Journal of Management Economics and Financial Accounting

e-ISSN: 3110-4924
p-ISSN: 3110-5475

NSGA-II Portfolio Optimization: A Comparison of Shariah Stocks (JII70) and Conventional Stocks (LQ45)

Delila Nasywa Ramananda [1], Dwi Eko Waluyo [2]*, Ana Kadarningsih [3], Suhita Whini Setyahuni [4]

[1] Dian Nuswantoro University; Semarang, Central Java; Indonesia; e-mail : 211202207608@mhs.dinus.ac.id
[2] Dian Nuswantoro University; Semarang, Central Java; Indonesia; e-mail : dwi.eko.waluyo@dsn.dinus.ac.id
[3] Dian Nuswantoro University; Semarang, Central Java; Indonesia; e-mail : ana.kadarningsih@dsn.dinus.ac.id
[4] Dian Nuswantoro University, Semarang, Central Java; Indonesia; e-mail : whinihita@dsn.dinus.ac.id
* Corresponding Author : Dwi Eko Waluyo

Abstract: This study analyzes and compares the performance of shariah and conventional stock portfolios in the Indonesian capital market using the Non-Dominated Sorting Genetic Algorithm II (NSGA-II) method. The study uses daily closing stock price data from January 3, 2022, to December 30, 2025, which was processed into measures of return and risk as the basis for portfolio construction. Optimization was performed by maximizing expected return and minimizing risk to generate an efficient frontier. Portfolio performance was then evaluated using the Sharpe Ratio, Sortino Ratio, and Omega Ratio. The results show that the shariah stock portfolio outperformed the conventional stock portfolio, as evidenced by a Sharpe Ratio of 0.15 compared to 0.04. Nevertheless, a combination portfolio consisting of shariah stocks and conventional stocks yielded the best overall performance, with a Sharpe Ratio of 0.15, a Sortino Ratio of 0.22, and an Omega Ratio of 1.56. These findings indicate that diversification between shariah and conventional stocks can enhance portfolio efficiency and generate more optimal performance compared to using each group of stocks separately. Thus, the NSGA-II method has proven effective in generating optimal portfolios to support investment decision-making in the Indonesian capital market.

Keywords: Multi-Objective Optimization; NSGA-II; Shariah Stocks; Conventional Stocks; Efficient Frontier; Risk-Adjusted Return; Indonesian Capital Market

Received: June 1, 2026
Revised: June 9, 2026
Accepted: June 19, 2026
Published: June 30, 2026
Curr. Ver.: June 30, 2026

1. Introduction

Developments in global capital markets have led to increased complexity in investment decision-making due to economic uncertainty and increasingly dynamic market volatility. Investors are no longer solely focused on achieving maximum returns but also simultaneously consider risk to obtain an optimal portfolio [1] . Although much research has been conducted on portfolio optimization using evolutionary algorithms, most studies still focus on a single asset class or use limited evaluation metrics. Research comparing conventional stock portfolios, shariah-compliant stock portfolios, intersection stock portfolios, and combination portfolios using the Non-Dominated Sorting Genetic Algorithm II (NSGA-II) and evaluating them simultaneously using the Sharpe Ratio, Sortino Ratio, and Omega Ratio remains relatively limited, particularly in the Indonesian capital market. This research gap highlights the need for a more comprehensive study to identify the portfolio group with the highest level of efficiency.

The mean-variance approach is widely used in portfolio construction because it explains the trade-off between return and risk [2], [3], [4] . However, this approach has limitations in accommodating various optimization objectives simultaneously, especially in complex and dynamic market conditions. Furthermore, stock price movements do not always reflect fully efficient market conditions because they are influenced by delays in information adjustment, investor behavior, and market microstructure factors [5] . In investment practice, investors are also faced with a choice between conventional stocks and shariah-compliant stocks, which have different risk and return characteristics. Shariah-compliant stocks tend to have a more conservative financial structure and demonstrate greater resilience during periods of crisis [6], [7], [8], [9], while increased inter-asset correlations under certain market conditions can reduce the effectiveness of diversification [10]. These differing characteristics make conventional and shariah-compliant stocks worth comparing when constructing an optimal portfolio.

With the advancement of computing technology, optimization methods based on evolutionary algorithms have become widely used to address the limitations of conventional approaches. One widely applied method is the Non-Dominated Sorting Genetic Algorithm II (NSGA-II), which is capable of generating a set of optimal solutions through a multi-objective approach based on Pareto optimality. This approach allows investors to obtain various optimal portfolio alternatives by simultaneously considering more than one objective, such as maximizing return and minimizing risk. Previous research has shown that the NSGA-II method is capable of generating portfolios that are more efficient and adaptive to changing market conditions compared to traditional optimization methods [11] . Therefore, NSGA-II was selected because it is capable of generating a set of Pareto-optimal solutions in a single optimization process while maintaining solution diversity through the crowding distance mechanism.

The Indonesian capital market has seen a significant increase in the number of investors, particularly retail investors, driven by easier access to investment opportunities through digital platforms. However, this growth has not been fully accompanied by an understanding of risk management and portfolio diversification. Low financial literacy and a lack of understanding of investment risks can lead to suboptimal investment decisions [12] . This situation is further compounded by the characteristics of the Indonesian capital market as an emerging market with relatively high volatility, making a quantitative approach necessary to help investors determine the optimal asset mix.

The LQ45 Index consists of stocks with high liquidity and market capitalization on the Indonesia Stock Exchange, while the Jakarta Islamic Index (JII70) is a shariah-compliant stock index that meets shariah principles based on specific criteria. Both indices are used in this study to represent conventional and shariah-compliant stocks in the Indonesian capital market. The LQ45 was chosen because it represents actively traded conventional stocks with high liquidity, while the JII70 was chosen because it represents shariah-compliant stocks with good liquidity that meet shariah criteria.

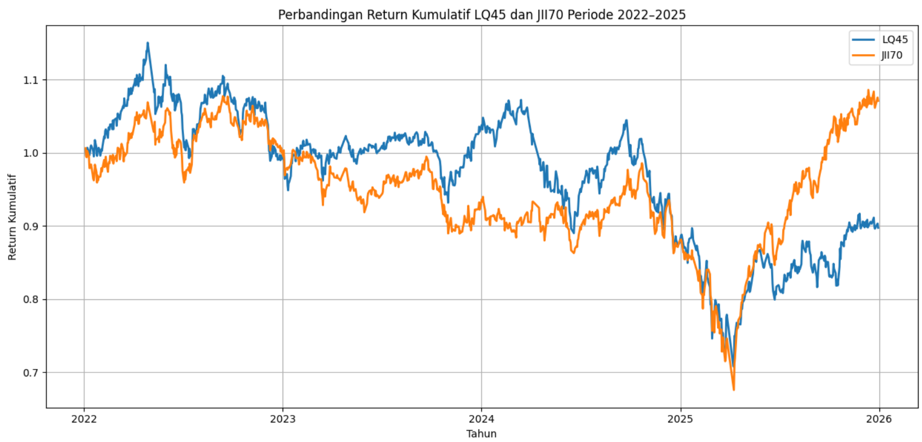

Figure 1. Comparison of Cumulative Returns for the LQ45 and JII70 Indices (2022–2025)
Source: Investing.com, processed by the author (2026)

Figure 1 shows that the LQ45 and JII70 indices exhibited different movement patterns during the 2022–2025 period. Although the LQ45 outperformed the JII70 for most of the observation period, the JII70 experienced a stronger recovery following a decline in 2025 and achieved a higher cumulative return by the end of the period. These findings indicate that shariah-compliant stocks and conventional stocks have different return characteristics, thereby potentially offering diversification benefits in the construction of an optimal portfolio.

Although various studies have addressed portfolio optimization using evolutionary algorithms and have compared shariah-compliant stocks with conventional stocks, most studies still focus on a single group of stocks or compare only two portfolio groups. Furthermore, performance evaluations generally use one or two risk-adjusted return indicators. To date, research comparing four portfolio groups namely, conventional, shariah, intersection, and combination using the Non-Dominated Sorting Genetic Algorithm II (NSGA-II) and evaluating them simultaneously using the Sharpe Ratio, Sortino Ratio, and Omega Ratio in the Indonesian capital market remains very limited. This gap forms the basis of this study.

Portfolio performance evaluation requires risk-adjusted return metrics so that the relationship between return and risk can be measured more comprehensively. The Sharpe Ratio, Sortino Ratio, and Omega Ratio not only evaluate the relationship between return and risk, but also take into account asymmetric return distributions and downside risk [13], [14] .

