Available online at http://iorajournal.org/indx.php/orics /index

Operations Research: International Conference Series

e-ISSN: 2722-0974
p-ISSN: 2723-1739

Vol. 5, No. 4, pp. 155-160, 2024

Health Sector Portfolio Optimization Using the Markowitz Approach with Risk Aversion and Risk Tolerance Parameters

Muhammad Iqbal Al-Banna Ismail[1*], Dede Irman Pirdaus[2]

[1]*School of Mathematical Sciences, Sunway University, No.5, Jalan Universiti, Bandar Sunway, 47500 Subang Jaya, Selangor, Malaysia.*
[2]*Faculty of computer science, University of informatics and business, Bandung, Indonesia*

**Corresponding author email: iqbal@nmit.edu.my*

Abstract

This study analyzes the optimal portfolio formation of health sector stocks listed on the Indonesia Stock Exchange using the Markowitz approach with dual risk parameters. Unlike traditional mean-variance optimization, this research incorporates both risk aversion (ρ) and risk tolerance (τ) parameters to better accommodate varying investor risk preferences. Using daily closing price data from six health sector stocks during the period January 2022 to December 2023, this study employs web scraping techniques for data collection and implements portfolio optimization calculations. The results show that the dual risk parameters approach produces consistent portfolio weights across both risk measures, with SIDO.JK receiving the highest allocation (approximately 41.6%) followed by SOHO.JK (23.0%) and SILO.JK (16.9%). The efficient frontier analysis demonstrates portfolio risk ranges from 0.015 to 0.030 with returns between 0.10% to 0.45%. This study contributes to the literature by demonstrating how incorporating dual risk parameters can provide more nuanced portfolio allocations while maintaining the fundamental benefits of diversification.

Keywords: Portfolio optimization, markowitz model, risk aversion, risk tolerance, healthcare sector stocks.

1. Introduction

The growth of investors in the capital market always increases every year (Ganiarto et al., 2021). is the 11% (year-to-date) increase in the number of capital market investors. Based on SIDs, the number of capital market Investors has jumped from 12.17 million investors in 2023 to 13.45 million investors as of August 9, 2024 (BEI, 2024). How to effectively manage the investment risks of these stocks and obtain better returns is of great interest to investors and policy makers (Wu dkk., 2022). The Markowitz mean–variance portfolio selection model has been widely used in theoretical and empirical studies, which aim to maximize investment returns at a given level of risk and minimize investment risk (Zhang dkk., 2018).

Markowitz accurately defined return and risk as mean and variance, and introduced powerful mathematical statistical methods into the study of asset portfolio selection. The selection of portfolio investors can balance the two factors of the expected return of the portfolio and its variance. Through diversification of securities, namely reducing the correlation between securities can reduce risk (Lu, 2021). Many previous researchers have applied the Markowitz model as a portfolio.

Based on the research results of Tian (2023), the Markowitz mean-variance model shows that although the complexity of the calculation can be an obstacle, this model still helps investors in determining the optimal weight for their portfolio. The analysis shows that, regardless of how the weight portfolio is changed, the results from the historical data used in this study estimate the potential for future losses. The traditional Markowitz mean-variance model does have some weaknesses, even though it has been widely used in investment theory and practice, such as assuming that investment returns follow a normal distribution, which does not always reflect the reality in the market (Škarica and Lukač, 2012).

In the development of modern portfolio theory, the Markowitz model has undergone various modifications to better reflect the complexity of investor risk preferences. Although the traditional mean-variance approach has proven effective, this model has limitations in accommodating the variation of different investor risk preferences (Fransisca et

al., 2023). Investors not only consider the trade-off between return and risk, but also have different levels of risk tolerance depending on their individual characteristics and investment goals (Rajasekar et al., 2023).

Recent research shows the importance of considering multiple risk parameters in portfolio optimization. Becker et al., (2024) propose a robust multi-objective optimization framework that incorporates benchmark comparisons to address uncertainty in portfolio outcomes. This approach improves the adaptability and reliability of strategies in real-world scenarios by minimizing regret and aligning with practical investment benchmarks.

Based on the research gap, this study proposes the use of dual risk parameters in optimizing the healthcare sector portfolio. This approach not only considers the trade-off between return and risk as in the traditional Markowitz model, but also integrates investor risk preferences through risk aversion (ρ) and risk tolerance (τ) parameters. Using daily data from six healthcare sector stocks on the Indonesia Stock Exchange, this study aims to produce a portfolio allocation that is more in line with various investor risk profiles.

