Digital Business and Entrepreneurship Journal
Vol. 4, No. 2, 2026, 89-99

E-ISSN: 3032-2480
https://journal.feb.uniku.ac.id/digibe

MEAN-VARIANCE PORTFOLIO OPTIMIZATION FOR EMDE AND MTDL STOCKS: A MARKOWITZ APPROACH

Zahra Rohadatul Aisylah[1], Ferdiansyah Saputra[2], Arief Surya Lesmana[3*], Hadi Satria Ganefi[4]
[1,2,3,4]Universitas Kuningan, Jawa Barat, Indonesia
*Coresponding Author; Email: arief.surya@uniku.ac.id

How to Cite: Aisylah, Z. R., Saputra, F. & Lesmana, A. S. (2026). Mean-Variance Portfolio Optimization for EMDE and MTDL Stocks: A Markowitz Approach. *Digital Business and Entrepreneurship Journal*, 4(2), 89-99.

Received: 06-07-2026 Accepted: 12-07-2026 Published: 31-07-2026

Abstrak

Pembentukan portofolio optimal merupakan langkah krusial bagi investor dalam menyeimbangkan *trade-off* antara return yang diharapkan dan risiko investasi. Penelitian ini bertujuan mengonstruksi portofolio optimal dari dua saham, yaitu EMDE dan MTDL, dengan menerapkan model *mean-variance* Markowitz untuk meminimalkan varians *return* pada tingkat *return* tertentu. Metode yang digunakan adalah optimasi *mean-variance* dengan mengestimasi *expected return*, varians, dan kovarians berdasarkan data *return* historis kedua saham, kemudian menentukan bobot portofolio yang efisien. Hasil analisis menunjukkan bahwa portofolio optimal terdiri dari 19,27% saham EMDE dan 80,73% saham MTDL. Kombinasi ini menghasilkan *expected return* portofolio sebesar 1,33% dengan simpangan baku return 8,43%, yang mencerminkan profil risiko-*return* yang lebih efisien dibandingkan alokasi pada satu saham saja. Temuan ini mengindikasikan bahwa diversifikasi antara EMDE dan MTDL mampu memperbaiki karakteristik risiko portofolio tanpa mengorbankan return secara signifikan. Berdasarkan hasil tersebut, investor disarankan mempertimbangkan kombinasi kedua saham ini sebagai bagian dari strategi alokasi aset, terutama bagi investor dengan preferensi risiko moderat yang mengutamakan efisiensi *mean-variance*. Penelitian ini memberikan bukti empiris sederhana mengenai penerapan model Markowitz pada pasar saham Indonesia dan dapat menjadi referensi bagi studi lanjutan dengan cakupan aset dan periode data yang lebih luas.

Kata kunci: portofolio; *mean-variance*; model Markowitz; *return*; risiko

Abstract

Constructing an optimal portfolio is a crucial step for investors in balancing the trade-off between expected return and investment risk. This study aims to construct an optimal portfolio comprising two stocks, EMDE and MTDL, by applying the Markowitz mean-variance model to minimize return variance at a specific return level. The methodology employs mean-variance optimization, estimating expected return, variance, and covariance based on historical return data for both stocks to determine efficient portfolio weights. The analysis reveals that the optimal portfolio consists of 19.27% EMDE stock and 80.73% MTDL stock. This combination yields an expected portfolio return of 1.33% with a return standard deviation of 8.43%, reflecting a more efficient risk-return profile compared to an allocation in a single stock. These findings indicate that diversification between EMDE and MTDL can improve portfolio risk characteristics without significantly sacrificing returns. Consequently, investors are advised to consider this combination as part of their asset allocation strategy, particularly those with moderate risk preferences who prioritize mean-variance efficiency. This study provides empirical evidence regarding the application of the Markowitz model in the Indonesian stock market and serves as a reference for future research involving a broader range of assets and data periods.

Keyword: *portfolio; mean–variance; Markowitz model; return; risk*

E-ISSN: 3032-2480
https://journal.feb.uniku.ac.id/digibe

INTRODUCTION

Capital markets play a pivotal role as a source of external funding for companies and an investment avenue for capital providers, thereby serving as a capital allocation mechanism that connects parties with surplus funds to issuers requiring capital for business expansion and capital structure optimization (Levine, 1997; Ehrmann & Fratzscher, 2005; Lesmana et al, 2024). In this context, investors participate in capital markets primarily to generate returns; however, any potential return entails risk that must be managed systematically (Elton et al, 2014). The positive relationship between risk and return requires investors to consider various factors, such as stock price dynamics, dividend policies, and fluctuating macroeconomic conditions, when formulating investment decisions (Nabila et al, 2025). To address this risk-return trade-off, diversification through the construction of an optimal stock portfolio stands as a fundamental strategy recommended by modern financial theory (Budiandriani et al, 2025).

