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Stock Portfolio Construction Using the Capital Asset Pricing Model, Mean–Variance Efficient Portfolio, and Monte Carlo–Based Risk Measurement

Muhammad Rizal Fanani [a], Rita Rahmawati [a]*, Agus Rusgiyono [a]

[a] *Statistics Department, Faculty of Science and Mathematics, Diponegoro University, Semarang Indonesia*
[*] *E-mail: ritarahmawati@gmail.com*

A B S T R A C T

The development of digital technology has made it easier for people to access various types of information, including financial information related to investment and stocks. The uncertainty of investment returns makes stock investment a high-risk endeavor. This situation necessitates the use of tools and models that can help investors make well-informed, data-driven decisions. One of the models that can be used is the Capital Asset Pricing Model (CAPM) and the Mean Variance Efficient Portfolio (MVEP). CAPM is used to calculate the expected stock return based on measured risk, while MVEP helps optimize the asset weight distribution within a portfolio to minimize risk relative to the expected return. Portfolio risk or the maximum possible loss of a stock portfolio can be measured using Value at Risk (VaR), one of the methods being Monte Carlo simulation. This study uses monthly stock data from the Jakarta Islamic Index (JII) covering the period from January 2020 to October 2024. Based on calculations and analysis, the selected portfolio stocks and their respective weights are PT Bumi Resources Minerals Tbk. (BRMS) with a weight of 18.05%, PT Bukit Asam Tbk. (PTBA) with a weight of 44.34%, and PT United Tractors Tbk. (UNTR) with a weight of 37.61%. The calculation of the maximum potential portfolio loss using the Monte Carlo simulation method, with a 95% confidence level and an investment period of one month, resulted in a VaR value of 13.1%. This means that, with 95% confidence, the investor's loss will not exceed 13.1% of the invested funds within one month after October 2024.

Keywords: Jakarta Islamic Index; Capital Asset Pricing Model; Mean Variance Efficient Portfolio; Value at Risk; Monte Carlo simulation

1. Introduction

The rapid development of digital technology has made financial information increasingly accessible to the public, particularly information related to investment and stock markets. According to Adnyana (2020), stock investment refers to the allocation of funds with the expectation of generating future returns by purchasing securities in the form of shares, with the aim of earning profits from capital invested in stock exchange transactions. Investment has become increasingly attractive due to its potential for substantial gains, although this potential is accompanied by inherent risks. Consequently, investors must exercise careful analysis and informed decision-making, especially in uncertain market conditions. A strong understanding of market dynamics and the characteristics of target stocks is essential, and effective risk-management strategies are critical to achieving optimal returns without excessive exposure to risk.

One widely used approach to balancing returns and risk is through portfolio construction. A portfolio is a combination of two or more selected stocks held by an investor over a specific period and based on predetermined criteria (Maruddani & Purbowati, 2009). Portfolio theory provides a normative framework grounded in the assumption that investors are generally risk-averse. Instead of allocating all capital to one or a few individual stocks, investors are encouraged to diversify their holdings (Inrawan et al., 2022). Sound investment decisions should rely on robust quantitative analysis rather than speculation or intuition alone. Various models and methods—such as the Capital Asset Pricing Model (CAPM), Mean–Variance Efficient Portfolio (MVEP), and the Single Index Model—offer structured approaches for evaluating risk and return, enabling investors to select assets aligned with their risk preferences and construct portfolios that optimize performance. The Capital Asset Pricing Model (CAPM) provides a framework for determining the expected return of a stock based on its systematic risk (Adnyana, 2020). Meanwhile, the Mean–Variance Efficient Portfolio (MVEP), introduced by Harry Markowitz through Modern Portfolio Theory (MPT), enables investors to combine assets to form an optimal portfolio that either maximizes returns for a given level of risk or minimizes risk for a desired return. In the context of the Indonesian stock market, both CAPM and MVEP offer structured approaches for stock selection and portfolio optimization. CAPM can be used to estimate expected returns of shares listed on the Indonesia Stock Exchange based on measured risk, while MVEP facilitates the optimal allocation of weights across stocks to achieve the most favorable risk–return trade-off.