Based on this phenomenon, this study focuses on the formation of an optimal portfolio using a multi-objective approach based on NSGA-II. Therefore, the research questions in this study are: (1) how to construct an optimal portfolio using the Non-Dominated Sorting Genetic Algorithm II (NSGA-II) method, (2) how to compare the performance of conventional stock portfolios, shariah stock portfolios, intersection stock portfolios, and combination portfolios, and (3) which portfolio group demonstrates the highest level of efficiency.

This study aims to analyze the formation of optimal portfolios using the Non-Dominated Sorting Genetic Algorithm II (NSGA-II) method, compare the performance of conventional stock portfolios, shariah stock portfolios, intersection stock portfolios, and combination portfolios, and identify the portfolio groups with the highest levels of efficiency. This study contributes by providing a comprehensive analysis of these four portfolio groups using NSGA-II in the Indonesian capital market an approach that has been relatively limited in previous research. In addition to enriching the study of portfolio optimization based on evolutionary algorithms, the results of this study can serve as a reference for investors in constructing more efficient portfolios based on the principles of diversification and risk-adjusted return.

2. Literature Review

2.1. Portfolio Theory and Concepts

a. Modern Portfolio Theory

Modern Portfolio Theory (MPT) posits that investors can construct an optimal portfolio by combining various assets to achieve maximum return at a given level of risk or to minimize risk at a given level of return. The central concept of this theory is the trade-off between return and risk, which defines the efficient frontier as the set of most efficient portfolios. Over time, the modern portfolio approach has evolved to not only consider the linear relationship between return and risk but also to accommodate the increasing complexity of dynamic markets, including factors such as volatility, liquidity, and changes in global economic conditions. Diversification is a key principle in this theory because combining different assets can help reduce overall portfolio risk [15], [16].

b. Shariah Stocks and Conventional Stocks

Shariah-compliant stocks are investment instruments that adhere to shariah principles, such as the prohibition of riba, gharar, and maysir, whereas conventional stocks are not subject to these restrictions, resulting in a broader investment scope. These differences in investment principles lead to distinct return and risk characteristics between shariah-compliant and conventional stocks. Research shows that shariah-compliant stocks tend to have a more conservative financial structure, making them relatively more stable in the face of market pressures and global economic uncertainty. Additionally, the screening process for shariah-compliant stocks ensures that the selected assets are focused on companies whose business activities align with shariah principles, resulting in investment characteristics that differ from those of conventional stocks [17].

c. Efficient Frontier

Modern Portfolio Theory (MPT) introduces the concept of the efficient frontier, which is a curve representing a set of optimal portfolios capable of providing the highest return at a given level of risk or the lowest level of risk at a given level of return. This concept is used to identify the most efficient asset combinations based on the relationship between risk and return in the portfolio optimization process. The efficient frontier curve is plotted on a two-dimensional plane consisting of a horizontal axis (X) representing portfolio risk and a vertical axis (Y) representing portfolio return. The curve illustrates the trade-off between risk and return, where an increase in return is generally accompanied by an increase in risk. Every point on the curve represents an efficient portfolio combination, while portfolios located below the curve are considered inefficient because they yield a lower rate of return for the same level of risk. Therefore, the efficient frontier serves as the basis for determining the optimal portfolio that aligns with an investor's risk preferences [18], [19].

The concept of the efficient frontier in Modern Portfolio Theory (MPT) serves as the foundation for the development of various portfolio optimization methods, including multi-objective optimization approaches. Although MPT can explain the relationship between return and risk, its application to investment problems involving multiple assets and several objectives simultaneously requires more adaptive optimization methods. Therefore, the Non-Dominated Sorting Genetic Algorithm II (NSGA-II) is used to generate a set of Pareto-optimal solutions that represent efficient portfolio alternatives in accordance with investors' preferences regarding the trade-off between return and risk [20], [21].

2.2. Multi-Objective Portfolio Optimization

Multi-objective portfolio optimization is an optimization approach that simultaneously considers more than one investment objective, such as maximizing return and minimizing risk. This approach has emerged because traditional optimization methods are considered inadequate for representing the complexity of modern investment decision-making, which involves various constraints and objectives simultaneously. The key concept in multi-objective optimization is Pareto optimality a condition in which a solution cannot improve one objective without sacrificing another. This approach yields a efficient frontier that provides various optimal portfolio alternatives based on an investor's preferences regarding risk and return [20], [21].

The NSGA-II Algorithm

The Non-Dominated Sorting Genetic Algorithm II (NSGA-II) is an evolutionary algorithm used to solve multi-objective optimization problems. This algorithm employs a non-dominated sorting mechanism to group solutions based on their dominance levels, as well as crowding distance to maintain solution diversity on the Pareto frontier. The optimization process is carried out iteratively through the stages of selection, crossover, and mutation until a set of optimal solutions is obtained. NSGA-II is considered effective in handling portfolio optimization problems because it is capable of producing solutions that are more flexible and adaptive to changing market conditions compared to traditional optimization methods [20], [22].

Several studies have applied the Non-Dominated Sorting Genetic Algorithm II (NSGA-II) to portfolio optimization and have shown that this algorithm is capable of generating a diverse range of Pareto-optimal solutions compared to traditional optimization approaches [20], [22]. However, most studies still focus on constructing optimal portfolios within a single asset class or merely compare shariah-compliant stocks and conventional stocks separately. Furthermore, portfolio performance evaluation is generally conducted using one or two risk-adjusted return indicators. Unlike previous studies, this research integrates NSGA-II-based portfolio optimization with a comparison of four portfolio groups conventional, shariah, intersection, and combination and evaluates their performance using the Sharpe Ratio, Sortino Ratio, and

Omega Ratio simultaneously. Thus, this study provides a more comprehensive perspective on portfolio efficiency in the Indonesian capital market.

2.3. Portfolio Performance Evaluation

a. Sharpe Ratio

The Sharpe Ratio is a risk-adjusted return metric used to measure a portfolio's ability to generate excess returns relative to the total risk borne by investors. Risk in the Sharpe Ratio is measured using the standard deviation of the portfolio's returns, so this ratio indicates the portfolio's efficiency in generating returns relative to its volatility. The higher the Sharpe Ratio, the better the portfolio's performance, as it is able to generate greater returns at a given level of risk. The Sharpe Ratio is widely used in portfolio evaluation because it provides an overview of the overall efficiency of an investment [17], [23].

b. Sortino Ratio

The Sortino Ratio is an extension of the Sharpe Ratio that considers only downside risk that is, the risk of a decline in returns. Unlike the Sharpe Ratio, which uses total volatility, the Sortino Ratio focuses more on the risk of losses that are of genuine concern to investors. Therefore, this indicator is considered more relevant in highly volatile market conditions because it provides a more specific assessment of a portfolio's downside risk. The higher the Sortino Ratio, the better the portfolio's ability to generate returns relative to the downside risk borne by investors [16].

c. Omega Ratio

The Omega Ratio is a portfolio evaluation metric that compares the probabilities of gains and losses based on the distribution of portfolio returns. Unlike the Sharpe Ratio and Sortino Ratio, which focus only on the mean and volatility of returns, the Omega Ratio captures the characteristics of the return distribution more comprehensively, including returns that are not normally distributed. A higher Omega Ratio indicates that the probability of portfolio gains is greater than the potential for losses, thus reflecting better investment performance [17].

These three indicators are used simultaneously because they provide a more comprehensive evaluation of portfolio performance based on the concept of risk-adjusted return compared to using a single indicator.

2.4. Research Conceptual Framework

The conceptual framework of this study illustrates the relationship between stock groups, the optimization process using NSGA-II, portfolio performance evaluation, and performance comparisons to identify the portfolio with the highest level of efficiency. The relationships among the components in this conceptual framework are presented in Figure 2.