Constructing an efficient stock portfolio is a cornerstone of modern portfolio theory, wherein investors seek to maximize expected returns for a given level of risk, or conversely, minimize risk for a targeted level of return (Markowitz, 1952). Within the mean-variance framework, an efficient portfolio is defined as a combination of assets that yields the highest expected return for a specific level of risk, or the lowest risk for a specific level of return, thereby forming the "efficient frontier" that serves as a benchmark for investment decision-making (Waluyo et al, 2025). However, capital market volatility, including in Indonesia, renders the achievement of a truly efficient portfolio an empirical challenge requiring rigorous quantitative approaches. In this context, stock returns serve not only as a yield on investment but also as a primary motivation for investors to remain active in the capital market, given that returns reflect compensation for the risks borne (Lesmana & Maulana, 2025).

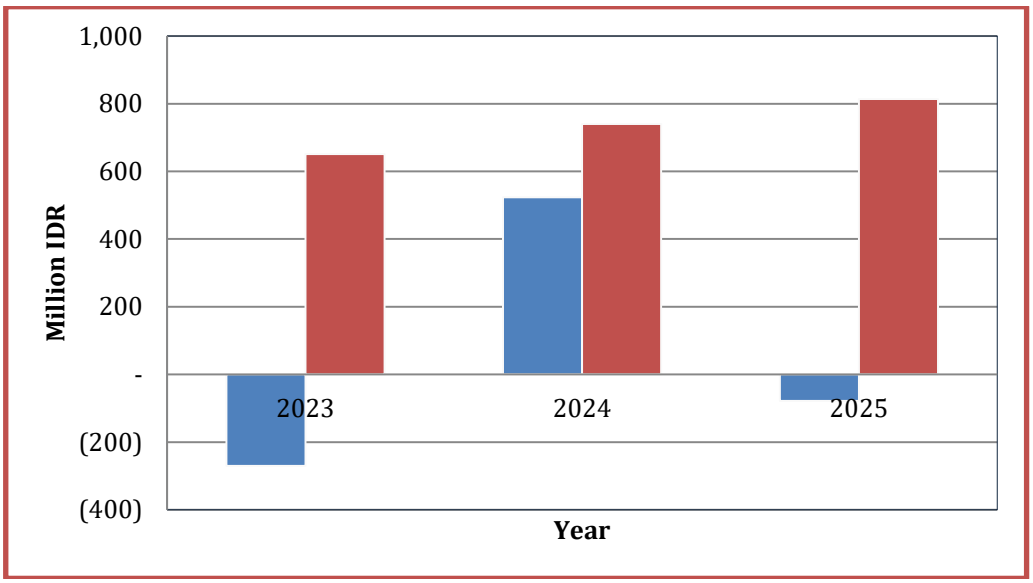
In the Indonesian capital market, the phenomenon of high stock price volatility, particularly among stocks with distinct sectoral and fundamental characteristics, underscores the importance of appropriate diversification. Stocks in the financial and construction sectors, for instance, often exhibit differing return and risk patterns in response to shifts in economic cycles, monetary policy, and real-sector conditions (Sequeira, 2021; Lee & Karim, 2025). These divergent characteristics create potential opportunities for diversification, as combining stocks with low correlation can reduce portfolio risk without significantly sacrificing returns. Empirical studies on the Indonesia Stock Exchange indicate that an optimal portfolio constructed from a small number of stocks, even just two from different sectors, can yield a more efficient risk-return profile compared to investing in individual stocks (Ridwanudin & Sari, 2023).

In practice, however, many retail investors still tend to concentrate on one or two favorite stocks without systematically considering the trade-offs between expected return, variance, and inter-asset. This situation raises an empirical question regarding how a specific combination of two stocks with differing sectoral characteristics, such as those from the financial and construction sectors, can be optimized using the mean-variance model to generate an efficient portfolio for investors with specific risk preferences.

