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Building an optimal portfolio of Sharia-compliant stocks using the Markowitz model: A study of listed JII companies

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Abstract

Purpose – This study analyzes the expected returns and risks associated with these stocks and identifies the optimal portfolio composition.

Methodology – This study utilized operational data analysis and the Markowitz model to assess 30 stocks listed on the JII from 2017 to 2020. Through purposive sampling, 13 companies that met the specific sample criteria were selected for analysis.

Findings – The analysis successfully identified an optimal portfolio composed of six stocks: ANTM (Aneka Tambang Tbk), ICBP (Indofood CBP Sukses Makmur), INCO (Vale Indonesia Tbk), KLBF (Kalbe Farma Tbk), PTBA (Bukit Asam Tbk), and UNTR (United Tractors Tbk). This portfolio demonstrates an expected rate of return ranging from 0.28% to 1.88%. Notably, the portfolio's overall risk value was calculated to be only 0.19%, which is significantly lower than the individual risk associated with any single stock within the portfolio.

Implication – This study provides valuable insights for investors looking to build a balanced and Shariah-compliant investment portfolio, improving their understanding of expected returns and associated risks in Islamic financial markets.

Originality – The abstract does not explicitly state the originality section. However, the unique combination of focusing on JII-listed Sharia stocks and applying the Markowitz model to identify an optimal portfolio can be inferred as the original contribution of this study. The context of Islamic financial markets distinguishes it from that of a general investment study.

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Introduction

Investing in capital markets is becoming increasingly popular among individuals, facilitated by the growing number of securities companies that offer educational resources and services in Indonesia. The capital market serves as a platform for individuals and groups with surplus funds to connect with companies that need capital, offering various investment instruments with different levels of risk and return (Wahyuliantini & Suarjaya, 2015). Investors are not only motivated by the potential for financial gain but also by the opportunity to participate in the growth of companies and the overall economy.

However, investing in stocks entails both benefits and risk. Before investing, it is crucial for investors to conduct thorough research on the company in which they wish to invest, assessing factors such as potential rates of return and associated risks (Afriana et al., 2017). This allows investors to align their investments with their risk tolerance and financial goals, ensuring the

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prudent allocation of funds across various investment instruments (Zulfikar, 2016). In addition, understanding market trends and economic conditions is essential, as these external factors can significantly influence stock performance and investment outcomes.

Stock trading in Indonesia mainly occurs on the Indonesia Stock Exchange (IDX), where the number of investors has consistently grown from 2017 to 2020. According to data from the PT. According to the Indonesian Central Securities Depository (PT Kustodian Sentral Efek Indonesia, KSEI), the number of registered capital market investors increased from 1.12 million in 2017 to 1.61 million in 2018, marking a significant increase of 44.24% (KSEI New, 2020).

Investing in capital markets involves inherent risks corresponding to the capital invested. This principle is generally expressed as "high risk, high return; Low risk, low return," indicating that high-risk investments typically offer higher potential returns, whereas low-risk investments result in lower returns. The actual return on investment depends on the investor's level of risk tolerance, with risk and return serving as fundamental factors in investment decision making (Mary & Rathika, 2015).

However, diversification, although important, does not eliminate all investment risks. In the capital market, certain risks such as market risk persist despite diversification efforts. Market risk comes from systemic factors that affect most companies, including inflation and interest-rate fluctuations. The relationship between risk and return was originally formalized by Markowitz, (1959) Harry Markowitz, who was awarded the Nobel Prize for his innovative theoretical contributions to financial economics and corporate finance. His groundbreaking work laid the foundation for the Modern Portfolio Theory (Mangram, 2013). Markowitz's model is a widely used framework for investors to optimize their portfolios by balancing returns and risk factors (Anam et al., 2021).

Markowitz's research findings highlight that the returns on assets in a portfolio are not independent, but rather correlated with each other. As a result, calculating portfolio risk becomes a nuanced process, as investors must analyze the effects of the returns of these interrelated assets. The coefficient of covariance and correlation play an important role in measuring the contribution of risk resulting from the relationship between asset returns. Investors should optimize their portfolios to achieve maximum returns with minimal risk (London et al., 2018).

Markowitz's portfolio model stands out as one of the main approaches for determining an optimal portfolio, usually achieved through efficient portfolio formation (Botero et al., 2024). However, an efficient portfolio alone is not necessarily optimal, it may prioritize higher expected returns or lower risk. Investors often choose an optimal portfolio from a variety of efficient portfolios based on their preferences.

Based on an in-depth review of various prior research literature, there has been no development of an optimal Markowitz portfolio specifically for Sharia-based stocks. This is despite the fact that, according to Sukardi et al. (2023) one of the main reasons was that Markowitz was among the most well-known portfolio optimization models. In modern portfolio theory, the Markowitz model is also recognized as a mean-variance model, which constitutes a core component of modern portfolio theory (Avella, 2024; Leung et al., 2012).

Therefore, this study is important in conducting an analysis using the Markowitz model, with a focus on stocks listed in the Jakarta Islamic Index (JII). The stocks listed in this index comply with the Sharia principles, reflecting companies that do not engage in gambling, usury, immoral activities, or harmful practices (Indriyani et al., 2023). In addition, the JII considers liquidity and capitalization perspectives, prioritizing stocks with high levels of liquidity, market capitalization, and trading frequency. Thus, only 30 Sharia-compliant stocks were periodically evaluated for inclusion and retention in the index. It is important to note that not all Sharia stocks are eligible for inclusion in the JII; thus, the stocks listed represent high-quality, selected equities (Susilo & Najah, 2018).

Considering these factors and addressing the issues previously outlined, this study aims to determine the expected return and minimum risk associated with a portfolio composed of JII-listed stocks using the Markowitz model. This model effectively explains the process of calculating optimal portfolio solutions along with its underlying principles,(Guo, 2022). Accordingly, this research is expected to provide valuable insights and references for both current and prospective Sharia-compliant investors in allocating their funds to Sharia stocks that offer optimal returns with minimal risk.

Literature Review

In this section, we review the relevant literature on portfolio optimization, Sharia-compliant investments, and the Markowitz model, focusing on studies that apply the model to shark-compliant stocks.

Optimal portfolio theory

Sahputra (2020) and Latifah (2022) provided a comprehensive definition of a portfolio, characterizing it as a collection of investment instruments tailored to meet overarching investment objectives. From a financial perspective, a portfolio represents an aggregation of investments owned by an individual or institution, which includes a diverse range of asset classes and investment opportunities. Expanding on this concept, Dewi and Candradewi (2020) underline that a portfolio consists of a strategic mix of various stocks that aims to optimize returns while mitigating associated risks. Otoritas Jasa Keuangan. (2021) distinguishes between efficient and optimal portfolios, with efficient portfolios representing the peak of the risk-return trade-off optimization. In contrast, an optimal portfolio is part of an efficient portfolio tailored to the investor's specific return and risk preferences (Nasution et al., 2015). Inrawan et al. (2022) emphasizes the important role of investor choice in structuring an optimal portfolio, emphasizing the importance of aligning investment choices with the desired risk-return profil. Overall, the portfolio concept serves as the cornerstone of investment management, facilitating the development of a diversified investment strategy to achieve optimal risk-adjusted returns.