The objective of this study is to apply and evaluate the effectiveness of stock portfolio construction using CAPM and MVEP within the Indonesian market. Using stocks included in the Jakarta Islamic Index (JII), this research estimates expected returns through CAPM and constructs an optimal portfolio using MVEP. The findings are expected to assist investors in making more informed investment decisions. Furthermore, this study aims to demonstrate how these two models can complement one another in forming a portfolio that achieves an optimal balance between risk and return in the domestic market.

2. Literature Review

The Jakarta Islamic Index (JII) is a stock index published by the Indonesia Stock Exchange in collaboration with PT Danareksa Investment Management. This index consists of 30 selected stocks that meet Islamic Sharia screening principles and is expected to serve as a benchmark for the performance of Sharia-based stocks. The Jakarta Islamic Index is evaluated semiannually, in January and July, or in accordance with the period determined by Bapepam-LK. Meanwhile, changes in the business sectors of listed issuers are continuously monitored based on publicly available information (Indonesia Stock Exchange, 2008).

Stock investment is defined as an activity involving the allocation of funds with the purpose of generating future profit. This is conducted by channeling capital through the purchase of securities in the form of stocks, with the expectation that returns will be obtained from the invested funds through stock trading activities in the capital market (Adnyana, 2020). Return refers to the gain expected by companies or investors. The primary objective of investing is to obtain a return (Darmadji & Fakhruddin, 2018). Stock return values may be calculated using the formulation presented (Maruddani, 2019):

$$R_t = \frac{P_t - P_{t-1}}{P_{t-1}}$$

Expected return represents an estimation illustrating future return potential and is typically employed as a reference for investor decision-making during the investment process (Metasari & Marlinah, 2021). Expected return is computed by taking the average (mean) of returns as shown in Equation:

$$E(R) = \frac{1}{n}\sum_{t=1}^{n} R_t$$

Portfolio return is defined as the weighted average of realized returns of each individual stock comprising the portfolio (Wahyuni & Darmayanti, 2019). According to Markowitz's framework, CAPM assumes that every investor diversifies their portfolio and determines the optimal composition based on the balance between expected return and risk. Expected return is obtained from the sum of the risk-free rate and the risk premium. Stock risk and expected return increase proportionally with risk levels (Santoso et al., 2023). Mean Variance Efficient Portfolio (MVEP) is defined by Maruddani and Purbowati (2009) as a portfolio with the lowest variance among all possible combinations. If investors are risk-averse, then an MVEP represents the minimum variance portfolio for a given average return. Optimization is achieved by determining weights that minimize variance relative to expected return.

Risk is conceptualized as the deviation between realized return and expected return, typically expressed using standard deviation. Value at Risk (VaR) is one method used to quantify investment risk by estimating maximum potential loss across a time frame and confidence level. VaR measurement techniques include historical simulation, variance–covariance, and Monte Carlo simulation. Monte Carlo simulation has been employed since Boyle introduced its use in 1977.

3. Research Methodology

This study uses monthly closing price data from 25 constituent stocks of the Jakarta Islamic Index (JII) covering the period January 2020–October 2024. The analytical procedures consist of the following steps:

1. Return Calculation, Monthly stock returns were computed using price changes across consecutive periods.
2. Market Return and Risk-Free Rate Estimation, Market return was derived from the JII index movement, while the risk-free rate was based on applicable government benchmark rates.
3. CAPM-Based Expected Return and Beta, Each stock's expected return and beta were calculated to determine pricing status (undervalued or overvalued) and to categorize risk levels.
4. Stock Selection, Stocks qualified as portfolio candidates if:their realized return exceeded expected return (undervalued), and beta ranged between 0 and 1 (defensive).
5. Normality Assessment, Univariate and multivariate normality tests were conducted to confirm suitability for MVEP optimization and Monte Carlo simulation.
6. MVEP Weight Optimization, The Mean–Variance Efficient Portfolio model was used to form minimum-variance weights based on the variance–covariance matrix of selected returns.
7. Portfolio Return Measurement, Portfolio return was computed using weighted averages of individual stock returns.