PT Megapolitan Developments Tbk (EMDE) and PT Metrodata Electronics Tbk (MTDL) represent distinct sectoral characteristics and risk profiles on the Indonesia Stock Exchange. EMDE operates in the property and real estate sector, focusing on the development of residential units, commercial properties, and shopping centers, making its performance highly sensitive to property cycles, interest rates, and consumer purchasing power (IDNFinancials, 2025). In contrast, MTDL operates in the technology sector, specifically in the distribution of IT hardware and software and the provision of digital

E-ISSN: 3032-2480
https://journal.feb.uniku.ac.id/digibe

solution services, making it more sensitive to corporate IT spending dynamics, digital transformation trends, and macroeconomic conditions affecting the technology sector (IDNFinancial, 2025). These fundamental differences can lead to return and volatility patterns that are not fully correlated; consequently, combining these two stocks offers an attractive diversification opportunity within a mean-variance framework (Lesmana et al, 2025).



Source: Processed by the authors

Figure 1. Profit (Loss) of EMDE and MTDL (Million IDR)

Tabel 1. Financial Profile of EMDE and MTDL

Company	Year	Operating Revenues (million IDR)	Total Assets (million IDR)	Total Equity (million IDR)
EMDE	2023	140	3,519	1,358
	2024	1,354	3,748	1,880
	2025	207	3,333	2,130
MTDL	2023	22,100	10,140	5,040
	2024	25,170	11,650	5,660
	2025	27,178	13,122	6,315

Source: Processed by the authors

Based on financial data from the 2023-2025 period, EMDE and MTDL exhibit distinct fundamental characteristics relevant to constructing an optimal portfolio. EMDE displays relatively small and fluctuating operating revenue, starting at IDR 140 million in 2023, surging to IDR 1,354 million in 2024, and subsequently falling to IDR 207 million in 2025, alongside total assets that remained relatively stable in the IDR 3.3-3.7 billion range and total equity that grew from IDR 1.358 billion to IDR 2.130 billion. In contrast, MTDL demonstrates a significantly larger business scale and more consistent growth; its operating revenue rose from IDR 22,100 million in 2023 to IDR 27,178 million in 2025, accompanied by increases in total assets (from IDR 10,140 million to IDR 13,122 million) and total equity (from IDR 5,040 million to IDR 6,315 million). These differences in business scale, growth trends, and financial structure indicate distinct risk-return profiles for EMDE and MTDL, making both companies worthy of further analysis within the context of portfolio diversification.

E-ISSN: 3032-2480
https://journal.feb.uniku.ac.id/digibe

Given the fundamental differences in characteristics and diversification potential between EMDE and MTDL, this study aims to construct an optimal portfolio comprising these two stocks using the Markowitz mean-variance model and to measure the resulting expected return and portfolio risk. Specifically, the study addresses the optimal fund allocation between EMDE and MTDL to achieve a minimum-risk portfolio for a given level of expected return, and compares the portfolio's risk-return profile with that of investing in each stock individually. By focusing on two stocks from different sectors, each with distinct business scales and growth trends, this study provides empirical evidence of the Markowitz model's application to a two-asset portfolio in the Indonesian capital market. It serves as a reference for retail investors and academics alike in understanding portfolio efficiency through a simple yet quantitatively rigorous analytical framework.

METHODS

This study employs a quantitative descriptive approach to determine an optimal portfolio model based on historical data. The optimal portfolio is analyzed using the Markowitz model, focusing on the stocks of Megapolitan Developments and Metrodata Electronics during the period from Januari 2021 to Desember 2025. Research data were obtained from the official website www.id.investing.com. The mean-variance model minimizes return variance subject to constraints on the weights (allocations) for each stock.

Suppose there are two stocks with expected returns of $E(R_1)$ and $E(R_2)$, respectively. Capital is allocated to these two stocks with weights of w and $(1-w)$, respectively. The expected return of the resulting risky portfolio is

$$E(R_p) = wE(R_1) + (1-w)E(R_2) \tag{1}$$

Suppose the return variances for the two stocks are denoted by σ_1^2 and σ_2^2 respectively and the covariance of returns of the two stocks is denoted by $Cov(R_1, R_2)$. We want to minimize the portfolio return variance subject to capital allocation constraints (Bodie et al, 2018).

$$\min_w \sigma_p^2 = w^2\sigma_1^2 + (1-w)^2\sigma_2^2 + 2\,w(1-w)Cov(R_1, R_2) \tag{2}$$