Jakarta Sharia Index (JII)

The Jakarta Sharia Index (JII) has a significant interest in the Indonesian capital market, especially for investors who adhere to the principles of Sharia investment. Introduced on July 3, 2000, the JII serves as a benchmark for Shariah-compliant stocks, embodying the ethical and moral standards defined by Islamic finance. Consisting of 30 of the most actively traded Shariah-compliant stocks listed on the Indonesia Stock Exchange (IDX), the JII offers investors a choice of Islamic-aligned securities. As a key component of the Indonesian stock market, JII undergoes periodic reviews to ensure compliance with Sharia guidelines. This review process is carried out every six months in May and November, in line with the Sharia Securities List (DES) regulated by the Financial Services Authority (Otoritas Jasa Keuangan, OJK) (Susanti et al., 2021). The inclusion of shares in JII is contingent on their compliance with Sharia principles, reinforcing its role as a reliable indicator of Sharia-compliant investments in Indonesia's financial landscape. In summary, JII plays a crucial role in facilitating Sharia-compliant investment opportunities by providing investors with a trusted platform to engage in ethical and morally aligned financial activities in the Indonesian capital market (Chandranegara, et al., 2023). This is in line with the press release published by the Indonesia Stock Exchange (IDX) on its official website dated January 31, 2025, stating thatThe Sharia stock market also dominates the Indonesian stock market, with Sharia stock market capitalization accounting for 55% of the total market capitalization and the average daily trading value of Sharia stocks comprising 55% of the total average daily stock trading as of January 31, 2025.

Markowitz model

Markowitz (1952) as quoted in Desiyanti (2017) introduced portfolio theory with the aim of illustrating the relationship between investors' confidence and their investment portfolio selection based on the relationship of "expected return-return variance." The core idea is to maximize the present value of the "anticipated" or "expected" returns while considering the risks. Markowitz's diversification strategy seeks to combine assets in a portfolio with returns that have a less-than-perfect positive correlation to reduce portfolio risk without sacrificing returns. His work laid the foundation for modern portfolio management, emphasizing the importance of diversification in managing risk effectively (Chaweewanchon & Chaysiri, 2022). In classical portfolio theory, optimal investment allocation is unique, and portfolios that deviate from this optimal allocation can produce lower returns. Markowitz's approach to diversification differs from naïve diversification in that it incorporates covariance analysis among asset returns, making it more effective in maintaining

returns while reducing risk (Fabozzi, 2003). The Markowitz model provides a useful framework for selecting stocks from a variety of portfolio options that offer profitable returns with reasonable risk. Investors can tailor their portfolio choices based on preferences such as risk tolerance and expected returns. Its simplicity lies in determining the optimal portfolio based on the lowest point on the efficient portfolio surface, which makes it easy to apply (Maf'ula, et al., 2018).

Capital markets

The capital market is an important market that facilitates the exchange of long-term financial instruments, which include a diverse range of assets, such as bonds, stocks, mutual funds, derivatives, and securities issued by companies and government agencies (Rachmany & Tajudin, 2022). Additionally, it serves as a vital avenue for facilitating investment-related business activities (Zulfikar, 2016). On the other hand, the Sharia capital market includes all activities within the capital market that comply with the principles of Islamic law. This particular market segment operates under the regulatory scope of the Financial Services Authority (OJK) and falls within the broader domain of the Islamic financial industry, with special supervision provided by the Directorate of Sharia Capital Markets (Pangiuk, 2022).

Investment

Investment, as defined by Rosyadi, et al., (2024) requires strategic allocation of funds or capital in the present with the anticipation of generating profitable returns in the future. This process typically involves the acquisition of various securities or financial assets such as stocks, bonds, or derivatives such as options and futures contracts. In the context of Islamic principles, investment is considered a muamalah activity that is allowed and encouraged. This is because investing in assets has the potential to generate productivity and benefit others, in line with Islamic teachings seeking prosperity both in this world and the hereafter (Aziz, 2010). In addition, investment theory underlines the fundamental relationship between risk and return, advocating the formation of a well-diversified portfolio to optimize investment returns (Hariasi & Wirama, 2016). According to Linge and Ahmad (2021), entrepreneurship has a symbiotic relationship with scientific and economic activity. Consequently, investment activities can be viewed through the lens of entrepreneurship, where investors are involved in economic efforts to meet future needs, which involves making decisions regarding the type of investment, financial management, and risk assessment.

Stock

Shares represent ownership in a company, allowing shareholders to participate in the company's profits through dividends and potentially capitalize on capital gains through sales at a price higher than the purchase price (Azis et al., 2015). They serve as leading investment instruments in the capital market, providing investors with equity participation in the companies in which they invest (Koni et al., 2021). Shareholding provides evidence of the involvement of an individual or organization in a company's operations, usually represented by a share certificate issued by the company (Darmadji & Fakhrudin, 2001). From a Shariah-compliant perspective, stocks are seen as a form of shirkah, a type of joint venture in capital and wealth that adheres to Islamic principles. Sharia-compliant securities are those whose contracts, methods, and business activities are aligned with Sharia principles, ensuring that they are allowed to invest in capital markets (Koni et al., 2021). The Jakarta Islamic Index (JII), which is held on the Indonesia Stock Exchange (IDX), consists of 30 company stocks that meet the criteria for Indonesian Sharia stocks, providing investors with the opportunity to invest in accordance with Islamic principles (Yunita, 2018).

Return

Return refers to the expected level of return that investors anticipate from their investments, serving as compensation for the opportunity costs incurred and risks associated with the potential loss of purchasing power (Azis et al., 2015). This includes the benefits that companies, individuals, and institutions derive from investment strategies (Partha & Sedana, 2019). In investing, the relationship between risk and return is widely recognized, with higher risk usually associated with

greater potential returns, and vice versa. Defined by Gitman and Joehnk (2016), return represents the gain or loss realized in an investment over time, often expressed as a percentage of the initial investment. Specifically, returns refer to the rate of profit earned from investing in stocks. Returns can be categorized into realized returns, namely, the actual returns that occur, and expected returns, which are the returns anticipated by investors (Sudarsono, 2016).

Risk

Risk is a fundamental aspect of investing that includes the uncertainty surrounding the expected return on investment and its actual return (Rogers, 2009). This underlines that investors operate under conditions of uncertainty regarding their investment returns, exposing them to risk. This risk arises when investors anticipate profits and possible losses. Typically, higher expected returns entail higher associated risk. Markowitz's investment evaluation model describes two main types of investment risk: unsystematic and systematic. Unsystematic risk, also known as business risk, relates to fluctuations and business cycles inherent in a particular industry. Each industry exhibits different risk characteristics that are affected by certain economic variables, leading companies in the same sector to face similar unsystematic risks (Hue et al., 2019). Diversification can reduce unsystematic risk by spreading investments across a variety of assets. In contrast, systematic risk comes from the external aspect of the business and includes broader economic factors, such as inflation and global economic conditions. This risk is inherent in the market and cannot be diversified. Portfolio risk, a key consideration in investment analysis, is measured using a distribution measure that assesses the extent to which potential returns deviate from the expected value. Standard deviation (σ) or variance (σ2) serves as a common metric for revealing portfolio risk, providing insight into the level of uncertainty associated with investment returns (Natalia, 2014).