8. Monte Carlo Value at Risk (VaR), Portfolio VaR was simulated using multivariate normal return generation across 1,000 iterations to estimate maximum one-month loss at a 95% confidence level.

The general procedure for computing VaR using Monte Carlo simulation consists of:

1. Determining mean return and variance–covariance structure.
2. Simulating return data based on a multivariate normal distribution repeatedly.
3. Calculating simulated portfolio returns for each iteration.
4. Identifying quantile-based loss corresponding to selected confidence levels.
5. Computing VaR using initial capital, quantile return, and holding period.

Repeating simulations multiple times generates stabilized results that better represent probabilistic loss distribution.

4. Results and Discussion

This study constructs an optimal stock portfolio through three core analytical stages: (1) security screening using the Capital Asset Pricing Model (CAPM), (2) weight optimization through the Mean–Variance Efficient Portfolio (MVEP) approach, and (3) portfolio risk measurement using Monte Carlo-based Value at Risk (VaR).

4.1 Security Selection Using CAPM

Expected return and beta values were calculated for all JII constituents. A stock was classified as undervalued when its realized return exceeded expected return, and categorized as defensive when beta was greater than 0 but less than 1. From the screening results, three stocks met these criteria: BRMS, PTBA, and UNTR.

This indicates that the selected securities provide returns exceeding CAPM-based expected performance while exhibiting risk sensitivity below the market level ($\beta < 1$). Accordingly, these stocks possess defensive characteristics, making them suitable for risk-conscious Islamic market investors.

4.2 Normality Assessment

Normality testing was conducted for both univariate and multivariate distributions. The Kolmogorov–Smirnov p-values for BRMS, PTBA, and UNTR were all greater than 0.05, indicating normal univariate behavior. Multivariate normality also held, as the computed statistic exceeded the critical value at $\alpha = 0.05$.

Because CAPM return modeling, MVEP optimization, and Monte Carlo simulation generally require normal-based return assumptions, these validation results justify the continuation of subsequent stages.

4.3 Weight Determination Using MVEP

A variance–covariance matrix was constructed from return interactions among BRMS, PTBA, and UNTR, followed by matrix inversion for optimization. The MVEP allocation yielded:

Stock	Weight	Percentage
BRMS	0.1805	18.05%
PTBA	0.4434	44.34%
UNTR	0.3761	37.61%

BRMS contributes diversification benefit due to its comparatively moderate volatility distribution, PTBA provides dominant yet stable exposure, and UNTR strengthens return consistency.

Collectively, the portfolio lies on the efficient frontier, meaning that no other combination of these three securities generates lower variance for the same expected return level.

4.4 Monte Carlo-Based VaR Estimation

Value at Risk was simulated using 1,000 multivariate draws with mean return vector and variance–covariance structure identical to empirical estimates. This produced 1,000 simulated monthly portfolio returns; the 5th percentile served as the 95% confidence loss benchmark.

The average VaR derived was 13.1% for a one-month holding period. This implies that with 95% confidence, an investor is unlikely to experience losses exceeding 13.1% of the invested amount within one month. Although VaR fluctuates slightly between simulations due to stochastic generation, outcome variability remains narrow because all simulations were parameterized using the same empirical risk structure.

These findings confirm that Monte Carlo simulation is an appropriate approach in Islamic market risk assessment, providing loss quantification aligned with probabilistic return uncertainty.

4.5 Interpretation

Integrated interpretation of CAPM, MVEP, and Monte Carlo outputs indicates that:

- screening based on undervaluation and defensiveness successfully identifies stocks with favorable risk–return positioning,
- the resulting MVEP allocation produces a minimum-variance structure without sacrificing expected performance,
- Monte Carlo results validate risk levels and provide quantifiable downside thresholds for investor decision-making.