To obtain the optimal w^* that minimizes σ_p^2, we differentiate σ_p^2 with respect to w and set the first derivative to zero.

$$\frac{d\sigma_p^2}{dw} = 0 \tag{3}$$

$$w^* = \frac{\sigma_1^2 - Cov(R_1, R_2)}{\sigma_1^2 + \sigma_2^2 - 2Cov(R_1, R_2)} \tag{4}$$

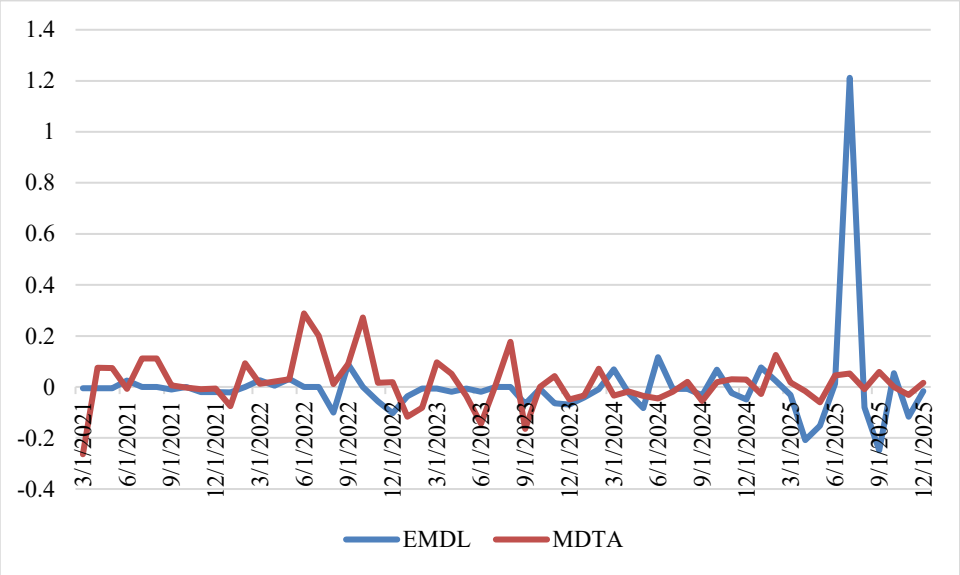
RESULT AND DISCUSSIONS

Result

The calculation of stock returns plays a crucial role in evaluating stock performance and determining which stocks are suitable for investment. Returns represent the gains derived from stock investments, realized through either price appreciation (capital gains) or dividends. By analyzing returns, investors can assess whether the yield obtained aligns with

E-ISSN: 3032-2480
https://journal.feb.uniku.ac.id/digibe

their expectations and the level of risk assumed. Details regarding the returns of the stocks from the sample companies are presented in the following chart:



Source: Processed by the authors

Figure 2. Monthly Return of EMDE and MTDL 2021-2025

Stock return data for Megapolitan and Metrodata reveals significant fluctuations throughout the observed period. Positive returns reflect gains from rising stock prices, whereas negative returns indicate losses resulting from price declines. On certain dates, specifically January 6, 2020, January 8, 2020, and January 10, 2020, Megapolitan's stock return was recorded as zero, indicating no change in price during those periods. Metrodata's stock appears more volatile than Megapolitan's. For instance, on January 2, 2020, Metrodata's return hit -26.38%, while Megapolitan's was only -0.5%. Conversely, Metrodata also recorded substantial gains, such as a 27.21% return on January 2, 2021. However, Megapolitan's stock experienced a sharp decline on January 4, 2024, with a return of -20%, highlighting the high level of risk involved.

Table 2. The Expected Return, Variance, and Covariance

Stocks	Expected Return	Variance	Covariance
EMDE	0.0006	0.0301	0.0016
MTDL	0.0164	0.0084	