Research Methods

This study uses secondary data consisting of data on the closing price of company shares recorded in JII for the period from 2017 to 2020. The data were sourced from the official website of the Indonesia Stock Exchange, especially www.idx.co.id and www.yahoo.finance.com. The study population consisted of all stocks listed on JII during the specified period, with a total of 30 companies.

This study used a purposive sampling method to ensure a representative sample. The sampling criteria include: (1) companies with shares listed on the Indonesia Stock Exchange and (2) companies with shares consistently listed on JII during the research period from 2017 to 2020. Consequently, 13 companies met the criteria for this sample. This methodology ensures that the selected sample accurately represents the population of interest, thus facilitating a comprehensive analysis of the construction of an optimal portfolio of Shariah-compliant stocks using the Markowitz model. The Company's data used as a sample are:

Table 1. List of consistent companies listed in the Jakarta Islamic Index (JII)

Not.	Code	Company Name
1	ADRO	Adaro Energi Tbk.
2	AKRA	AKR Corporindo Tbk
3	ANTM	Aneka Tambang (Persero) Tbk.
4	EXCL	XL Axiata Tbk
5	ICBP	Indofood CBP Sukses Makmur Tbk.
6	INCO	Vale Indonesia Tbk
7	INDF	Indofood Sukses Makmur Tbk.
8	KLBF	Kalbe Pharma Tbk
9	PTBA	Bukit Asam Coal Mine (Persero) Tbk.
10	TLKM	Telkom Indonesia (Persero) Tbk.
11	UNTR	Traktor Bersatu Tbk
12	UNVR	Unilever Indonesia Tbk.
13	WIKA	Wijaya Karya (Persero) Tbk

Source: Jakarta Islamic Index (JII)

The study uses the following steps to analyze the data to determine the optimal portfolio using the Markowitz model:

1) We calculate the rate of return (profit) for each stock using the following equation:

$$R_{it} = \frac{P_t - P_{t-1}}{P_{t-1}}$$

2) We calculate the expected return (expected value) for each stock using the following formula:

$$E_{(R_i)} = \frac{\sum_{t=1}^{n} R_{it}}{N}$$

3) Calculate the risk of each stock using the following equation.

$$\sigma_i^2 = \frac{\sum_{t=1}^{n} [R_{it} - E(R_i)]^2}{n}$$

4) Calculate the covariance between the stocks of each sample company.

$$\sigma_{R_i R_j} = \sum_{i=1}^{n} \frac{\left[\left(R_{it} - E(R_i)\right), \left(R_{jt} - E\left(R_j\right)\right)\right]}{n}$$

5) Calculate the correlation coefficient of stock prices between companies.

$$\sigma_{i,j} = \frac{\sigma R_i R_j}{\sigma_i \sigma_j}$$

6) Calculate the expected return and portfolio risk in equal proportions.
The risk of stocks in a portfolio can be calculated using the following equation:

$$E\left(R_p\right) = \sum_{i=1}^{n} W_i \, E(R_i)$$

$$\sigma_p^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} W_i \, W_j \sigma_{i,j}$$

7) We calculate the expected return and optimal portfolio risk by minimizing the value of the variance and using objective functions.

$$\sigma_p^2 = \sum_{i=1}^{n} w_i^2 \, \sigma_i^2 + 2 \sum_{i=1}^{n} \sum_{j>1}^{n} w_i \, w_j \, \sigma_{i,j}$$

Calculating the return on each share

Stock returns are the profits earned from each share of the stock. To determine the rate of return on individual shares, the stock price of the previous period is subtracted from the stock price of the current period, and then divided by the stock price of the previous period. Changes in the closing price of stocks per month are used to determine the prices of individual shares.

Calculate the expected return of each share

The stocks included in the optimal portfolio were generated from the expected returns earned from each stock. Expected stock returns were calculated by determining the average daily stock returns over the research period. Expected returns are calculated by dividing the number of daily returns from 2017 to 2020 by the number of days of observation, or, in other words, finding the average value of daily returns. The expected return of each stock is presented in Table 2.

Based on Table 3, from the results of the calculation of the 13 stocks, six stocks have positive return expectations, which is the optimal portfolio. Stocks with positive yield expectations are ANTM (Aneka Tambang Tbk), ICBP (Indofood CBP Sukses Makmur Tbk), INCO (Vale

Indonesia Tbk), KLBF (Kalbe Farma Tbk), PTBA (Bukit Asam Tbk), and UNTR (United Tractors Tbk). The stock with the highest expected positive return is ANTM (Aneka Tambang Tbk), with a return of 0.018793 or 1.88%. Meanwhile, the stock with the lowest yield expectation is PTBA (Bukit Asam Tbk), with a level of 0.004077 or 0.41%.

Table 2. Individual stock expected rate of return

No.	Code	E(Ri)
1	ADRO	-0.003617
2	AKRA	-0.0157763
3	ANTM	0.018793
4	EXCL	-0.00136
5	ICBP	0.002786
6	INCO	0.016305
7	INDF	-0.003102
8	KLBF	0.000436
9	PTBA	0.004077
10	TLKM	-0.0033257
11	UNTR	0.004185
12	UNVR	-0.00243
13	WIKA	-0.0055

Source: Author's processing

Table 3. Stocks with positive expected returns

No.	Code	Re
1	ANTM	0.018793
2	ICBP	0.002786
3	INCO	0.016305
4	KLBF	0.000436
5	PTBA	0.004077
6	UNTR	0.004185

Source: Author's processing

Table 4 provides information on stocks that have negative return expectations during the observation period, including ADRO (Adaro Energy Tbk), AKRA (AKR Corporindo Tbk), EXCL (XL Axiata Tbk), INDF (Indofood Sukses Makmur Tbk), TLKM (Telecommunication Indonesia (Persero) Tbk), UNVR (Unilever Indonesia Tbk), and WIKA (Wijaya Karya (Persero) Tbk. Stocks with negative returns mean that they cannot provide optimal returns for investors, so they are not worthy of inclusion as an optimal portfolio. Stocks with negative yield expectations were not included in the subsequent calculation.

Table 4. Stocks with negative expected returns

No.	Code	E(Ri)
1	ADRO	-0.003617
2	AKRA	-0.0157763
3	EXCL	-0.00136
4	INDF	-0.003102
5	TLKM	-0.0033257
6	UNVR	-0.00243
7	WIKA	-0.0055

Source: Author's processing

Calculating the risk (variance and standard deviation) of each stock

Risk indicates the possibility of deviations in the realized returns (rate of return) and expected returns (expected rate of return), where returns and risks move simultaneously. This indicates that stocks with high yields tend to have a high risk.

Table 5 presents the risk values for each stock. It can be seen that the stock with the highest risk is WIKA (Wijaya Karya Tbk), with a risk of 0.175833 or 17.58%, and the stock with the lowest

risk is ICBP (Indofood CBP Sukses Makmur Tbk), with a risk of 0.05829 or 5.83%. The highest stock risk is proportional to investors' expectations of returns. This suggests that the greater the expected return an investor receives, the greater the risk.