In the context of Sharia index constraints, the portfolio is deemed sufficiently diversified and empirically resilient against market fluctuations.

5. Conclusion

Based on the analyses conducted, several conclusions can be drawn as follows:

1. Portfolio Stock Selection.

Screening using the Capital Asset Pricing Model (CAPM) identified three stocks that met the decision criteria of being undervalued and classified as defensive assets, namely PT Bumi Resources Minerals Tbk. (BRMS), PT Bukit Asam Tbk. (PTBA), and PT United Tractors Tbk. (UNTR). These stocks demonstrated realized returns exceeding CAPM-based expected returns and beta values below 1, indicating less sensitivity to market fluctuations relative to the broader index.

2. Distributional Assumptions

Univariate and multivariate normality testing confirmed that all three selected stocks follow a normal return distribution, thereby fulfilling statistical prerequisites for Mean–Variance Efficient Portfolio (MVEP) optimization and Monte Carlo-based Value at Risk (VaR) estimation.

3. Optimal Portfolio Construction

The resulting minimum-variance allocation using MVEP produced stock weights of 18.05% for BRMS, 44.34% for PTBA, and 37.61% for UNTR. This allocation is empirically positioned on the efficient frontier, providing the lowest possible risk for the expected return achievable within the three-asset selection space.

4. Risk Measurement via Monte Carlo Simulation

The Monte Carlo simulation, performed with a 95% confidence level and a one-month holding period, produced an average VaR of 13.1%. This indicates that, with 95% confidence, maximum potential loss is unlikely to exceed 13.1% of invested capital within one month following October 2024. Although VaR values may vary between simulation iterations, fluctuations remain stable because the simulation parameters consistently reflect empirical means and covariance structures.

Overall, the integration of CAPM, MVEP, and Monte Carlo simulation provides an effective methodological framework for constructing Sharia-compliant investment portfolios with balanced return expectations and quantifiable downside risk. The formed portfolio is suitable for investors prioritizing defensive positioning while maintaining return potential consistent with Jakarta Islamic Index performance dynamics.

References

Adnyana, I. M. (2020). Manajemen Investasi dan Portofolio. Lembaga Penerbitan Universitas Nasional (LPU-UNAS).

Darmadji, T., & Fakhruddin, H. M. (2018). Pasar Modal di Indonesia. Salemba Empat.

Indonesia Stock Exchange. (2008). Buku Panduan Indeks Harga Saham Bursa Efek Indonesia. Indonesia Stock Exchange.

Inrawan, A., Hastutik, S., Tonnis, B., Nugroho, H., Manik, E., Indriani, S., Hamdana, Salam, A., Atika, Kusumaningsih, A., Mindosa, B., Wijayangka, C., Djuanda, G., & Firmansyah, H. (2022). Dasar-dasar Teori Portofolio dan Analisis Sekuritas. Widina Bhakti Persada Bandung.

Maruddani, D. A. I. (2019). Value at Risk untuk Pengukuran Risiko Investasi Saham: Aplikasi dengan Program R. Wade Group.

Maruddani, D. A. I., & Purbowati, A. (2009). Pengukuran Value At Risk pada aset tunggal dan portofolio dengan simulasi Monte Carlo. Media Statistika, 2(2), 93–104. https://doi.org/10.14710/medstat.2.2.93-104

Metasari, M., & Marlinah, A. (2021). Return saham: Manajemen laba dan faktor lainnya. 1(1), 43–60.

Santoso, A., Syahputri, A., Puspita, G., Nurhikmat, M., & Dewi, S. (2023). Manajemen Investasi dan Teori Portofolio. EUREKA MEDIA AKSARA.

Wahyuni, N. C. T., & Darmayanti, N. P. A. (2019). Pembentukan portofolio optimal berdasarkan model indeks tunggal pada saham indeks IDX30 di BEI. E-Jurnal Manajemen, 8(6), 3814–3842.