2. Methodology

This study aims to analyze the optimal portfolio based on health sector stocks using the Markowitz approach with minimum risk and risk tolerance. The following research flow is shown in Figure 1:

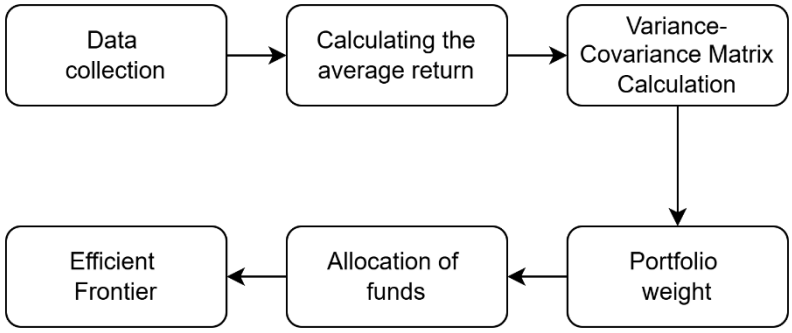

Figure 1: Flowchart

2.1. Data collection

Daily stock price data from the health sector was obtained through the yahoo finance platform. The data period used is from January 1, 2022 to December 31, 2023, focused on the daily closing price feature for each issuer. As for obtaining stock price data, the web scrapping method will be used, namely taking data directly from the data provider site. The following are the names and stock codes that will be used for this research:

Table 1: company name and code

No	Company Code	Company name
1	RSCH.JK	PT Charlie Hospital Semarang Tbk
2	PEVE.JK	PT Penta Valent Tbk
3	SOHO.JK	PT Soho Global Health Tbk
4	KAEF.JK	PT Kimia Farma Tbk
5	SILO.JK	PT Siloam International Hospitals Tbk
6	SIDO.JK	PT Industri Jamu dan Farmasi Sido Muncul Tbk

2.2. Calculating the average return

The expected return is the average of the daily returns calculated over a specified period. Daily returns are calculated as the simple holding period return rate between days (Bartholdy and Peare, 2005). The following formula is used to calculate the average daily return:

$$\mu_i = \frac{\sum_{t=1}^{T} R_{i,t}}{T} \tag{1}$$

where

μ_i : expected return for stocks i
T : number of days in the analysis period
$R_{\mathrm{i,t}}$: daily return of stock i on day t

2.3. Variance-Covariance matrix calculation

The variance-covariance matrix measures the relationship between the returns of existing stocks. This matrix shows how the returns of two stocks move together (covariance) (Irsan et al., 2022). The following formula is used to calculate the variance-covariance matrix:

$$Cov(R_i, R_j) = \frac{\sum_{t=1}^{T}(R_{i,t} - \mu_i)(R_{j,t}\mu_j)}{T-1} \tag{2}$$

where
$Cov(R_i, R_j)$: covariance between stock returns i and j
μ_i, μ_j : expected return of shares i and j

2.4. Optimal portfolio weight calculation

Calculating the optimal weight for a portfolio using risk aversion (ρ) and risk tolerance (τ), so that asset allocation can reflect investor risk preferences more accurately. approach using the formula:

$$w = \frac{\sum^{-1}(\mu - \rho 1)}{1^T \sum^{-1}(\mu - \rho 1)} \tag{3}$$

where
w : optimal portfolio weights
Σ : stock return covariance matrix
μ : stock expected return vector
ρ : risk aversion parameters
1 : unit vector ($[1,1,\ldots,]^T$)

2.5. Allocation of Funds

Allocating funds based on portfolio weight in this study the formula used:

$$A_i = w_i \times A_{total} \tag{4}$$

where
A_i : allocation of funds for shares i
w_i : stock weight i
A_{total} : total funds invested

2.6. Efficient Frontier

The Efficient Frontier is visualized in a two-dimensional graph with the X-axis representing risk (σ_p) and the Y-axis represents the return (μ_p). The optimal portfolio with minimum risk and maximum return is marked in the graph to show the best combination. The graph is generated using the matplotlib library.

3. Results and Discussion

3.1. Calculation of Expected Return (Average Return)

Expected return is calculated for each stock based on the average daily return in a specified period. Here are the expected return values for each stock:

Table 2: Calculation of expected return

Stock	Expected Return (μ)
RSCH.JK	0.006111
PEVE.JK	0.002327
SOHO.JK	0.001405
KAEF.JK	0.001030
SILO.JK	0.001611
SIDO.JK	0.000842

From the table, RSCH.JK shares have the highest expected return value among other shares with a value of 0.006111. Conversely, SIDO.JK shares have the lowest expected return of 0.000842. This shows that RSCH.JK is more profitable based on the calculated average return, but investors must consider the associated risk factors.