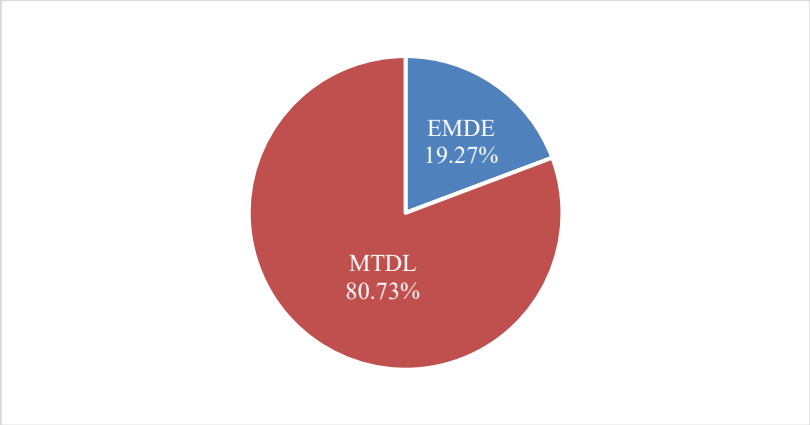
Source: Processed by the authors

Based on the calculations, EMDE stock has an expected return of 0.06%, whereas MTDL stock has an expected return of 1.64%. This indicates that the potential investment return for MTDL stock is significantly higher than that of EMDE stock. However, these results should not serve as the sole basis for making investment decisions; investors must still consider risks, market conditions, and other factors before determining their investment strategy. EMDE stock exhibits a variance of 3.01%, indicating that its price tends to be more volatile, or subject to greater fluctuations, compared to MTDL stock, which has a variance of only 0.84%. Consequently, EMDE stock entails a higher level of uncertainty, resulting in greater risk relative to MTDL stock. A higher variance implies a greater likelihood of significant price changes. The covariance shown in the table reveals the relationship between the stock price movements of EMDE and MTDL. With a covariance value of 0.155%, it can

E-ISSN: 3032-2480
https://journal.feb.uniku.ac.id/digibe

be concluded that the stock price movements of EMDE and MTDL tend to move in the same direction. This means that when EMDE's stock price rises or falls, MTDL's stock price is likely to follow a similar pattern.

Determining capital allocation is a crucial step in optimally managing an investment portfolio. By considering capital proportions, investors can determine the appropriate allocation for each stock, enabling the portfolio to control risk while maximizing returns. In this study, we conduct an in-depth analysis of the capital proportions allocated to EMDE and MTDL based on Equations (3) and (4). The results of these calculations are presented in the following table:



Source: Processed by the authors
Figure 3. Capital Allocation Proportion

The analysis indicates that the portfolio's investment funds are allocated to two stocks: EMDE and MTDL. Specifically, 19.27% of the total funds are invested in EMDE, while the majority, 80.73%, is allocated to MTDL. The larger allocation to MTDL reflects investor confidence in the stock's potential performance, regarding both returns and stability. Conversely, the smaller proportion allocated to EMDE may reflect a diversification strategy or a cautious approach to risk management.

The portfolio expected return, $E(R_p)$, is the average return anticipated from an investment portfolio, calculated by combining the returns of the stocks within the portfolio based on the proportion of funds invested in each stock. We use Equation (1) to estimate the portfolio's expected return. The calculation results are as follows:

$$E(R_p) = (0.0006 \times 0.1927) + (0.0164 \times 0.8073) = 1{,}33\%$$

Based on the analysis, a portfolio consisting of a combination of EMDE and MTDL stocks yields a total expected return of 1.333%. A larger allocation of funds to MTDL shares contributes more significantly to the portfolio's total return. These results indicate that a higher allocation to MTDL shares has a positive impact on the portfolio's total expected return.

Risk evaluation plays a crucial role in investment decision-making, as it reflects the potential discrepancy between the actual return received and the expected return. The return-risk trade-off indicates that the higher an asset's risk, the greater the opportunity for high returns, but also the greater the potential for loss. Therefore, risk analysis is essential to understand the level of uncertainty associated with a stock and to determine whether it is

E-ISSN: 3032-2480
https://journal.feb.uniku.ac.id/digibe

suitable for inclusion in an investment portfolio. The following are the results of the risk calculation using Equation (2):

$$\sigma_p^2 = (0.1927^2 \times 0.0301) + (0.8073^2 \times 0.0084) + (2 \times 0.1927 \times 0.8073 \times 0.0016) = 0.0071$$
$$\sigma_p = \sqrt{0.0171} = 8{,}43\%$$

Based on the analysis, the risk associated with the combination of EMDE and MTDL stocks is recorded at 8.43%. This figure indicates the potential return fluctuation for a portfolio comprising these two stocks. If this combined risk is lower than the risk of each stock individually, it demonstrates the benefits of diversification, where combining the two stocks helps reduce overall risk. However, if the risk remains high, it may be necessary to consider adjusting the stock proportions or adding other stocks with lower correlation to lower the risk. With a risk level of 8.43%, this portfolio falls into the moderate risk category.

