in their decision-making:

a) "High expected return," which is desirable.

b) "Return uncertainty," which is undesirable.

To achieve optimal portfolio selection in the Markowitz method, which seeks to minimize variance for a given level of return, the following linear programming model is used:

$$\text{Min } z = \delta_p^2$$

$$\text{St} : \bar{r}_p = \sum_{j=1}^{n} w_j . \bar{r}_j$$

$$\sum_{j=1}^{n} w_j = 1$$

$$w_j > 0$$

In the above equation, we have:

Wi = the weight of stock i in the portfolio

rp = the expected return of the portfolio

δp = the variance of the portfolio return

ri = the return of stock i

By analyzing the performance of the Markowitz portfolio, it can be stated that Bahman Group has a higher performance compared to other companies in the Markowitz model (0.1187). In other words, after that, Kharg Petrochemical and Golgohar have a better performance compared to other companies in the Markowitz model. The weakest performance is associated with Bahonar Copper Company.

Table 3. Company Performance in the Markowitz Model

Rank	Company	Markowitz Model Performance
1	Bahman Group	0.1235
2	Kharg Petrochemical	0.1145
3	Golgohar	0.1088
4	Saipa	0.0426
5	Bahonar Copper	0.0010

The expected return on investment and the variance of companies based on each variable in the Markowitz model are presented below. Specifically, earnings per share (EPS) has a higher variance compared to other variables in the Markowitz model, and the return on investment for EPS is also higher than that of the other variables. The variance of companies and the return on investment for other variables are as follows:

Table 4. Markowitz Portfolio

Company	Markowitz Portfolio	Weight Percentage
Bahman Group	0.1235	20%
Kharg Petrochemical	0.1145	18%
Golgohar	0.1088	15%
Khorasan Steel	0.0989	15%
Chadormalu	0.0975	14%
Absal	0.0844	10%
Zamyad	0.0689	8%

According to the results, it can be stated that the highest variance in the Markowitz model is associated with the EPS variable, which is 4.244. Additionally, the highest return is also related to EPS in the Markowitz model, with a value of 1.4314.

4. Discussion and Conclusion

The present study aimed to explain a portfolio optimization model using Similarity and TOPSIS methods and to compare it with the Markowitz model. Below is a summary of the conclusions drawn from the data.

The mean and dispersion: The mean return on assets (ROA) is 13.77, and the mean gross profit ratio is 23.74. These figures indicate the relative efficiency and profitability of these companies in the long term. Earnings per share (EPS) shows the highest standard deviation (1918.23), reflecting the significant variability in profitability and substantial fluctuations in these companies' performance.

Skewness and kurtosis: Most variables exhibit positive skewness and kurtosis, suggesting that their distribution skews to the right and is slightly more peaked than normal. For instance, the EPS variable has high skewness (3.68) and kurtosis (15.45), indicating a non-normal distribution with heavy tails. The debt ratio is the only variable with negative skewness, implying that the data leans to the left, and some companies may not carry significant debt.

Portfolio selection: The Markowitz model, as a mathematical framework for optimizing investment portfolios based on the mean and variance of returns, suggests the selection of companies. This model enables investors to achieve desirable returns while managing risk. Companies such as Bahman Group, Kharg Petrochemical, and Golgohar rank highly in this model due to their relatively higher returns and lower risks, making them suitable options for an optimal portfolio.

Variance and return analysis: The EPS variable shows the highest variance (4.244) and also registers the highest return

(1.4314). This highlights that during the period under review, the returns of this variable were highly sensitive to market changes and company performance. Other variables, such as the gross profit ratio and quick ratio, exhibit lower variance and returns compared to EPS, making them more suitable for low-risk investors.

Proposed portfolio and company weights: Based on the Markowitz model, the proposed portfolio includes companies that not only provide relatively high returns but also reduce portfolio risk. Bahman Group accounts for 20% of the portfolio, Kharg Petrochemical 18%, and Golgohar 15%. This weight distribution aims to achieve the highest possible returns with the lowest variance.

Data analysis based on the Markowitz model concludes that in an optimal investment portfolio, companies with high returns and relatively low risks are prioritized. Companies like Bahman Group and Kharg Petrochemical, given their favorable returns and variance, are selected as recommended options by the model. These findings can assist investors in making optimal investment decisions during unstable economic conditions.

Moreover, the analysis suggests that variables such as EPS and the debt ratio, due to their high skewness and kurtosis, have shown more significant fluctuations in returns. These variables require special attention as their changes could significantly impact portfolio performance.

This analysis ultimately provides investors with valuable information, enabling them to make more precise and optimal decisions in the stock market. Based on the scientific results confirmed in this research, it is recommended that not only individual investors but also companies with stock market portfolios, investment funds, pension funds, banks, insurance companies, government-owned investment companies, stock market brokerage firms, and portfolio management companies utilize the results of this study to invest and form optimal stock portfolios using the proposed TOPSIS and Similarity models.

In conclusion, it is worth noting that the results of this study can be useful and applicable for banks, financial institutions, credit institutions, and companies engaged in credit rating, risk management, and investment evaluation. By reviewing the investment portfolios of individuals and companies and applying the models discussed in this research, these institutions can improve their decision-making processes. Furthermore, the following suggestions are made for implementing portfolio optimization models using these methods and comparing them with the Markowitz model:

Utilizing the Similarity method to identify positive and negative correlations: The Similarity method helps identify strong relationships between assets and find assets with similar behaviors. This method uses correlation metrics to compare and match assets. With Similarity, it is possible to identify assets that behave similarly but are independent of others, thereby reducing systematic risk and increasing portfolio diversification. The Similarity method is especially suited for volatile markets, helping investors select assets with negative correlations that can counterbalance negative effects during market downturns.

Leveraging the TOPSIS method to evaluate and rank assets: In TOPSIS, performance criteria such as expected return, variance, and liquidity are used as key parameters. Each asset is compared with optimal criteria, and its distance from the positive and negative ideal is calculated. With this method, assets that have the shortest distance to the positive ideal and the longest distance from the negative ideal are ranked and selected as the best investment options. TOPSIS helps investors choose assets that best balance risk and return based on market conditions and individual needs. This method is particularly effective in evaluating assets with multiple features, such as liquidity and return.

Comparing and combining Similarity, TOPSIS, and Markowitz methods: Each method has strengths and weaknesses. The Markowitz model is based on variance and return, making it suitable for balanced markets and assets with high variance. Similarity can account for correlations and identify diversified assets. TOPSIS can evaluate multiple criteria simultaneously and is effective for complex markets with diverse parameters. Combining the results of all three methods can lead to a more optimal portfolio that not only provides high returns but is also resilient to systematic risks and other factors. For example, Similarity can first be used to identify diverse assets, followed by TOPSIS to rank these assets based on multiple criteria, and finally, the Markowitz model can be applied to optimize the weights and proportions of the assets.

Practical suggestions for investment: Using analytical platforms and investment management software, the Similarity and TOPSIS methods can be implemented and compared with the Markowitz model. This allows investors to create more optimized portfolios based on real data and statistical analysis. Furthermore, portfolios should be continuously monitored and reviewed in response to market fluctuations. Utilizing Similarity and TOPSIS enables investors to revise their assets based on changing market conditions and improve their portfolios accordingly.

These recommendations help investors select a portfolio with optimized returns and managed risk, tailored to the specific characteristics of the market and comprehensive analysis. This approach can result in overall improved investment performance and increased investor satisfaction.

Authors' Contributions

Authors equally contributed to this article.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

All procedures performed in this study were under the ethical standards.

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