3.2. Variance-Covariance Matrix Calculation

The variance-covariance matrix measures the relationship between the returns of existing shares. The covariance matrix obtained is as follows:

$$\sum = \begin{bmatrix} 0.002330 & 0.000045 & -0.000050 & -0.000006 & 0.000014 & 0.000109 \\ 0.000045 & 0.001466 & 0.000036 & 0.000312 & -0.000006 & -0.000014 \\ -0.000050 & 0.000036 & 0.000677 & -0.000054 & -0.000040 & 0.000021 \\ -0.000006 & 0.000312 & -0.000054 & 0.002420 & -0.000017 & 0.000122 \\ 0.000014 & -0.000006 & -0.000040 & -0.000017 & 0.000927 & 0.000024 \\ 0.000109 & -0.000014 & 0.000021 & 0.000122 & 0.000024 & 0.000335 \end{bmatrix} \quad (5)$$

This variance-covariance matrix shows how much correlation there is between the returns of the existing stocks. For example, RSCH.JK stock has a positive covariance with SIDO.JK (0.000109), indicating that both tend to move in the same direction. Conversely, there is a negative covariance between RSCH.JK and SOHO.JK (-0.000050), indicating that these two stocks tend to move in opposite directions.

3.3. Portfolio Weight with Risk Aversion and Risk Tolerance

Using the Markowitz approach, portfolio weights are calculated for two types of risk measurements, namely risk aversion and risk tolerance.

Table 3: Portfolio weight

Stock	Weight (Risk Aversion)	Weight (Risk Tolerance)
RSCH.JK	0.049890	0.049671
PEVE.JK	0.096461	0.096409
SOHO.JK	0.230502	0.230497
KAEF.JK	0.037889	0.037902
SILO.JK	0.169049	0.169034
SIDO.JK	0.416209	0.416486

The portfolio weighting results show that SIDO.JK shares have the largest weight, which is 41.62% in the risk aversion approach and 41.65% in risk tolerance, indicating the dominance of this stock in the portfolio. SOHO.JK shares have the second largest weight with a proportion of around 23.05% in both approaches. SILO.JK shares are in third place with a weight of around 16.90%. Meanwhile, PEVE.JK, RSCH.JK, and KAEF.JK shares have smaller weights, ranging from 3.79% to 9.65% each. The difference in weight between the two approaches is very small, reflecting the consistency of the portfolio in considering risk and return.

3.4. Allocation of funds

Fund allocation is calculated based on portfolio weight for each stock. In this study, the total fund is IDR100,000,000, then the fund allocation for each stock is as follows:

Table 4: Allocation of funds

Stock	Fund allocation (IDR)	Fund allocation (IDR)
RSCH.JK	IDR 4,989,007.54	IDR 4,967,119.31
PEVE.JK	IDR 9,646,055.89	IDR 9,640,931.73
SOHO.JK	IDR 23,050,231.44	IDR 23,049,743.99
KAEF.JK	IDR 3,788,942.45	IDR 3,790,232.33
SILO.JK	IDR 16,904,861.30	IDR 16,903,362.34
SIDO.JK	IDR 41,620,901.38	IDR 41,648,610.30

The results of the fund allocation show that SIDO.JK shares received the largest allocation, both in the risk aversion approach (IDR 41,620,901.38) and risk tolerance (IDR 41,648,610.30). SOHO.JK shares received the second largest

allocation, amounting to IDR 23,050,231.44 and IDR 23,049,743.99, respectively. SILO.JK shares received the third allocation with IDR 16,904,861.30 and IDR 16,903,362.34. Meanwhile, PEVE.JK, RSCH.JK, and KAEF.JK shares received smaller allocations, ranging from IDR 3,788,942.45 to IDR 9,646,055.89. The difference in allocation between the two approaches is relatively small, indicating a consistent distribution of funds with the aim of maintaining portfolio efficiency while adjusting investor risk tolerance.

3.5. Efficient Frontier

Efficient Frontier graph aims for optimal portfolio combinations with different trade-offs between risk and return.