Table 5: Individual stock variances and standard deviation

No.	Code	Varians (σi)	Deviation (σi2)
1	ADRO	0.012138	0.110172
2	AKRA	0.01178285	0.10854882
3	ANTM	0.027281	0.16517
4	EXCL	0.012157	0.110259
5	ICBP	0.003398	0.05829
6	INCO	0.019038	0.137979
7	INDF	0.0045771	0.0676542
8	KLBF	0.004135	0.064307
9	PTBA	0.012049	0.109767
10	TLKM	0.00446925	0.06685245
11	UNTR	0.007749	0.08803
12	UNVR	0.003442	0.058668
13	WIKA	0.030917	0.175833

Source: Author's processing

Calculating covariance between stocks

Covariance is a value that indicates the extent to which two variables, or, in this context, the returns of both assets, have a tendency to move simultaneously. The stocks used in the formation of the portfolio are stocks with positive return expectations, namely ANTM (Aneka Tambang Tbk), ICBP (Indofood CBP Sukses Makmur), INCO (Vale Indonesia Tbk), KLBF (Kalbe Farma Tbk), PTBA (Bukit Asam Tbk), and UNTR (United Tractors Tbk).

Table 6: Covariance value between return on stock

	ANTM	ICBP	INCO	KLBF	PTBA	UNTR
ANTM	0.0272812	0.0012349	0.015346	0.002764	0.006809	0.004268
ICBP	0.0012349	0.0033978	0.001168	0.001144	-0.00068	-0.00034
INCO	0.0153459	0.0011678	0.019038	0.003871	0.006709	0.004645
KLBF	0.0027645	0.0011435	0.003871	0.004135	0.000198	0.000927
PTBA	0.0068087	-0.000679	0.006709	0.000198	0.012049	0.004266
UNTR	0.0042684	-0.000344	0.004645	0.000927	0.004266	0.007749

Source: Author's processing

Table 6 shows that the covariance value between the same share returns is the variance value of share returns. The results of the correlation calculation between the returns of shares were obtained with the R application, as presented in Table 7.

Table 7: Stock correlation coefficients

	ANTM	ICBP	INCO	KLBF	PTBA	UNTR
ANTM	1	0.1282646	0.673358	0.260269	0.375546	0.293566
ICBP	0.1282646	1	0.1452	0.305068	-0.10609	-0.06707
INCO	0.673358	0.1452004	1	0.436302	0.442946	0.382421
KLBF	0.2602686	0.3050683	0.436302	1	0.02799	0.16367
PTBA	0.3755461	-0.106087	0.442946	0.02799	1	0.441454
UNTR	0.2935657	-0.067074	0.382421	0.16367	0.441454	1

Source: Author's processing

Calculating the correlation coefficient between stocks

A correlation coefficient is a value that indicates the relative concurrent movement, or in this context, a value that indicates the extent to which the return of one asset is related to another. There are three interpretations of the results of the correlation analysis. First, we examine the strength of the correlation between two variables by using the correlation coefficient. The

correlation coefficient is a statistical measure of the covariance or association between two variables. The correlation coefficients ranged from +1 to -1.

Second, the significance of the correlation between two variables is based on the significance number generated from the results of the calculation process. This interpretation provides evidence of the significance of the correlation between the two variables. Third, we determine the direction of the correlation, whether it is directed or not. The direction of the correlation is seen from the correlation coefficient, if the correlation coefficient is positive, the correlation between the two variables is unidirectional. Conversely, if the correlation coefficient is negative, then the correlation between the two variables is not in the same direction.

Table 7 shows the correlation coefficients between the stock returns. The covariance value can affect the risk of the portfolio created. The correlation coefficients between the stock returns are all positive. After obtaining the covariance between stock returns, the next step is to calculate the portfolio weight using the mean–variance efficient portfolio (MVEP) method. Calculating portfolio weights with MVEP requires the inverse of the variance matrix, the covariance of the return data of the stocks that make up the portfolio. The covariance values in Table 4 can be written in matrix notation as follows:

$$\Sigma = \begin{bmatrix} 0.0272812 & 0.00123491 & 0.0153459 & 0.0027645 & 0.00680874 & 0.00426841 \\ 0.0012349 & 0.00339776 & 0.0011678 & 0.0011435 & -0.0006788 & -0.0003442 \\ 0.0153459 & 0.00116783 & 0.0190383 & 0.0038713 & 0.00670867 & 0.004645 \\ 0.0027645 & 0.00114355 & 0.0038713 & 0.0041354 & 0.00019758 & 0.00092653 \\ 0.0068087 & -0.0006788 & 0.0067087 & 0.0001976 & 0.0120488 & 0.00426567 \\ 0.0042684 & -0.0003442 & 0.004645 & 0.0009265 & 0.00426567 & 0.00774924 \end{bmatrix} \quad (1)$$

Furthermore, the inverse of the variance-covariance matrix (equation 1) is calculated with the help of the R. software. The inverse matrix obtained can be written as follows:

$$\Sigma^{-1} = \begin{bmatrix} 68.459131 & -11.630463 & -51.8526 & 7.055016 & -9.635828 & -2.683107 \\ -11.630463 & 333.614311 & -8.023232 & -84.171968 & 23.048589 & 23.542408 \\ -51.8522826 & -8.023232 & 126.98112 & -75.807382 & -33.352728 & -20.483293 \\ 7.055016 & -84.171968 & -75.807382 & 334.52589 & 35.730205 & -21.849898 \\ -9.635828 & 23.048589 & -33.357278 & 35.730205 & 124.10459 & -46.26088 \\ -2.683107 & 23.542408 & -20.483293 & -21.84989 & -46.26088 & 171.923674 \end{bmatrix} \quad (2)$$

Furthermore, after obtaining the inverse variance-covariance matrix, the weights of each portfolio stock are calculated by distributing Equation 2.

$$w = \begin{bmatrix} 68.459131 & -11.630463 & -51.8526 & 7.055016 & -9.635828 & -2.683107 \\ -11.630463 & 333.614311 & -8.023232 & -84.171968 & 23.048589 & 23.542408 \\ -51.8522826 & -8.023232 & 126.98112 & -75.807382 & -33.352728 & -20.483293 \\ 7.055016 & -84.171968 & -75.807382 & 334.52589 & 35.730205 & -21.849898 \\ -9.635828 & 23.048589 & -33.357278 & 35.730205 & 124.10459 & -46.26088 \\ -2.683107 & 23.542408 & -20.483293 & -21.84989 & -46.26088 & 171.923674 \end{bmatrix} \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix}$$

$$[1 \quad 1 \quad 1 \quad 1 \quad 1 \quad 1] \begin{bmatrix} 68.459131 & -11.630463 & -51.8526 & 7.055016 & -9.635828 & -2.683107 \\ -11.630463 & 333.614311 & -8.023232 & -84.171968 & 23.048589 & 23.542408 \\ -51.8522826 & -8.023232 & 126.98112 & -75.807382 & -33.352728 & -20.483293 \\ 7.055016 & -84.171968 & -75.807382 & 334.52589 & 35.730205 & -21.849898 \\ -9.635828 & 23.048589 & -33.357278 & 35.730205 & 124.10459 & -46.26088 \\ -2.683107 & 23.542408 & -20.483293 & -21.84989 & -46.26088 & 171.923674 \end{bmatrix} \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} \quad (3)$$

Calculate the expected returns and risks on the portfolio in equal proportions

The expected return of a portfolio is the weighted average of the expected return of each stock in the portfolio in percentage units. The expected return of a portfolio is calculated by multiplying the expected returns of individual stocks by the proportion of each individual stock. Based on Equation 3, the weights of the stocks constituting the portfolio are presented in Table 8.