Discussion

The results of this study provide strong empirical evidence regarding the continued relevance of the Markowitz Mean-Variance approach in explaining portfolio optimization mechanisms, particularly in the context of stocks with distinct characteristics such as EMDE and MTDL. Fundamentally, the findings reveal an imbalance between risk and return across the assets; MTDL offers a significantly higher expected return alongside relatively lower risk compared to EMDE. Within the framework of modern portfolio theory, this indicates that MTDL lies closer to the efficient frontier, where as EMDE tends to fall within an inefficient region. These findings directly address the study's objective of identifying an optimal portfolio combination and reinforce the argument that not all high-volatility assets yield a proportional return.

This interpretation aligns with recent literature affirming that the Markowitz model remains a fundamental cornerstone of portfolio decision-making, despite facing various empirical limitations. Recent studies indicate that the core of portfolio optimization still hinges on the trade-off between expected return and variance, even as modern approaches increasingly integrate additional elements such as factor models and more complex data-driven estimation techniques (Boyd et al, 2024; Shkolnik et al, 2025). In the context of this study, the allocation dominance of MTDL (80.73%) over EMDE (19.27%) reflects optimization results consistent with this principle, wherein portfolio weights are determined by marginal contributions to risk and return rather than merely by absolute return levels.

Furthermore, the finding of a positive covariance between EMDE and MTDL indicates that the two stocks tend to move in the same direction, which theoretically reduces the effectiveness of diversification. In recent literature, the issue of inter-asset correlation is a primary concern due to its direct impact on portfolio efficiency. Recent studies demonstrate that a suboptimal correlation structure can lead to portfolio concentration in specific assets, thereby significantly diminishing diversification benefits (Lolic, 2024). This phenomenon is also evident in your research results, where the portfolio tends to be concentrated in MTDL, reflecting a characteristic trait of Markowitz optimization, which is sensitive to statistical inputs, particularly the covariance matrix.

Regarding portfolio performance, the expected return of 1.333%, derived from the combination of the two stocks, demonstrates a trade-off between maximizing returns and ensuring risk stability. This aligns with recent empirical studies in the Indonesian market showing that portfolios optimized using the Markowitz model do not necessarily yield the highest absolute returns; rather, they deliver superior risk-adjusted performance compared to non-optimal strategies (Yusan & Riyadi, 2024). In other words, these findings reinforce

E-ISSN: 3032-2480
https://journal.feb.uniku.ac.id/digibe

the view that portfolio optimality is not measured solely by absolute returns, but by the efficiency of the risk-return combination.

However, interesting findings indicate that EMDE carries high risk without being compensated by high returns. Recent literature often attributes this phenomenon to market inefficiency or distortions, particularly regarding stocks with low liquidity or emerging market characteristics. Recent studies highlight the limitations of mean-variance models in capturing asymmetric return distributions and complex market dynamics, often resulting in inaccurate estimates under specific market conditions (Mandal & Thakur, 2024). In this context, your research findings provide empirical evidence that the classical assumption of a linear relationship between risk and return does not always hold true, especially for stocks like EMDE.

Furthermore, the high volatility observed in EMDEs aligns with market characteristics that are more susceptible to extreme fluctuations. the optimal portfolio's inability to generate an expected return exceeding its standard deviation stems from the intrinsic qualities of the assets' historical data. The data structure of EMDE reflects an extreme imbalance between risk and return (high risk, low reward). Consequently, even when diversification successfully suppresses volatility to the level of the Global Minimum Variance Portfolio (GMVP), the absolute lower bound of portfolio risk remains above the expected return. This phenomenon carries a significant implication: mathematical optimization in portfolio construction serves only to minimize existing mathematical risk, but it cannot manipulate or improve the inherent fundamental performance of the assets being analyzed. Recent literature indicates that high-volatility markets often require more sophisticated optimization approaches, such as integrating GARCH models, copulas, or even machine learning, to enhance the accuracy of risk and return estimations (Jeleskovic et al, 2024). This suggests that while the Markowitz model serves as an effective baseline, its practical application necessitates adjustments to account for dynamic market conditions.