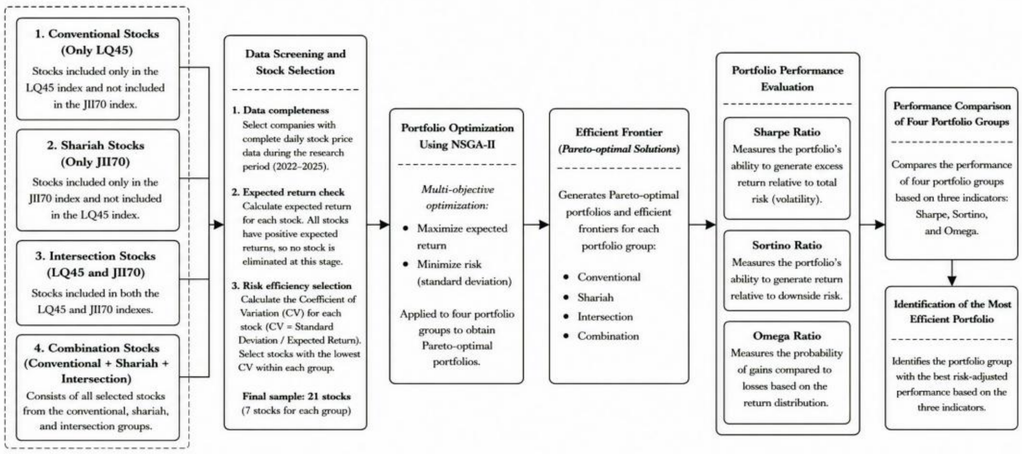

Figure 2. Conceptual Framework of the Study
Source: Adapted by the author (2026)

Figure 2 shows that this study began by grouping stocks into four categories: conventional stocks, shariah-compliant stocks, intersection stocks, and combination stocks. Next, each stock group was optimized using the NSGA-II algorithm with two primary objectives: maximizing return and minimizing risk. The optimization results yielded a set of Pareto-optimal solutions that formed an efficient frontier for each stock group. These optimal portfolios were then evaluated using three performance indicators: the Sharpe Ratio, the Sortino Ratio, and the Omega Ratio. Based on the evaluation results, the performance of the four portfolios was compared to identify the portfolio group with the highest level of efficiency.

3. Proposed Method

This study employs a descriptive quantitative approach to construct and analyze an optimal portfolio using a multi-objective optimization method based on the Non-Dominated Sorting Genetic Algorithm II (NSGA-II). This approach was chosen because the study focuses on processing numerical data specifically, historical stock prices converted into returns and risk which are then analyzed using mathematical models and optimization algorithms. A computationally based quantitative approach allows the portfolio evaluation process to be conducted objectively, systematically, and in a replicable manner through algorithmic procedures [5], [24]
.
The NSGA-II workflow used in this study is presented in Figure 3.

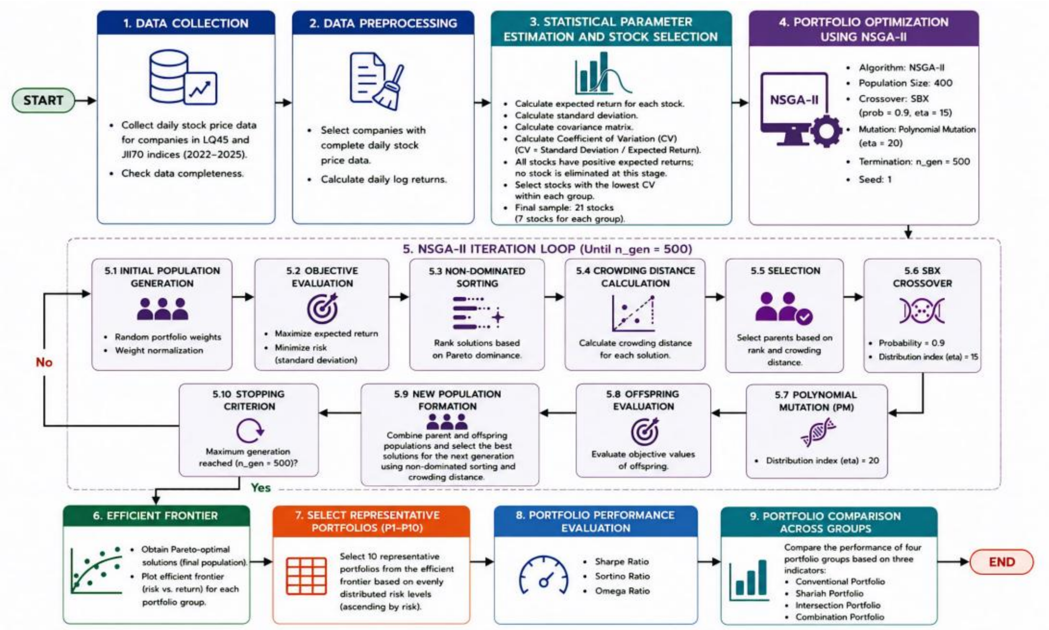

Figure 3. NSGA-II Flowchart
Source: Adapted by the author (2026)

The diagram illustrates the research stages, beginning with data collection, preprocessing, calculation of returns and risk, optimization using NSGA-II, and ending with portfolio performance evaluation using the Sharpe Ratio, Sortino Ratio, and Omega Ratio.

The research subjects consist of stocks listed on the Indonesia Stock Exchange (IDX) and drawn from the LQ45 and Jakarta Islamic Index 70 (JII70). This study uses secondary data in the form of daily closing prices for the period January 2022–December 2025, obtained from Yahoo Finance. The 2022–2025 period was selected because it represents market conditions following the end of the main impact of the COVID-19 pandemic through the period of economic recovery and normalization of capital market activity in Indonesia. This timeframe also encompasses a variety of market movements, thereby allowing for the evaluation of portfolio performance under a wider range of market conditions.

The sample was selected using a purposive sampling technique based on:
a. The completeness of stock price data during the observation period;

b. Positive expected return;
c. The lowest Coefficient of Variation (CV) value.

A summary of the study population and sample is presented in Table 1.

Table 1. Population and Sample

Criteria	Number
Companies listed on the LQ45 (conventional)	45
Companies listed on the JII70 (shariah)	70
Total Population	**115**
Companies listed on both the LQ45 and JII70 indices (intersection)	31
Total Companies After Duplicate Removal	**84**
Companies with complete stock price data for the 2022–2025 period on Yahoo Finance	45
Companies eliminated based on their Coefficient of Variation (CV)	24
Final Sample Size	**21**

Source: Compiled by the author (2026)

Based on Table 1, the study population consisted of 115 companies from the LQ45 and JII70 indices. After eliminating duplicates, 84 companies remained. Selection based on the completeness of stock price data resulted in 45 companies that met the study criteria. All of these companies had positive expected returns, so no stocks were eliminated at this stage. Next, stocks were selected based on their Coefficient of Variation (CV) values. A lower CV value indicates a lower level of risk for each unit of return generated, meaning the stock is considered to have better risk-return efficiency. The results of the calculations for expected return, standard deviation, and Coefficient of Variation (CV) are presented in Table 2.

Table 2. Expected Return, Standard Deviation, and Coefficient of Variation (CV) Values for Selected Stocks

Stock Code	Expected Return (%)	Standard Deviation (%)	Coefficient of Variation (CV)
Conventional Group			
BRPT.JK	0.21	3.71	17.82
BMRI.JK	0.08	1.88	23.03
BBNI.JK	0.07	1.87	28.81
AMRT.JK	0.08	2.44	29.23
SCMA.JK	0.08	3.29	40.39
BBCA.JK	0.03	1.47	45.48
BBRI.JK	0.03	1.80	57.46
Shariah Group			
PTRO.JK	0.53	4.28	8.12
PANI.JK	0.58	4.93	8.52
ENRG.JK	0.36	4.03	11.08
FILM.JK	0.41	5.03	12.13
BRMS.JK	0.32	4.08	12.77
WIFI.JK	0.28	4.40	15.77
AUTO.JK	0.14	2.26	15.88

Intersection Group			
ADMR.JK	0.35	4.36	12.47
MEDC.JK	0.18	3.13	17.58
ITMG.JK	0.11	1.95	18.49
UNTR.JK	0.10	2.05	19.88
MAPA.JK	0.15	3.05	20.42
PGAS.JK	0.09	1.94	21.44
ADRO.JK	0.12	2.76	23.35

Source: Data processed using Python (2026)

In the shariah stock group and the intersection stock group, the seven stocks with the lowest CV values were selected to identify assets with the best risk-return efficiency. Meanwhile, in the conventional stock group, all stocks that met the research criteria were used as the sample because there were only seven stocks that met those criteria. Thus, no additional selection based on CV values was necessary in the conventional group. The sample sizes in each group were made equal to ensure the comparability of portfolio optimization results, reduce potential bias due to differences in sample size, and enhance the reliability of the research results.