Table 8 shows that the stock with the highest weight is ICBP (Indofood CBP Sukses Makmur Tbk), while the stock with the lowest weight is ANTM (Aneka Tambang Tbk).

Table 8: Markowitz portfolio weights table

Code	Weight (wi)
ANTM	-0.0005
ICBP	0.45811
INCO	-0.1026
KLBF	0.32054
PTBA	0.15353
UNTR	0.17084

Source: Author's processing

Calculate expected portfolio returns and portfolio return deviation standards

Table 9 shows the calculation results of the expected returns of the Markowitz portfolio.

Table 9. Results of the calculation of the expected return of the Markowitz portfolio

Expected returns			
Stock	E(Ri)	WI	E(Rp)
ANTM	0.01879257	-0.00047238	-0.00001
ICBP	0.00278561	0.458113039	0.00128
INCO	0.01630533	-0.10255477	-0.00167
KLBF	0.00043571	0.320541568	0.00014
PTBA	0.00407696	0.153528678	0.00063
UNTR	0.00418533	0.170843855	0.00072
	E(Rp)		0.001076

Source: Author's processing

Table 9 shows that the expected portfolio return is 0.001076. The highest portfolio returns per share obtained by ANTM were 0.01879257 and 1.88%, by ICBP at 0.00278561 and 0.28%, by INCO at 0.01630533 and 1.63%, by KLBF at 0.00043571 and 0.04%, by PTBA at 0.00407696 and 0.41%, and by UNTR at 0.00418533 and 0.42%.

Table 10. Results of Markowitz portfolio deviation standard calculation

Portfolio return deviation standard			
Stock	Stdev	WI	(Stdev^2) *(wi^2)
ANTM	0.165170156	-0.000472375	0.000000006
ICBP	0.058290307	0.458113039	0.000713080
INCO	0.137979222	-0.102554765	0.000200235
KLBF	0.064307409	0.320541568	0.000424904
PTBA	0.10976703	0.153528678	0.000284003
UNTR	0.088029786	0.170843855	0.000226182
ANTM*ICBP	0.035141258	-0.000216401	0.000000000
ANTM*INCO	0.12387842	4.84443E-05	0.000000000
ANTM*KLBF	0.05257837	-0.000151416	0.000000000
ANTM*PTBA	0.082515096	-7.25231E-05	0.000000000
ANTM*UNTR	0.0653331	-8.07024E-05	0.000000000
ICBP*INCO	0.034173458	-0.046981675	0.000002578
ICBP*KLBF	0.033816387	0.146844272	0.000024659
ICBP*PTBA	0.026053428	0.070333489	0.000003358
ICBP*UNTR	0.018551943	0.078265798	0.000002108
INCO*KLBF	0.064307409	-0.032873065	0.000004469
INCO*PTBA	0.014056241	-0.015745097	0.000000049
INCO*UNTR	0.030438962	-0.017520851	0.000000284
KLBF*PTBA	0.014056241	0.049212323	0.000000479
KLBF*UNTR	0.030438962	0.054762557	0.000002779
PTBA*UNTR	0.065312093	0.026229431	0.000002935
	Varia		0.001935803
	Stdev		0.043997756

Source: Author's processing

Table 10 shows that the standard deviation of the portfolio return or risk accepted by the investor is 0.042 or 0.42%, respectively. ICBP shares have the highest risk, whereas the lowest risk is borne by ANTM and ICBP, ANTM and INCO, ANTM and KLBF, ANTM and PTBA, and ANTM and UNTR.

Discussion

In building an optimal portfolio using the Markowitz model, the initial step involves calculating individual stock returns. Stock returns, defined as the profit earned per share, are an important factor in portfolio optimization. The calculation of stock returns considers fluctuations in monthly closing stock prices over a certain period (Putra & Dana, 2020). According to Gitman and Joehnk (2016), stock returns reflect the rate of return or profit earned from an investment, serving as a driving factor for investors because of their ability to account for price changes. This definition underscores the importance of understanding stock returns in investment decision making.

In this study, the returns of 13 research samples were calculated based on the monthly closing stock price fluctuations. The results revealed positive returns for six stocks: ANTM, ICBP, INCO, KLBF, PTBA, and UNTR. These positive returns signal the profitability of these stocks over a specified period and highlight their potential appeal to investors seeking to optimize their portfolios. By analyzing stock returns, investors can identify promising investment opportunities and make informed decisions regarding portfolio composition. In the context of building an optimal portfolio of Shariah-compliant stocks using the Markowitz model, understanding stock returns is essential for choosing assets that offer a favorable risk-return profile (Hanif et al., 2021). This is in line with the findings of Lee et al. (2016), who recommend the application of Markowitz portfolio diversification to reduce unsystematic risk. The portfolio concept introduced by Markowitz represents an optimization framework intended for standard investors, as it relies on a single explanation of portfolio returns (Balqis et al., 2021).

After calculating the stock returns, the next step in the analysis involves calculating the expected return for each sample. Expected returns play an important role in evaluating the profitability of each stock and in determining its suitability for investment allocation (Indrayanti & Darmayanti, 2013). It represents the anticipated level of return for each stock and provides insight into the potential return on investment. In the context of portfolio optimization, the expected return portfolio serves as a key metric for assessing the overall potential return of the built portfolio. Stocks with positive return expectations are typically included in an optimal portfolio.

Table 2 shows stocks with positive yield expectations, including ANTM (Aneka Tambang Tbk), ICBP (Indofood CBP Sukses Makmur), INCO (Vale Indonesia Tbk), KLBF (Kalbe Farma Tbk), PTBA (Bukit Asam Tbk), and UNTR (United Tractors Tbk). Among them, ANTM shows the highest positive yield expectation of 1.88%, while PTBA has the lowest yield expectation of 0.41%. Moving on to Table 3, the stock risk calculation is presented. Portfolio risk, defined as the variance of the return of securities in a portfolio, is an important consideration in portfolio management. It determines the overall level of risk associated with the portfolio, which may differ from the weighted average risk of an individual security. For example, WIKA (Wijaya Karya Tbk) shows the highest risk of 17.58%, while ICBP (Indofood CBP Sukses Makmur Tbk) shows the lowest risk of 5.83%.

Tables 5 and 6 show the covariance and correlations between the stock returns. Covariance measures the level of movement between two variables, indicating whether movement is positively or negatively correlated. A positive covariance indicates that the stock is moving in the same direction, while a negative covariance indicates the opposite movement. Understanding covariance and correlation is essential for diversification strategies as it helps investors identify complementary assets that can reduce portfolio risk. By analyzing these metrics, investors can make informed decisions regarding portfolio composition, balancing expected returns with associated risks to build an optimal portfolio of Shariah-compliant stocks on JII. These findings are consistent with those of Rizqullah et al. (2024), and Riski and Sulistianingsih (2024) which demonstrated that the Markowitz method is capable of providing risk preferences and investment recommendations.

In addition, positive covariance occurs when there is a tendency for two securities to move in the same direction, and negative covariance indicates the tendency of two securities to move in different directions. Meanwhile, zero covariance means that the movement trends of the two securities are independent of each other. Stocks with a weak correlation or equal to -1 will help reduce the risk. The correlation coefficients of stock prices between companies ranged from +1 to -1. A coefficient of +1 indicated a perfect positive correlation, a coefficient of 0 indicated no correlation, and a coefficient of -1 indicated a perfect negative correlation. A positive covariance of two assets indicates that both assets are moving in the same direction, that is, if the value of one asset increases, that of the other asset will also increase. In addition, the negative covariance of the two assets indicates that the two assets are moving in different directions that is, if one asset increases, the other asset will decrease, and vice versa (Febriani & Rosha, 2020).