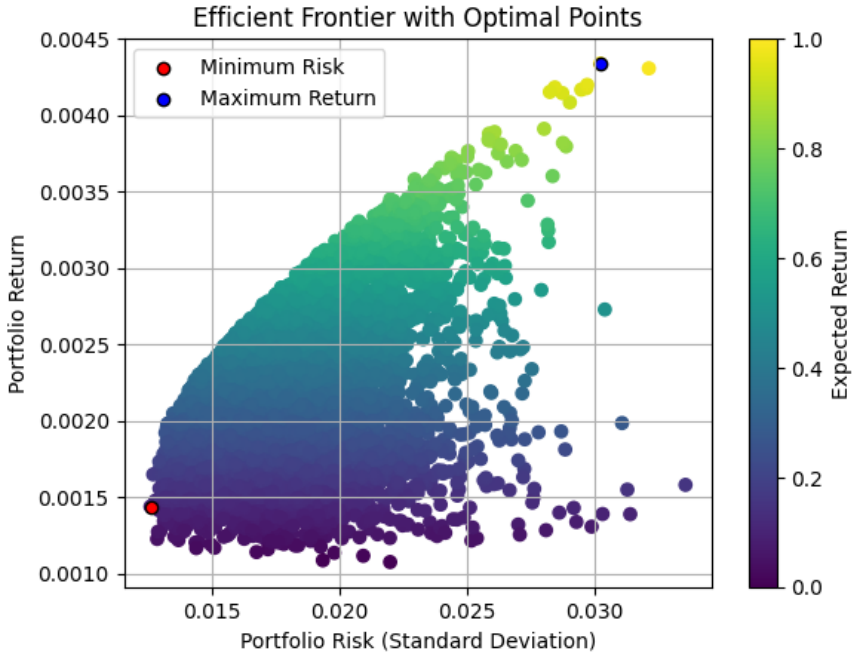

Figure 2: Efficient Frontier graph

It can be seen that the graph forms a convex curve which is a typical characteristic of the Efficient Frontier, where the upper part of the curve shows the optimal portfolios. There are two important points marked on the graph: the red point which shows the portfolio with minimum risk (Minimum Risk), and the blue point which shows the portfolio with maximum return (Maximum Return). The portfolio risk ranges from 0.015 to 0.030 (standard deviation), while the portfolio return ranges from 0.0010 to 0.0045 or 0.10% to 0.45%.

4. Conclusion

The implementation of the Markowitz model with dual risk parameters for health sector stocks has yielded several significant findings. First, the incorporation of both risk aversion and risk tolerance parameters produced remarkably consistent portfolio weights, suggesting the robustness of the optimization approach across different risk perspectives. The minimal variation in weight allocations between the two risk approaches (differences of less than 0.3%) indicates that the model successfully balances risk considerations while maintaining portfolio efficiency.

The dominance of SIDO.JK in the optimal portfolio, with an allocation of approximately 41.6% across both risk measures, followed by SOHO.JK and SILO.JK, demonstrates that the model identifies stocks with favorable risk-return characteristics regardless of the risk parameter used. This consistency in allocation suggests that these stocks possess fundamental strengths that make them attractive portfolio components under different risk considerations.

The efficient frontier analysis reveals a well-defined risk-return trade-off, with portfolio risks ranging from 0.015 to 0.030 and corresponding returns of 0.10% to 0.45%. This range provides investors with various optimal portfolio combinations based on their individual risk preferences, while the dual risk parameters approach ensures that these combinations remain practical and implementable.

References

Bartholdy, J., & Peare, P. (2005). Estimation of expected return: CAPM vs. Fama and French. *International Review of Financial Analysis*, *14*(4), 407-427.

Becker, Y., Halffmann, P., & Schöbel, A. (2024). Risk management in multi-objective portfolio optimization under uncertainty. *arXiv preprint arXiv:2407.19936*.

Bursa Efek Indonesia. (2024). Press Release Details. https://www.idx.co.id/en/news/press-release/2196

Fransisca, D. C., Sukono, Chaerani, D., & Halim, N. A. (2024). Robust Portfolio Mean-Variance Optimization for Capital Allocation in Stock Investment Using the Genetic Algorithm: A Systematic Literature Review. *Computation*, *12*(8), 166.

Ganiarto, E., Komalasari, F., & Manik, L. E. L. M. (2021). Novice investor behavior in Indonesia stock exchange: A comparative study before and during Covid-19 Pandemic.

Irsan, M. Y. T., Priscilla, E., & Siswanto, S. (2022). Comparison of Variance Covariance and Historical Simulation Methods to Calculate Value At Risk on Banking Stock Portfolio. *Jurnal Matematika, Statistika dan Komputasi*, *19*(1), 241-250.

Lu, Y. (2021). Research on the Application of Mean-Variance Model in Securities Investment Portfolio Planning: Evidence from China Stock Market. *Available at SSRN 4393576*.

Rajasekar, A., Pillai, A. R., Elangovan, R., & Parayitam, S. (2023). Risk capacity and investment priority as moderators in the relationship between big-five personality factors and investment behavior: a conditional moderated moderated-mediation model. *Quality & Quantity*, *57*(3), 2091-2123.

Škarica, B., & Lukač, Z. (2012). A comparison of basic and extended markowitz model on croatian capital market. *Croatian operational research review*, *3*(1), 236-244.

Tian, Y. (2023). A simple study of the applicability of the Markowitz model in the current stock market. BCP Business & Management, 44, 527–536. https://doi.org/10.54691/bcpbm.v44i.4882

Wu, Y., Huang, L., & Jiang, H. (2023). Optimization of large portfolio allocation for new-energy stocks: Evidence from China. *Energy*, *285*, 129456.

Zhang, Y., Li, X., & Guo, S. (2018). Portfolio selection problems with Markowitz's mean–variance framework: a review of literature. *Fuzzy Optimization and Decision Making*, *17*, 125-158.