Table 3. Research Data Groups

Conventional	Shariah	Intersection	Combination		
AMRT.JK	AUTO.JK	ADMR.JK	AMRT.JK	AUTO.JK	ADMR.JK
BBCA.JK	BRMS.JK	ADRO.JK	BBCA.JK	BRMS.JK	ADRO.JK
BBNI.JK	ENRG.JK	ITMG.JK	BBNI.JK	ENRG.JK	ITMG.JK
BBRI.JK	FILM.JK	MAPA.JK	BBRI.JK	FILM.JK	MAPA.JK
BMRI.JK	PANI.JK	MEDC.JK	BMRI.JK	PANI.JK	MEDC.JK
BRPT.JK	PTRO.JK	PGAS.JK	BRPT.JK	PTRO.JK	PGAS.JK
SCMA.JK	WIFI.JK	UNTR.JK	SCMA.JK	WIFI.JK	UNTR.JK

Source: Compiled by the author (2026)

Table 4. NSGA-II Optimization Parameters

Parameter	Value
Population Size	400
Number of Generations	500
Sampling Method	Float Random Sampling
Selection Method	Tournament Selection (default NSGA-II)
Crossover Operator	Simulated Binary Crossover (SBX)
Crossover Probability	0.9
Crossover Distribution Index (ηc)	15
Mutation Operator	Polynomial Mutation (PM)
Mutation Probability	1/n (default in pymoo)
Mutation Distribution Index (ηm)	20
Random Seed	1

Source: Compiled by the author (2026)

The NSGA-II parameters in this study were set based on the configuration commonly used in multi-objective portfolio optimization research and the default recommendations of the pymoo library. A population size of 400 individuals and 500 iterations were selected to strike a balance between solution quality and computational efficiency. The Simulated Binary Crossover (SBX) operator with a crossover probability of 0.9 was used to enhance the exploration of the solution space, while Polynomial Mutation (PM) with a distribution index of 20 was used to maintain population diversity during the optimization process. This configuration is widely used in NSGA-II implementations to generate a stable and representative set of Pareto solutions [20], [21], [24] .

3.1. Algorithm/Pseudocode

Algorithm 1. NSGA-II Portfolio Optimization

INPUT: Stock price data, stock returns, covariance matrix, population size = 400, number of generations = 500
OUTPUT: Set of Pareto-optimal solutions and optimal portfolio

1: Collect daily stock price data;
2: Perform data preprocessing and calculate log returns;
3: Calculate expected returns, standard deviations, the covariance matrix, and the coefficient of variation;
4: Identify stocks with positive expected returns and select stocks based on the lowest coefficient of variation (CV);
5: Initialize the initial population randomly using Float Random Sampling;
6: Calculating the return and risk values for each individual;
7: Performing non-dominated sorting;
8: Calculating the crowding distance;
9: Performing selection;
10: Perform crossover using Simulated Binary Crossover (SBX);
11: Performing mutation using Polynomial Mutation (PM);
12: Evaluating the offspring and forming a new generation population;
13: Repeat the process until the number of generations reaches 500;
14: Generate a set of Pareto-optimal solutions (efficient frontier);
15: Select 10 representative portfolios based on risk level;
16: Evaluate portfolio performance using the Sharpe Ratio, Sortino Ratio, and Omega Ratio.

Although the optimization process yields hundreds of Pareto-optimal solutions, this study selects 10 representative portfolios that are proportionally distributed along the efficient frontier, ranging from the portfolio with the minimum risk to the portfolio with the maximum expected return. This selection aims to simplify the analysis process and facilitate performance comparisons among stock groups without compromising the representation of the efficient frontier characteristics generated by the NSGA-II algorithm.

3.2. Mathematical Component Formats

Stock price data is transformed into log returns using Equation (1).

$$\boldsymbol{R_{i,t} = ln\left(\frac{P_{i,t}}{P_{i,t-1}}\right)} \tag{1}$$

where$\boldsymbol{R_{i,t}}$ is the return on stock i in period t,$\boldsymbol{P_{i,t}}$ is the closing price of stock i in period t, and$\boldsymbol{P_{i,t-1}}$ is the closing price of stock i in the previous period.

The expected return is calculated using Equation (2).

$$\boldsymbol{\mu_i = \frac{1}{T}\sum_{t=1}^{T} R_{i,t}} \tag{2}$$

Inter-asset risk is measured using the covariance matrix as shown in Equation (3).

$$\boldsymbol{\Sigma ij = Cov(Ri, Rj)} \tag{3}$$

The Coefficient of Variation (CV) is calculated using Equation (4)

$$\boldsymbol{CV_i = \frac{\sigma_i}{\mu_i}} \tag{4}$$

Portfolio weights are expressed in Equation (5).

$$\boldsymbol{w = (w1, w2, \ldots, wn)} \tag{5}$$

with the constraint:

$$\boldsymbol{\sum_{i=1}^{n} wi = 1,} \tag{6}$$

$$\boldsymbol{0 \leq wi \leq 1} \tag{7}$$

The expected return of the portfolio is calculated using Equation (8).

$$\boldsymbol{E(R_p) = \sum_{i=1}^{n} w_i E(R_i)} \tag{8}$$

Portfolio risk is calculated using Equation (9).

$$\boldsymbol{\sigma_p = \sqrt{w^T \Sigma w}} \tag{9}$$

The first objective function is used to maximize the expected return, as shown in Equation (10).

$$\boldsymbol{Minimize\ \ f\,1\,(w) = -\left(\sum_{i=1}^{n} wi\mu i\right)} \tag{10}$$

The second objective function is used to minimize risk, as shown in Equation (11).

$$\boldsymbol{Minimize\ \ f\,2\,(w) = \sqrt{\sum_{i=1}^{n}\sum_{j=1}^{n} wiwj\sigma_{ij}}} \tag{11}$$

Equation (10) and Equation (11) are used to generate the set of Pareto solutions that form the efficient frontier[20] .

Portfolio performance is evaluated using the Sharpe Ratio, Sortino Ratio, and Omega Ratio, as shown in Equations (12)–(14).

$$\boldsymbol{sharpe = \frac{E(R_P) - Rf}{\sigma_p}} \tag{12}$$

$$\boldsymbol{sortino = \frac{E(R_P) - Rf}{\sigma_{downside}}} \tag{13}$$

$$\boldsymbol{omega} = \frac{\int_{r}^{\infty}[\mathbf{1} - \boldsymbol{F(x)}]\boldsymbol{dx}}{\int_{-\infty}^{r}\boldsymbol{F(x)dx}} \tag{14}$$

where$\boldsymbol{E(R_P)}$ is the expected return of the portfolio,$\boldsymbol{Rf}$ is the risk-free rate,$\boldsymbol{\sigma_p}$ is the standard deviation of the portfolio return,$\boldsymbol{\sigma_{downside}}$ is the downside deviation,$\boldsymbol{F(x)}$ is the cumulative distribution function of the portfolio return, and$\boldsymbol{r}$ is the threshold return.

In this study, the risk-free rate (Rf) is assumed to be 5% per year and converted to a daily rate by dividing that value by the 252 trading days in a year. This Rf value is used in the calculation of the Sharpe Ratio and Sortino Ratio to measure the portfolio's excess return relative to the risk-free rate of return.

These three indicators are used to evaluate portfolio efficiency based on the concept of risk-adjusted return.

4. Results and Discussion

Data processing and portfolio optimization in this study were performed using the Python programming language, utilizing the yfinance, pandas, NumPy, pymoo, and Matplotlib libraries. The data used consisted of daily closing stock prices for the period January 3, 2022 to December 30, 2025, obtained from Yahoo Finance. The optimization process was performed on four stock groups: conventional, shariah, intersection, and combination. The optimization results yielded a set of Pareto-optimal solutions that formed an efficient frontier for each portfolio group.

The optimization results using the Non-Dominated Sorting Genetic Algorithm (NSGA-II) method yielded 400 portfolio solutions for each stock group. All of these solutions represent various combinations of return and risk obtained from the multi-objective optimization process. The efficient frontier illustrates the trade-off between return and risk, where an increase in return is generally accompanied by an increase in risk. Based on the optimization results, each stock group produced a distinct efficient frontier corresponding to the return and risk characteristics of each portfolio. These differences indicate that the stock composition within each group influences the efficiency level of the resulting portfolios. Although the optimization process generated 400 Pareto-optimal solutions for each stock group, this study presents only 10 representative portfolios to facilitate the interpretation of the results. These ten portfolios were selected based on risk levels that are gradually distributed along the efficient frontier, ranging from the portfolio with the lowest risk (minimum variance) to the portfolio with the highest expected return (maximum expected return). Thus, portfolios P1–P10 can represent the overall characteristics of the set of Pareto solutions generated by the NSGA-II algorithm.

4.1. Portfolio Optimization for the Conventional Group

The results of conventional group portfolio optimization using the NSGA-II algorithm are presented in Table 5.