Table 7 presents the weight of Markowitz's portfolio, which shows the stocks with the highest weight, namely (Indofood CBP Sukses Makmur Tbk) with 0.045811. On the other hand, the stock with the lowest weight is ANTM (Aneka Tambang Tbk), with a weight of -0.0005. The weight values were obtained from the Average Variant Model. The Mean-Variant Portfolio proposed by Markowitz emphasizes efforts to maximize expected returns (mean) and minimize uncertainty/risk (variance) to select and develop an optimal portfolio.

Portfolio theory includes an efficient portfolio and an optimal portfolio. An efficient portfolio provides investors with a certain return with minimum risk, or offers the same maximum rate of return conditions. Meanwhile, an optimal portfolio was selected from a large selection of efficient portfolios. To minimize risk at the desired rate of return, stock investment can be done by diversifying or investing funds in more than one type of security, or by forming a portfolio (Adnyana, 2020) diversification portfolio will minimize investment risk; in other words, investing in the form of a portfolio is more profitable than investing in just one stock.

This is in contrast to previous research Rachmatullah et al. (2021) using stocks that were consistently listed in the Jakarta Sharia Index (JII) from 2018 to November 2020. The results of the research using the Markowitz method for two optimal portfolio-forming stocks were obtained: ANTM (51%) and BRPT (49%). With an expected portfolio return of 0.0083 or 0.83% and portfolio risk level of 0.0659 or 6.59%, respectively. Meanwhile, in this study, the expected return and risk result from the formation of the optimal Markowitz model portfolio consisting of six stocks, namely ANTM 1.88%, INCO 1.63%, UNTR 0.42%, PTBA 0.41%, ICBP 0.28%, and KLBF 0.4%. A risk value of 0.19% indicates that portfolio risk is much smaller than individual stock risk. This was due to the collection of data at different times.

Markowitz, (1976) stated that, overall, this model serves as a valuable tool for constructing an optimal portfolio, enabling investors to balance risk and return effectively. Investors can make informed decisions to achieve their investment objectives by leveraging insights from covariance, correlation, and portfolio weighting. The Markowitz model contributes to the development of more resilient and sustainable investment portfolios.

An optimal stock portfolio is very important for an investor, namely, a portfolio that is in accordance with the preferences of the investor concerned with the profits or risks that they are willing to bear. If an investment is associated with investors' preferences for the level of return and risk, those preferences can be divided into three categories: (1) risk-seeking investors are investors who prefer to make investments that provide high returns and high risks; (2) risk-neutral investors are people who are cautious and flexible in making investment decisions and will ask for an increase in the rate of return; and (3) risk-averse investors prefer to take lower risks in investments; usually, they tend to consider investment decisions wisely and planned (Setyawan, 2017).

Conclusion

In conclusion, investing in Sharia-compliant stocks listed on JII presents promising opportunities in the securities market. However, to effectively navigate these investments, conducting a comprehensive portfolio analysis is essential to mitigate the risks attached. This study aims to determine expected returns and risks while identifying the optimal portfolio composition using the Markowitz model.

Based on the conceptual framework and sequential explanations above, this study successfully addresses all the research questions and objectives. The results reveal that the optimal portfolio consists of six stocks: ANTM (1.88%), INCO (1.63%), UNTR (0.42%), PTBA (0.41%), ICBP (0.28%), and KLBF (0.4%). Notably, a portfolio risk value of 0.19% indicates a substantial reduction in risk compared with individual stock investments. These results underscore the importance of a prudent investment strategy that emphasizes diversification to spread risk effectively. However, given the limited sample size of only 15 shares in this study, further research with a larger sample size is warranted to obtain stronger conclusions.

Investors who intend to build a stock portfolio should diversify their investments across various assets to align with their risk tolerance and return expectations. By spreading funds across assets that suit their preferences, investors can optimize their portfolios for desired returns while effectively managing risk. This study contributes valuable insights into building an optimal portfolio of Shariah-compliant stocks using the Markowitz model, offering a guide for investors who want to navigate the securities market while adhering to Islamic principles.

This study is limited by its focus on constructing an optimal portfolio using only stocks listed in the Jakarta Islamic Index (JII), despite the existence of three other Sharia-compliant stock indices on the Indonesia Stock Exchange (IDX). Furthermore, the research only examines mining sector stocks within a specific timeframe, although numerous mining stocks are listed on the IDX. Therefore, the researcher recommends that future studies apply the Markowitz optimal portfolio theory to other groups of Sharia-compliant stock indices, incorporating broader timeframes and adapting to evolving market developments.

Author contribution

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Reference

Adnyana, I. M. (2020). *Manajemen investasi dan portofolio*. Lembaga Penerbit Universitas Nasional. http://repository.unas.ac.id/3770/1/BUKU%20IINVESTASI%20REVISI%209%20OK.20.pdf

Afriana, T., Tarno, T., & Sugito, S. (2017). Analisis pembentukan portofolio pada perusahaan yang terdaftar di LQ45 dengan pendekatan metode Markowitz menggunakan GUI Matlab. *Jurnal Gaussian, 6*(2), 251–260. https://doi.org/10.14710/j.gauss.6.2.251-260

Anam, S. K., Aprianingrum, A., & Moorcy, N. H. (2021). Analisis penentuan portofolio optimal dengan model Markowitz pada Jakarta Islamic Index (JII) yang terdaftar di Bursa Efek Indonesia. *GeoEkonomi, 12*(3), 2086–1117. https://doi.org/10.36277/geoekonomi

Avella, A. (2024). Empirical analysis of portfolio optimization using the Markowitz model. *SSRN, 10*(12), 1–27. http://doi.org/10.2139/ssrn.4971433

Azis, M., Mintarti, S., & Nadir, M. (2015). *Manajemen investasi: Fundamental, teknikal, perilaku investor, dan return saham*. Budi Utama.

Aziz, A. (2010). *Manajemen investasi syariah*. Alphabeta. https://repository.syekhnurjati.ac.id/4586/1/Buku%20Manajemen%20Investasi%20Syariah.pdf

Balqis, V. P., Subiyanto, S., & Supian, S. (2021). Optimizing stock portfolio with Markowitz method as a reference for investment community decisions. *International Journal of Research in Community Service, 2*(2), 71–76. https://doi.org/10.46336/ijrcs.v2i2.213

Botero, S. B., Mazo, C. M. G., & Arboleda, F. J. M. (2024). Power generation mix in Colombia including wind power: Markowitz portfolio efficient frontier analysis with machine learning. *Journal of Open Innovation: Technology, Market, and Complexity, 10*(4), 100402. https://doi.org/10.1016/j.joitmc.2024.100402

Chandranegara, D. R., Afif, R. A., Aditya, C. S. K., Suharso, W., & Wibowo, H. (2023). Prediksi harga saham Jakarta Islamic Index menggunakan metode Long Short-Term Memory. *Jurnal Edukasi dan Penelitian Informatika, 9*(1), 129–135. https://doi.org/10.26418/jp.v9i1.57561

Chaweewanchon, A., & Chaysiri, R. (2022). Markowitz Mean-Variance Portfolio Optimization with Predictive Stock Selection Using Machine Learning. *International Journal of Financial Studies, 10*(3), 64. https://doi.org/10.3390/ijfs10030064

Darmadji, T., & Fakhrudin, H. M. (2001). *Pasar modal di Indonesia*. Salemba Empat. https://openlibrary.telkomuniversity.ac.id/pustaka/10021/pasar-modal-di-indonesia-3-e-.html

Desiyanti, R. (2017). *Teori investasi dan portofolio*. Bung Hatta University Press.