Table 5. Results of Conventional Group Portfolio Optimization

Conventional	Maximum Expected Return								Minimum Variance	
	Weight (%)									
	P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**
AMRT.JK	15.35	17.97	19.66	19.92	12.46	7.34	0.88	0.04	0.00	0.00

BBCA.JK	45.77	27.13	9.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BBNI.JK	7.88	12.07	11.41	3.46	0.07	0.24	0.01	0.32	0.02	0.00
BBRI.JK	11.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BMRI.JK	5.70	23.24	34.18	45.54	42.89	37.09	32.25	20.75	11.15	0.00
BRPT.JK	5.67	13.31	21.94	31.01	44.55	55.32	66.87	78.88	88.82	100.00
SCMA.JK	7.83	6.29	3.47	0.07	0.03	0.01	0.00	0.00	0.00	0.00
Expected Return (%)	0.04	0.06	0.07	0.09	0.10	0.11	0.12	0.12	0.13	0.14
Standard Deviation	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.04
Coefficient of Variation (CV)	33.36	23.42	20.81	20.14	20.61	21.47	22.58	23.77	24.76	25.86
Sharpe	0.01	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.03	0.03
Sortino	0.02	0.04	0.05	0.06	0.06	0.06	0.06	0.05	0.05	0.05
Omega	1.09	1.13	1.14	1.15	1.15	1.14	1.14	1.13	1.13	1.12

Source: Data processed using Python (2026)

Table 5 shows the results of optimizing a conventional stock portfolio using the NSGA-II algorithm. The portfolio with the maximum expected return is dominated by BRPT.JK with a weight of 100.00%, while the portfolio with the minimum risk consists primarily of BBCA.JK at 45.77%, AMRT.JK at 15.35%, and BBRI.JK at 11.80%. The maximum-return portfolio yields an expected return of 0.14 with a standard deviation of 0.04, while the minimum-risk portfolio yields an expected return of 0.04 with a standard deviation of 0.01. These results indicate a trade-off between return and risk.

A visualization of the efficient frontier for the conventional group is shown in Figure 4.

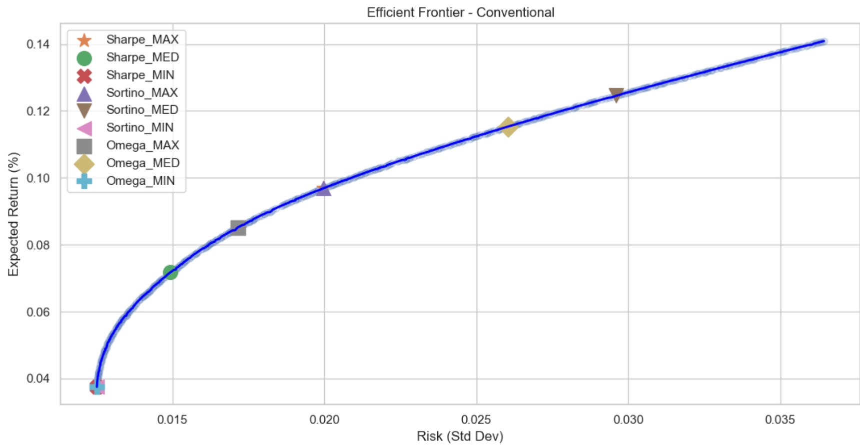

Figure 4. Efficient Frontier of Conventional Stocks
Source: Data processed using Python (2026)

Based on Figure 4, the efficient frontier curve moves from the lower left to the upper right, indicating a positive relationship between risk and return. Portfolios with the maximum Sharpe Ratio, maximum Sortino Ratio, and maximum Omega Ratio are located in the middle of the curve, indicating that portfolios with moderate risk levels offer the best efficiency. The maximum Sharpe Ratio is 0.04, the Sortino Ratio is 0.06, and the Omega Ratio is 1.15. The Coefficient of Variation (CV) ranges from 20.14 to 33.36, indicating that the conventional group's portfolio has a relatively high level of risk compared to the returns generated. A high CV value indicates that each unit of return is obtained with a higher level of risk, so the risk-return efficiency of the conventional group tends to be lower than that of the other groups.

4.2. Optimization of the Shariah Group Portfolio

The results of the shariah group portfolio optimization using the NSGA-II algorithm are presented in Table 6.

Table 6. Results of Shariah Group Portfolio Optimization

Shariah	Maximum Expected Return									Minimum Variance
	Weight (%)									
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
AUTO.JK	47.06	34.87	21.97	10.44	0.00	0.02	0.13	0.00	0.00	0.00
BRMS.JK	8.36	6.70	5.21	5.21	3.02	0.00	0.00	0.00	0.00	0.00
ENRG.JK	8.57	10.11	13.53	14.43	16.89	11.41	3.46	0.00	0.00	0.00
FILM.JK	7.16	8.32	10.99	10.91	11.33	10.90	4.01	0.00	0.00	0.00
PANI.JK	8.20	13.00	17.22	23.04	27.56	35.75	42.28	62.72	84.31	100.00
PTRO.JK	9.27	17.66	23.70	28.54	34.48	41.92	50.11	37.28	15.69	0.00

WIFI.JK	11.39	9.34	7.39	7.43	6.72	0.00	0.00	0.00	0.00	0.00
Expected Return (%)	0.22	0.26	0.31	0.34	0.38	0.41	0.44	0.45	0.46	0.46
Standard Deviation	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.05
Coefficient of Variation (CV)	7.46	6.50	6.26	6.29	6.45	6.74	7.16	7.81	9.07	10.34
Sharpe	0.12	0.14	0.15	0.15	0.15	0.14	0.13	0.12	0.11	0.09
Sortino	0.17	0.19	0.21	0.21	0.21	0.21	0.21	0.20	0.18	0.16
Omega	1.43	1.51	1.54	1.55	1.53	1.51	1.49	1.44	1.39	1.35

Source: Data processed using Python (2026)

Table 6 shows that the shariah group's fund allocation tends to be concentrated in PANI.JK and PTRO.JK stocks. The maximum-return portfolio is dominated by PANI.JK at 100.00%, while the minimum-risk portfolio consists primarily of AUTO.JK at 47.06%, WIFI.JK at 11.39%, and PTRO.JK at 9.27%. The maximum-return portfolio yields an expected return of 0.46 with a standard deviation of 0.05, while the minimum-risk portfolio yields an expected return of 0.22 with a standard deviation of 0.02.

A visualization of the shariah group's efficient frontier is shown in Figure 5.

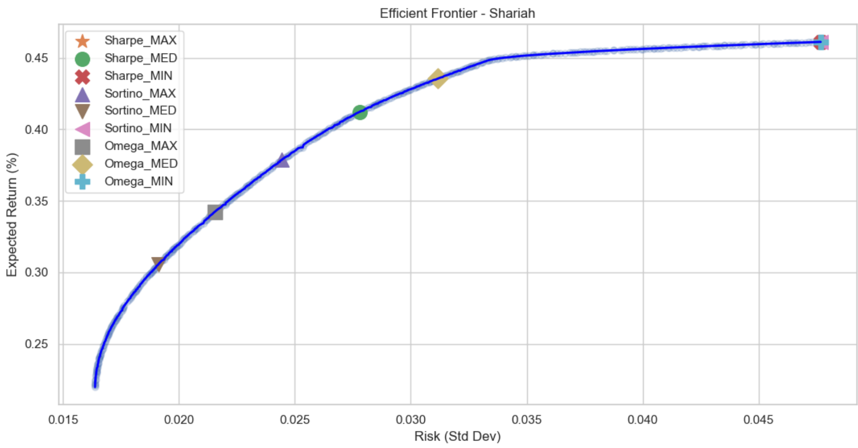

Figure 5. Efficient Frontier of Shariah Stocks
Source: Data processed using Python (2026)

As shown in Figure 5, the efficient frontier curve for the shariah group lies higher than that of the conventional group. The maximum Sharpe Ratio is 0.15, the Sortino Ratio is 0.21, and the Omega Ratio is 1.55. The CV value ranges from 6.26 to 10.34, which is the lowest among the other groups. These findings indicate that shariah stocks offer better risk-return efficiency because they are able to generate relatively higher returns at a lower level of risk. Thus, the shariah group's portfolio exhibits more efficient investment characteristics after adjusting for risk.

4.3. Portfolio Optimization for the Intersection Group

The results of the intersection group portfolio optimization are presented in Table 7.

Table 7. Results of Intersection Group Portfolio Optimization

Intersection	Maximum Expected Return									Minimum Variance
	Weight (%)									
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
ADMR.JK	2.52	17.01	26.02	35.18	45.80	56.14	68.36	79.14	89.79	100.00
ADRO.JK	0.00	0.00	00.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ITMG.JK	27.30	21.03	17.42	14.54	5.57	0.09	0.00	0.01	0.45	0.00
MAPA.JK	17.32	18.36	22.44	23.44	23.72	19.39	13.97	6.28	0.93	0.00
MEDC.JK	2.84	7.65	14.13	21.00	24.29	24.27	17.67	14.39	8.82	0.00
PGAS.JK	30.50	18.73	9.59	0.25	0.62	0.00	0.00	0.00	0.00	0.00
UNTR.JK	19.52	17.22	10.39	5.59	0.01	0.11	0.00	0.19	0.01	0.00
Expected Return (%)	0.09	0.12	0.14	0.16	0.18	0.20	0.22	0.23	0.25	0.26
Standard Deviation	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04
Coefficient of Variation (CV)	15.29	12.67	12.40	12.66	13.09	13.54	14.13	14.76	15.38	15.93
Sharpe	0.05	0.07	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06
Sortino	0.07	0.10	0.11	0.12	0.12	0.13	0.13	0.12	0.12	0.12
Omega	1.20	1.24	1.25	1.24	1.24	1.23	1.23	1.22	1.22	1.21

Source: Data processed using Python (2026)

Table 7 shows that the maximum-return portfolio is dominated by ADMR.JK at 100.00%, while the minimum-risk portfolio consists primarily of PGAS.JK at 30.50%, ITMG.JK at 27.30%, UNTR.JK at 19.52%, and MAPA.JK at 17.32%. The maximum-return portfolio yields an expected return of 0.26 with a standard deviation of 0.04, while the minimum-risk portfolio yields an expected return of 0.09 with a standard deviation of 0.01.

A visualization of the efficient frontier for the intersection group is shown in Figure 6.

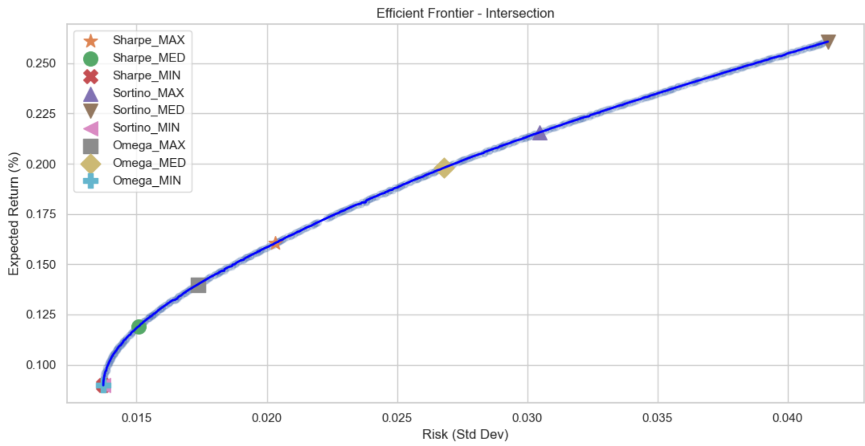

Figure 6. Efficient Frontier of Intersection Stocks
Source: Data processed using Python (2026)

Based on Figure 6, the intersection group's portfolio shows a pattern of steadily increasing returns as risk rises. The maximum Sharpe Ratio is 0.07, the Sortino Ratio is 0.13, and the Omega Ratio is 1.25. The CV values range from 12.40 to 15.93, indicating a higher level of stability compared to the conventional group but still lower than that of the shariah group. This CV range of 12.40–15.93 indicates that the risk-return efficiency of the intersection group falls between that of the shariah group and the conventional group.

4.4. Portfolio Optimization for the Combination Group

The results of the combination group's portfolio optimization are presented in Table 8.

Table 8. Results of Combination Group Portfolio Optimization

Combination	Maximum Expected Return								Minimum Variance	
	Weight (%)									
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
AMRT.JK	7.58	6.64	6.39	5.44	0.15	0.01	0.00	0.00	0.00	0.00
BBCA.JK	23.47	18.35	9.87	1.88	0.03	0.00	0.00	0.00	0.00	0.00
BBNI.JK	5.83	4.04	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00
BBRI.JK	1.23	0.08	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
BMRI.JK	0.34	0.32	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.00
BRPT.JK	0.52	0.19	0.08	0.10	0.00	0.22	0.00	0.00	0.00	0.00
SCMA.JK	2.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

AUTO.JK	12.22	11.08	13.22	16.24	15.53	0.02	0.00	0.00	0.00	0.00
BRMS.JK	0.82	2.16	2.40	3.37	4.01	2.75	0.13	0.01	0.00	0.00
ENRG.JK	1.43	4.56	7.66	9.53	11.88	14.19	10.93	0.70	0.03	0.00
FILM.JK	0.90	3.18	5.70	8.03	9.53	10.80	8.80	4.98	0.01	0.00
PANI.JK	2.13	7.43	10.47	14.69	18.32	23.71	34.18	44.75	78.18	99.08
PTRO.JK	1.88	7.21	13.11	17.68	23.49	31.46	39.73	49.29	21.72	0.87
WIFI.JK	2.60	3.90	4.44	6.84	5.83	5.27	0.01	0.00	0.00	0.00
ADMR.JK	0.86	2.22	6.25	8.25	10.80	11.44	6.18	0.21	0.03	0.02
ADRO.JK	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ITMG.JK	13.66	9.52	7.57	0.15	0.01	0.02	0.00	0.00	0.00	0.00
MAPA.JK	4.71	4.19	3.07	4.02	0.13	0.00	0.00	0.00	0.00	0.00
MEDC.JK	0.04	0.51	0.36	0.03	0.08	0.04	0.00	0.06	0.01	0.00
PGAS.JK	9.85	9.18	5.46	0.01	0.22	0.00	0.00	0.00	0.00	0.00
UNTR.JK	7.40	5.24	3.85	3.71	0.01	0.06	0.03	0.00	0.00	0.00
Expected Return (%)	0.09	0.15	0.21	0.27	0.32	0.37	0.40	0.44	0.46	0.46
Standard Deviation	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.04	0.05
Coefficient of Variation (CV)	11.36	7.51	6.46	6.16	6.10	6.25	6.60	7.23	8.64	10.26
Sharpe	0.07	0.12	0.14	0.15	0.15	0.15	0.14	0.13	0.11	0.09
Sortino	0.09	0.15	0.18	0.20	0.21	0.22	0.21	0.21	0.19	0.16
Omega	1.27	1.44	1.52	1.56	1.56	1.55	1.53	1.48	1.41	1.35

Source: Data processed using Python (2026)

Table 8 shows that the allocation of funds in the combination group is more diversified than in the other groups. The maximum-return portfolio is dominated by PANI.JK at 99.08%, while the minimum-risk portfolio consists primarily of BBCA.JK at 23.47%, AUTO.JK at 12.22%, AMRT.JK at 7.58%, and ITMG.JK at 13.66%.

Figure 7 presents the efficient frontier for the combination group.

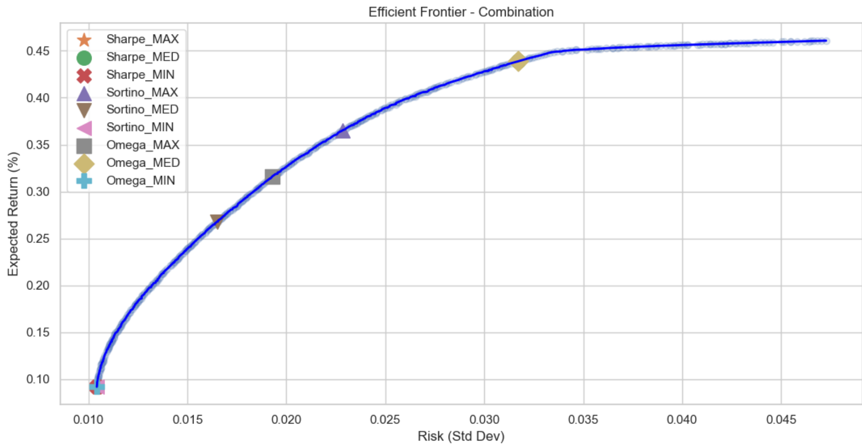

Figure 7. Efficient Frontier of Combination Stocks
Source: Data processed using Python (2026)

Based on Figure 7, the efficient frontier curve for the combination group's portfolio is at the highest point compared to the other groups. The maximum Sharpe Ratio is 0.15, the Sortino Ratio is 0.22, and the Omega Ratio is 1.56. The CV values range from 6.10 to 11.36, indicating an excellent level of risk-return efficiency. The combined group's minimum CV value is even lower than that of the shariah group, indicating that diversification across stock groups enhances overall portfolio efficiency through a more optimal balance of return and risk.