Dewi, N. K. A., & Candradewi, M. R. (2020). Optimal portfolio formation of IDX80 index stocks using the Markowitz model. *E-Journal of Management, 9*(4), 1614–1633. https://doi.org/10.24843/EJMUNUD.2020.v09.i04.p19

Fabozzi, F. J. (2003). *Manajemen investasi*. Salemba Empat. http://repository.unas.ac.id/3770/1/BUKU%20IINVESTASI%20REVISI%209%20OK.20.pdf

Febriani, F., & Rosha, M. (2020). Optimal portfolio formation with Markowitz model and two-fund theorem on LQ-45 stocks on the Indonesia Stock Exchange. *Journal of Mathematics UNP, 3*(3), 50–54. http://dx.doi.org/10.24036/unpjomath.v5i3.10594

Gitman, L. J., & Joehnk, M. D. (2016). *Dasar-dasar investasi* (13th ed.). Pearson Education. https://repository.latansamashiro.ac.id/283/1/23-02-20-EBOOK-Manajemen%20Investasi%20dan%20Portofolio.pdf

Guo, Q. (2022). Review of research on Markowitz model in portfolios. *Proceedings of the 2022 7th International Conference on Social Sciences and Economic Development (ICSSED)* (pp. 786–790). Atlantis Press. https://doi.org/10.2991/aebmr.k.220405.131

Hanif, A., Hanun, N. R., & Febriansah, R. E. (2021). Optimization of stock portfolio using the Markowitz model in the era of the Covid-19 pandemic. *TIJAB (The International Journal of Applied Business), 5*(1), 37–50. https://doi.org/10.20473/tijab.V5.I1.2021.37-50

Hariasi, N. P. N., & Wirama, I. D. G. (2016). Analisis perbedaan pengembalian portofolio berdasarkan model indeks tunggal dan portofolio acak. *E-Jurnal Ekonomi dan Bisnis Universitas Udayana, 5*(9), 2951–2976. https://ojs.unud.ac.id/index.php/eeb/article/view/22257/16159

Hue B, Jinks A, Spain J, Bora M, & Siew S. (2019). Investment risk for long-term investors: risk measurement approaches: Considerations for pension funds and insurers. *British Actuarial Journal*. 24:e16. https://doi.org/10.1017/S1357321719000102

Indrayanti, N. W. Y., & Darmayanti, N. P. A. (2013). Determination of optimal portfolio with Markowitz model on banking stocks on the Indonesia Stock Exchange. *E-Journal of*

Management of Udayana University, 2(8), 869–884. https://www.neliti.com/id/publications/253936/penentuan-portofolio-optimal-dengan-model-markowitz-pada-saham-perbankan-di-burs

Indriyani, S., Cahyani, N. D, & Amaroh, S. (2023). The Jakarta Islamic Index (JII) stock price in terms of oil, gold and exchange rates. *Islamic Economics Journal, 9*(1), 83–100. https://doi.org/10.21111/iej.v9i1.10118

Inrawan, A., et al. (2022). *Portofolio dan investasi*. Widina Bakti Persada.

Irfani, M. I., & Sudrajad, O. Y. (2023). Portfolio optimization using Markowitz model on Sri-Kehati Index. *International Journal of Current Science Research and Review, 6*(8), 5778–5792. https://doi.org/10.47191/ijcsrr/V6-i8-45

Koni, W., Dukalang, H., & Ningsih, S. (2021). Estimation of Sharia stock risk value using Monte Carlo simulation in Jakarta Islamic Index (JII) for the 2017–2020 period. *European Journal of Research Development and Sustainability, 2*(12), 15–25. https://scholarzest.com/index.php/ejrds/article/view/1583

KSEI News. (2020). *Komitmen KSEI dalam pengembangan infrastruktur digital pasar modal*. PT. Indonesian Central Securities Depository. https://www.ksei.co.id/files/uploads/fokuss_bulletins/fokuss_file/id-id/64_edisi_4_20210325190339.pdf

Latifah, E., Masyhuri, M., Pahlevi, R.W., Mulyani, S., Hasanah, N., Fidiana, F., Zunaidi, A., Nurjanah, N., Yulianti, M.L., Yunus, A.R., Fauzi, A., Dewi, A.K.R.S., Parmitasari, R.D.A., Koni, A. & Setiadi, R. (2022). *Manajemen Keuangan Syariah: Sebuah Konsep dan Teori*. Eureka Media Aksara. https://repository.penerbiteureka.com/media/publications/559407-manajemen-keuangan-syariah-a612e1d0.pdf

Lee, H.-S., Cheng, F.-F., Chong, S.-C., & Rahman, A. (2016). Special Issue for. *International Journal of Economics and Financial Issues, 6*(S3), 5–6. http://www.econjournals.com

Leung, P. L., Ng, H. Y., & Wong, W. K. (2012). An improved estimation to make Markowitz's portfolio optimization theory users friendly and estimation accurate with application on the US stock market investment. *European Journal of Operational Research*, *222*(1), 85-95. https://doi.org/10.1016/j.ejor.2012.04.003

Linge, A., & Ahmad, U. S. (2021). Empirical study of entrepreneurship in Tijarah concept. *Talaa: Journal of Islamic Finance, 1*(1), 26–33. https://doi.org/10.54045/talaa.v1i1.251

London, A., Gera, I., & Banhely, B. (2018). Markowitz portfolio selection using a variety of expected return estimators and screening techniques for correlation matrices. *Acta Polytechica Hungarica, 15*(1), 2017–229. https://acta.uni-obuda.hu/London_Gera_Banhelyi_80.pdf

Mafula, Z., Hndayani, S. R., & Zahroh, Z. A. (2018). Portofolio optimal dengan penerapan model Markowitz sebagai dasar keputusan investasi (Studi pada perusahaan yang tergabung dalam indeks LQ-45 tahun 2014). *Journal of Business Administration, 63*(1), 21–33. https://download.garuda.kemdikbud.go.id/article.php?article=801366&val=6468&title=PORTOFOLIO%20OPTIMAL%20DENGAN%20PENERAPAN%20MODEL%20MARKOWITZ%20SEBAGAI%20DASAR%20KEPUTUSAN%20INVESTASI%20Studi%20Pada%20Perusahaan%20Yang%20Tergabung%20Dalam%20Indeks%20LQ-45%20Tahun%202014

Mangram, M. E. (2013). A simplified perspective of the Markowitz portfolio theory. *Global Journal of Business Research, 7*(1), 59–70. https://ssrn.com/abstract=2147880

Markowitz, H. M. (1959). *Portfolio selection: Efficient diversification of Investment*. John Wiley & Sons, Inc.