4.5. Comparative Analysis of Portfolio Performance

A comparison of portfolio performance based on the risk-adjusted return indicator is presented in Table 9. The comparison was conducted using the maximum, median, and minimum values of 10 representative portfolios selected uniformly from the 400 Pareto solutions along the efficient frontier in each stock group. The median value was obtained from the average of portfolios P5 and P6, which represent the midpoint of the efficient frontier, thereby illustrating portfolio performance at a moderate level of risk.

Table 9. Comparison of Portfolio Performance Ratios

Group	Metric	Maximum	Median	Minimum
Conventional	Sharpe	0.04	0.04	0.01
	Sortino	0.06	0.05	0.02
	Omega	1.15	1.14	1.09
Shariah	Sharpe	0.15	0.14	0.09
	Sortino	0.21	0.20	0.16
	Omega	1.55	1.50	1.35
Intersection	Sharpe	0.07	0.07	0.05
	Sortino	0.13	0.12	0.07
	Omega	1.25	1.23	1.20
Combination	Sharpe	0.15	0.14	0.07
	Sortino	0.22	0.20	0.09

Omega	1.56	1.51	1.27

Source: Data processed using Python (2026)

Based on Table 9, the combination portfolio group showed the best performance compared to the other groups, with a maximum Sharpe Ratio of 0.15, a Sortino Ratio of 0.22, and an Omega Ratio of 1.56. The shariah portfolio group ranked second with a maximum Sharpe Ratio of 0.15, a Sortino Ratio of 0.21, and an Omega Ratio of 1.55. Compared to the shariah group, the combination group's Sortino Ratio was only about 4.76% higher, while its Omega Ratio was only about 0.65% higher, indicating that the performance of the two groups was relatively close.

The intersection portfolio group showed moderate performance, with a maximum Sharpe Ratio of 0.07, a Sortino Ratio of 0.13, and an Omega Ratio of 1.25. Meanwhile, the conventional portfolio group had the lowest ratio values compared to the other groups. These findings are consistent with the Coefficient of Variation (CV) values, where the blended and shariah portfolios have relatively lower CV values compared to the intersection and conventional portfolios, indicating better risk-return efficiency. These results indicate that diversification plays a crucial role in improving portfolio efficiency. The intersection portfolio group demonstrated the best performance because cross-group diversification was able to provide a more optimal balance of return and risk, while the shariah portfolio continued to show competitive performance.

A comparison of the efficient frontiers across portfolio groups is shown in Figure 8.

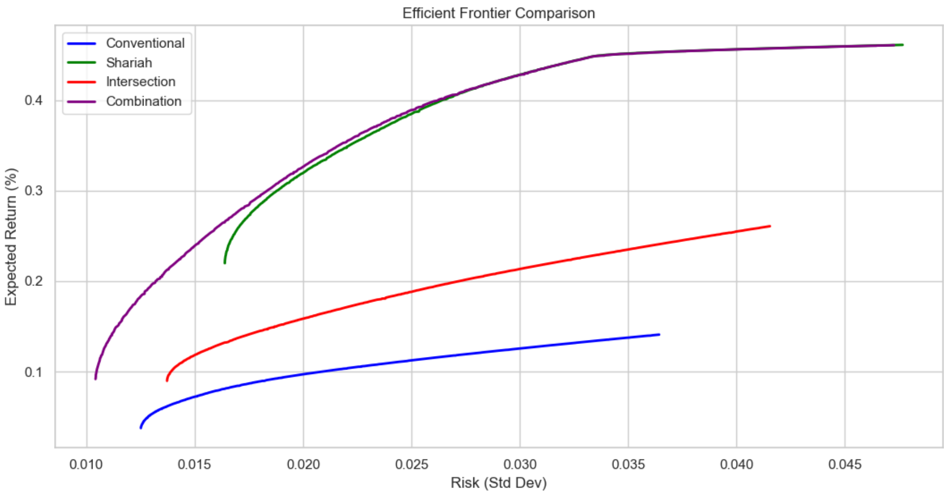

Figure 8. Comparison of the Efficient Frontier Among Stock Groups
Source: Data processed using Python (2026)

Based on Figure 8, the combination group's portfolio is positioned on the most optimal frontier compared to the other groups. This indicates that a combination of conventional, shariah, and intersection stocks can generate a higher expected return at a relatively controlled level of risk. The shariah group's portfolio also shows a high frontier, while the intersection group's portfolio is in an intermediate position with a relatively stable balance of risk and return. Meanwhile, the conventional group's portfolio has the lowest frontier, resulting in a lower expected return compared to the other groups.

The superior performance of the combination-group portfolio demonstrates that diversification across stock groups provides significant benefits in constructing an optimal portfolio. Combining conventional, shariah, and intersection stocks allows the portfolio to access a more diverse range of return sources while reducing risk through a mix of assets with different characteristics. This broader diversification results in a better balance between return and risk, as reflected in higher Sharpe, Sortino, and Omega ratios compared to other groups. These findings are consistent with modern portfolio theory, which states that diversification can improve portfolio efficiency by reducing unsystematic risk.

The shariah portfolio outperformed the conventional portfolio across all evaluation indicators. These results can be explained by the characteristics of shariah stocks, which generally have a more conservative financial structure, lower leverage, and a focus on business activities backed by real assets. These characteristics make shariah stocks more resilient to market fluctuations, enabling them to achieve a better balance between return and risk. Furthermore, the screening and purification processes involved in selecting shariah-compliant stocks ensure that companies included in the shariah index have met a specific set of criteria, potentially resulting in a more controlled risk profile. This is reflected in the shariah group's lower Coefficient of Variation (CV) compared to the conventional group, indicating that shariah-compliant stocks are capable of generating more efficient returns after adjusting for risk.

The portfolio of intersection stocks shows performance that falls between that of the shariah group and the conventional group. This finding indicates that intersection stocks have intersection characteristics because they simultaneously meet the criteria of both shariah and conventional indices. On the one hand, intersection stocks benefit from the characteristics of companies that comply with shariah principles; on the other hand, they remain influenced by the dynamics of large-cap and liquid stocks, which generally dominate conventional indices. As a result, the resulting levels of return and risk tend to fall in the middle range compared to the other two groups.

The results of this study also show that the Non-Dominated Sorting Genetic Algorithm II (NSGA-II) method is capable of generating efficient asset combinations based on the balance between return and risk. These findings are consistent with previous research showing that NSGA-II is effective in generating Pareto-optimal solutions to multi-objective portfolio optimization problems [20], [21]. Furthermore, prior research has also shown that multi-objective optimization approaches based on evolutionary algorithms can improve the balance between return and risk [24]. The difference is that this study simultaneously compares conventional stock portfolios, shariah-compliant stock portfolios, intersection stock portfolios, and combination stock portfolios in the Indonesian capital market, thereby providing a more comprehensive picture of the impact of diversification on portfolio efficiency.

In practical terms, the findings of this study can serve as a reference for investors and portfolio managers in Indonesia in developing diversification strategies to achieve a more optimal balance between return and risk. For investors who prioritize risk-return efficiency, the shariah stock group can be an attractive alternative because it yields a lower CV value. Meanwhile, a blended portfolio is worth considering because it generates the highest Sharpe Ratio, Sortino Ratio, and Omega Ratio compared to the other groups.

This study has several limitations. The portfolio analysis did not take into account transaction costs, inflation, or dynamic changes in market conditions during the observation period. Therefore, future research could incorporate these factors to make the portfolio optimization results more comprehensive.

5. Conclusions

This study successfully constructed optimal portfolios using the Non-Dominated Sorting Genetic Algorithm II (NSGA-II) method for conventional, shariah, intersection, and combination stock groups. The optimization results yielded a set of Pareto-optimal solutions that formed the efficient frontier for each stock group. Based on risk-adjusted return indicators, the combination portfolio demonstrated the best performance with a maximum Sharpe Ratio of 0.15, a Sortino Ratio of 0.22, and an Omega Ratio of 1.56. Next, the shariah portfolio ranked second with a maximum Sharpe Ratio of 0.15, a Sortino Ratio of 0.21, and an Omega Ratio of 1.55, followed by the intersection portfolio and the conventional portfolio.

The results of this study indicate that the research objective of constructing and comparing the performance of optimal portfolios using NSGA-II has been achieved. Diversification through the combination of conventional, shariah, and intersection stocks proved capable of improving portfolio efficiency compared to using a single group of stocks separately. Furthermore, the shariah stock group demonstrated better risk-return efficiency than the conventional stock group, as indicated by higher values for the Sharpe Ratio, Sortino Ratio, Omega Ratio, and Coefficient of Variation (CV). These findings support the concept of Modern Portfolio Theory, which states that a combination of assets with different characteristics can produce a more optimal balance of return and risk.

In practical terms, the research findings indicate that investors can leverage diversification across stock categories to achieve a better balance between return and risk. A blended portfolio can serve as an alternative for investors focused on optimizing portfolio performance, while shariah-compliant stocks can be considered a more efficient investment option after adjusting for risk. Furthermore, the findings of this study can provide insights for regulators in promoting the development of investment instruments and education regarding the importance of portfolio diversification in the Indonesian capital market.

This study has limitations in that the sample consists solely of stocks from the LQ45 and JII70 indices and does not account for transaction costs, inflation, and dynamic changes in market conditions. Therefore, future research is recommended to expand the sample scope, compare the performance of NSGA-II with other multi-objective optimization methods such as Multi-Objective Particle Swarm Optimization (MOPSO) or Multi-Objective Evolutionary Algorithm Based on Decomposition (MOEA/D), and incorporate more complex market variables so that the optimization results more closely reflect real investment conditions.

References

[1] H. Tjiwidjaja, "Optimization of Investment Portfolio Returns Through an Integrated Risk Management Approach," *J. Acad. Sci.*, vol. 2, no. 3, pp. 853–863, 2025.
[2] M. R. Nisardi, H. Husain, and A. Resky, "Penentuan Portofolio Saham Optimal Menggunakan Metode Markowitz Sebagai Dasar Keputusan Investasi," *Sq. J. Math. Math. Educ.*, vol. 6, no. 1, pp. 33–40, 2024.
[3] F. Seru and A. D. Saputro, "Pendekatan Optimalisasi Portofolio dengan Capital Asset Pricing Model dan Model Markowitz sebagai Strategi Investasi Cerdas bagi Investor Milenial," *JOMTA J. Math. Theory Appl.*, vol. 6, no. 2, pp. 214–224, 2024, doi: 10.31605/jomta.v6i2.4117.
[4] D. E. Waluyo, S. Fitriyyatul, A. History, and U. D. Nuswantoro, "Portfolio optimization using mean-variance model and single index model: Evidence from Indonesian and Malaysian capital markets," *Asian Econ. Financ. Rev.*, vol. 15, no. 11, pp. 1731–1747, 2025, doi: 10.55493/5002.v15i11.5662.
[5] H. Li and N. Shi, "Application of Genetic Optimization Algorithm in Financial Portfolio Problem," *Comput. Intell. Neurosci.*, vol. 2022, 2022, doi: 10.1155/2022/5246309.
[6] S. I. Abdullahi, "Islamic equities and COVID-19 pandemic: measuring Islamic stock indices correlation and volatility in period of crisis," *Islam. Econ. Stud.*, vol. 29, no. 1, pp. 50–66, 2021, doi: 10.1108/ies-09-2020-0037.
[7] M. Alamgir and M. C. Cheng, "Co-Movement and Performance Comparison of Conventional and Islamic Stock Indices during the Pre- and Post-COVID-19 Pandemic Era," *Risks*, vol. 11, no. 8, 2023, doi: 10.3390/risks11080146.
[8] I. Sadat and S. Gormus, "Divergent impacts of financial factors on Islamic vs conventional stock markets: insights from advanced countries using MM-QR," *J. Cap. Mark. Stud.*, vol. 9, no. 1, pp. 6–27, 2025, doi: 10.1108/JCMS-06-2024-0030.
[9] D. Puspita, A. Kolkiewicz, and K. S. Tan, "Markowitz-based Shariah compliant portfolio model with stochastic purification and probabilistic compliance screening constraints," *J. Islam. Account. Bus. Res.*, vol. 14, no. 8, pp. 1300–1323, 2023, doi: 10.1108/JIABR-08-2021-0230.
[10] F. Mathlouthi and S. Bahloul, "Co-movement and causal relationships between conventional and Islamic stock market returns under regime-switching framework," *J. Cap. Mark. Stud.*, vol. 6, no. 2, pp. 166–184, 2022, doi: 10.1108/JCMS-02-2022-0008.
[11] K. Nyakurukwa and Y. Seetharam, "Leveraging sentiment connectedness for portfolio optimisation: a minimum connectedness approach," *Rev. Behav. Financ.*, vol. 17, no. 5, pp. 908–917, 2025, doi: 10.1108/RBF-03-2025-0125.
[12] T. Hidayat, B. Oktavian, and R. Baharuddin, "Keputusan Investasi Berdasarkan Literasi Keuangan, Pengetahuan Investasi dan Persepsi Risiko," *J. Sci. Soc. Res.*, vol. 6, no. 2, pp. 441–452, 2023.
[13] D. T. Lim, K. W. Goh, and L. H. Lee, "A new class of Shariah-compliant portfolio optimization model: diversification analysis," *AIMS Math.*, vol. 8, no. 9, pp. 20933–20965, 2023, doi: 10.3934/math.20231066.
[14] L. Swinkels and T. Markwat, "Corporate carbon emissions data for equity and bond portfolios," *Manag. Financ.*, vol. 50, no. 1, pp. 118–139, 2024, doi: 10.1108/MF-02-2023-0077.
[15] Z. Chen, "Index Model with Modern Portfolio Theory and its Application to Find Optimal Portfolio in the American Stock Market," *Highlights Business, Econ. Manag.*, vol. 24, pp. 2015–2023, 2024.
[16] C. Henriques, "Exploring the trade-off between liquidity , risk and return under sectoral diversification across distinct economic settings," *J. Risk Financ.*, vol. 22, no. 2, pp. 130–152, 2021, doi: 10.1108/JRF-05-2020-0101.

[17] M. Jabeen and S. Kausar, "Performance comparison between Islamic and conventional stocks : evidence from Pakistan ' s equity market," *ISRA Int. J. Islam. Financ.*, vol. 14, no. 1, pp. 59–72, 2022, doi: 10.1108/IJIF-07-2020-0150.

[18] C. A. Rinaima, N. Fauziyah, A. N. Kamilah, and S. Economic, "OPTIMIZING SHARIA INVESTMENT PORTFOLIOS USING MODERN PORTFOLIO THEORY : A CASE STUDY OF ICBP AND SIDO IN INDONESIA," *Airlangga Int. J. Islam. Econ. Financ.*, vol. 8, no. 02, 2025.

[19] J. Ginting and Staenly, "Constructing Efficient Frontiers in Cryptocurrency Market Using Long-Run GARCH Volatility," *Zero J. Sains, Mat. dan Terap.*, vol. 9, no. 2, pp. 546–554, 2025, doi: 10.30829/zero.v9i2.25928.

[20] Q. Gao and A. Kresta, "FI N A N SE EMPIRICAL STUDY OF MULTI-OBJECTIVE RISK PORTFOLIO OPTIMIZATION BASED ON NSGA-II," *J. Financ. Financ. Law*, vol. Special Is, no. S1, pp. 61–75, 2024, doi: 10.18778/2391-6478.S1.2024.04.

[21] M. Ikhlef and M. Aider, "MULTIOBJECTIVE EVOLUTIONARY METAHEURISTIC APPROACH TO THE CONSTRAINED PORTFOLIO OPTIMIZATION PROBLEM," *Pesqui. Operacional*, vol. 43, pp. 1–23, 2023, doi: 10.1590/0101-7438.2023.043.00266962.

[22] H. Asgari and J. Behnamian, "Presenting a self-adjusting algorithm for optimizing the stock portfolio according to the fundamental index," *J. Model. Manag.*, vol. 20, no. 5, pp. 1656–1689, 2025, doi: 10.1108/JM2-01-2024-0032.

[23] M. Edil, A. Sukor, and A. A. Halim, "Portfolio optimisation of Shariah- compliant samples in the USA," *J. Islam. Account. Bus. Res.*, vol. 14, no. 1, pp. 34–57, 2022, doi: 10.1108/JIABR-10-2021-0278.

[24] J. W. M. Mwamba, L. M. Mbucici, and J. C. Mba, "Multi-Objective Portfolio Optimization: An Application of the Non-Dominated Sorting Genetic Algorithm III," *Int. J. Financ. Stud.*, vol. 13, no. 1, pp. 1–18, 2025, doi: 10.3390/ijfs13010015.