Markowitz, H. M. (1976). Markowitz revisited. *Financial Analysts Journal, 32*(5), 47–52. https://doi.org/10.2469/faj.v32.n5.47

Mary, J. F., & Rathika, G. (2015). The single index model and the construction of optimal portfolio with CNXPHARMA scrip. *International Journal of Management, 6*(1), 87–96. https://iaeme.com/MasterAdmin/Journal_uploads/IJM/VOLUME_6_ISSUE_1/10120140601010.pdf

Nasution, M. I. P., Maidalena, M., & Syahriza, R. (2015). *Bisnis dan Investasi Syariah*. FEBI UIN-SU PRESS.

Natalia, E. (2014). Determination of the optimal stock portfolio with the Markowitz model as the basis for determining stock investment (Study on food and beverage companies listed on the Indonesia Stock Exchange in 2012). *Jurnal Administrasi Bisnis S1 Universitas Brawijaya, 9*(1), 1–4. https://repository.ub.ac.id/id/eprint/116857/

Otoritas Jasa Keuangan. (2021). Modul Kompetensi Pengelolaan Investasi Syariah. Otoritas Jasa Keuangan. https://ojk.go.id/id/kanal/syariah/tentang-syariah/Documents/pages/pasar-modal-syariah/Modul%20Kompetensi%20Pengelolaan%20Investas%20Syariah%20-%20FINAL%20V2.pdf

Pangiuk, A. (2022). Determinant of financial ratios on stock price in multi-industrial sector manufacturing companies listed in The Sharia Indonesia Stock Index 2016-2020. *ILTIZAM Journal of Shariah Economics Research, 6*(1), 59–75. https://doi.org/10.30631/iltizam.v6i1.1182

Partha, C. G. G., & Sedana, I. B. P. (2019). Performance of primary, secondary, and tertiary sector stock portfolios on the IDX (Comparative study). *International Journal of Economics, Trade, and Management, 7*(2), 21–41. https://ijecm.co.uk/wp-content/uploads/2019/02/722.pdf

Putra, I. K. A. A. S., & Dana, I. M. (2020). Study of optimal portfolio performance comparison: Single Index Model and Markowitz Model on LQ45 stocks in Indonesia Stock Exchange. *American Journal of Humanities and Social Sciences Research, 4*(12), 237–244. https://www.ajhssr.com/wp-content/uploads/2020/12/ZE20412237244.pdf

Rachmany, H., & Tajudin, T. (2022). The effect of deferred tax expense on earnings management (Empirical study on PT. Matahari Department Store, Tbk listed on the Indonesia Stock Exchange in 2015 to 2019). *Journal of Tax and Business, 3*(1), 1–11. https://doi.org/10.55336/jpb.v3i1.40

Rachmatullah, I., Nawir, J., & Siswantini, T. (2021). Analisis portofolio optimal Markowitz dan Single Index Model pada Jakarta Islamic Index. *Jurnal Ekonomi dan Bisnis, 8*(1), 50–69. https://doi.org/10.35590/jeb.v8i1.2682

Riski, T. R., & Sulistianingsih, H. (2024). Portofolio saham optimal dengan model Markowitz pada saham Perbankan yang terdaftar di LQ 45 tahun 2023. *Jurnal Ekonomika dan Bisnis (JEBS), 4*(4), 606–618. https://doi.org/10.47233/jebs.v4i4.1926

Rizqullah, T. Z., Hidayat, W. W., Supardi, S., & Ridwan, R. (2024). Analisis pembentukan ortofolio optimal di Bursa Efek Indonesia dengan menggunakan Model Markowitz. *MASMAN: Master Manajemen, 2*(3), 94–108. https://doi.org/10.59603/masman.v2i3.473

Rogers, J. (2009). Investment Risk. In *Strategy, Value and Risk* (Palgrave Macmillan Finance and Capital Markets Series). Palgrave Macmillan, London. https://doi.org/10.1057/9780230353930_4

Rosyadi, R., Budiman, B., Miftahurrahmah, M., Meiriyanti, R., Nugroho, B. S., Amir, M.F., Hidayat, D., Citarayani, I., Lubis, J., & Fatmah, F.(2024). *Manajemen investasi Syariah*. Penerbit Penamuda Media.

Sahputra, N. (2020). *Manajemen keuangan Syariah*. Udhar Press. http://repository.dharmawangsa.ac.id/658/1/BUKU%20MANAJEMEN%20KEUANGAN%20SYARIAH.pdf

Setyawan, N. W., & Suwitho, S. (2017). Metode Markowitz untuk menentukan portofolio optimal pada perusahaan retail di BEI. *Jurnal ilmu dan riset manajemen, 6*(2), 1–22. https://jurnalmahasiswa.stiesia.ac.id/index.php/jirm/article/view/707/717

Sudarsono, B., & Sudiyatno, B. (2016). Faktor-faktor yang mempengaruhi return saham pada perusahaan property dan real estate yang terdaftar pada Bursa Efek Indonesia tahun 2009 S/D 2014. *Jurnal Bisnis dan Ekonomi, 23*(1), 30–51. https://media.neliti.com/media/publications/77507-ID-none.pdf

Sukardi, H., Sari, M., Nugraha, N., & Purnamasari, I. (2023). Markowitz portfolio optimization applied on companies listed on the Indonesia Stock Exchange LQ-45. *Ekono Insentif, 17*(1), 34-48. https://doi.org/https://doi.org/10.36787/jei.v17i1.1109

Susanti, E., Agriyanto, R., Musahadi, M., & Zuhri, S. (2021). Responsiveness of volatility analysis of the Jakarta Islamic Index on macroeconomic variables. *Muqtasid, 12*(1), 32–48. https://doi.org/10.18326/muqtasid.v12i1.32-48

Susilo, E., & Najah, A. (2018). Stock performance of Jakarta Islamic Index based on Sharpe, Treynor and Jensen method. *Jurnal Ekonomi & Keuangan Islam, 4*(2), 67–74. https://doi.org/10.20885/jeki.vol4.iss2.art2

Wahyuliantini, N. M., & Suarjaya, A. A. G. (2015). Pengaruh harga saham, volume perdagangan saham, dan volatilitas return saham pada bid-ask spread. *Jurnal Manajemen, Strategi Bisnis dan Kewirausahaan, 9*(2), 146–155. https://download.garuda.kemdikbud.go.id/article.php?article=1353705&val=954&title=PENGARUH%20HARGA%20SAHAM%20VOLUME%20PERDAGANGAN%20SAHAM%20DAN%20VOLATILITAS%20RETURN%20SAHAM%20PADA%20BID-ASK%20SPREAD

Maryam, N. M., & Dewi, A. R. S. (2022). Single index model in optimal portfolio formation on stock index LQ 45. *Journal of Economic Resources, 5*(2), 236–248. https://doi.org/10.57178/jer.v5i2.350

Yunita, I. (2018). Markowitz model dalam pembentukan portofolio optimal (Studi kasus pada Jakarta Islamic Index). *Jurnal Manajemen Indonesia, 18*(1), 77–85. https://doi.org/10.25124/jmi.v18i1.1262

Zulfikar. (2016). *Pengantar pasar modal dengan pendekatan statistik*. Deepublish. https://repository.deepublish.com/media/publications/588659-pengantar-pasar-modal-dengan-pendekatan-5a052187.pdf