The practical implications of this study are significant for investors. The results indicate that an optimal strategy depends not only on selecting high-return stocks but also on how the combination of assets minimizes overall risk. MTDL's dominance in the portfolio reflects a preference for more stable assets, while EMDE serves as a diversification instrument in limited proportions. However, concentrating the portfolio on a single asset also introduces specific risks, often referred to in recent literature as "concentration risk", stemming from the model's sensitivity to input data.

Regarding future research directions, these results open up several opportunities for further development. First, future studies could integrate multi-factor models or approaches based on higher moments to capture complex risks beyond variance. Second, employing more adaptive optimization methods, such as multi-period optimization or machine learning-based portfolio optimization, could enhance the robustness of portfolio results amidst fluctuating market conditions (Wu et al, 2024). Third, it is necessary to explore assets with negative or low correlations to improve diversification effectiveness and expand the efficient frontier.

Overall, this study not only confirms the relevance of Markowitz's theory in a modern context but also highlights its limitations in addressing the complexities of real-world markets. These findings enrich the literature by providing empirical evidence from the Indonesian stock market that portfolio optimization is a dynamic process heavily dependent on asset characteristics and the quality of the parameter estimates employed.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This study aims to identify the optimal portfolio combination of EMDE and MTDL stocks using the Markowitz Mean-Variance approach, focusing on the risk-return trade-off. The analysis concludes that MTDL is a more efficient asset than EMDE, evidenced by a higher expected return (1.64%) and lower risk (0.84%), whereas EMDE exhibits high-risk, low-return characteristics. In terms of portfolio optimization, the results yield an optimal allocation of 80.73% to MTDL and 19.27% to EMDE, reflecting the dominance of the asset with superior risk-return performance. The combination of these two stocks results in a portfolio expected return of 1.333% and a risk level of 8.43%, which is categorized as moderate risk. These findings demonstrate that the Markowitz approach can generate a more efficient portfolio through asset combination, although the benefits of diversification are not fully optimized due to the positive covariance between the two stocks.

From a scientific perspective, the study's findings indicate that the relationship between risk and return is not always linear, particularly for stocks with emerging market characteristics (such as EMDEs). This suggests potential market inefficiencies and highlights the limitations of classical models in capturing complex market dynamics. Nevertheless, the Mean-Variance approach remains relevant as a foundational framework for investment decision-making. However, the study has several limitations, including a sample size restricted to only two assets, the use of historical data that may not fully reflect future conditions, and the failure to account for external factors, such as macroeconomic conditions, market liquidity, or corporate fundamentals, that can significantly influence risk and return.

Recommendations

Based on these findings and limitations, it is recommended that future research expand the number of assets in the portfolio to derive a more representative efficient frontier and incorporate more complex models, such as multi-factor models or machine learning-based approaches, to enhance the accuracy of risk and return estimates. Furthermore, investors are advised not to focus solely on high returns but also to consider the stability and contribution of each asset to the overall portfolio. The inclusion of assets with low or negative correlations should also be considered to improve diversification effectiveness and optimize the reduction of portfolio risk.

DAFTAR PUSTAKA

Bodie, Z., Kane, A., & Marcus, A. J. (2018). *Investment* (Eleventh). New York: McGraw-Hill Education.

Boyd, S., Johansson, K., Kahn, R., Schiele, P., & Schmelzer, T. (2024). Markowitz Portfolio Construction at Seventy. *Journal of Portfolio Management*, *50*(8), 117–160. https://doi.org/10.3905/jpm.2024.50.8.117

Budiandriani, B., Sarira, W. T., Nurhasimah, N., Manjas, S. Z. M., & Rafiuddin, R. (2025). Optimal Portfolio Analysis Using the Markowitz Model: A Case Study in Mining Industry Companies Listed on the Indonesia Stock Exchange. *Jurnal Ilmu Akuntansi*, *7*(2), 184–194. Retrieved from https://journal.unismuh.ac.id/index.php/invoice

Ehrmann, M., & Fratzscher, M. (2005). Equal size, equal role? Interest rate interdependence between the euro area and the United States. *The Economic Journal*, *115*(506), 928–948. https://doi.org/10.1111/j.1468-0297.2005.01025.x

Elton, E. J., Gruber, M. J., & Stephen J. Brown. (2014). *Modern Portfolio Theory and Investment Analysis* (9th ed.). New York: John Wiley & Sons.

IDNFinancial. (2025). PT Metrodata Electronics Tbk [MTDL]. Retrieved May 10, 2025, from https://www.idnfinancials.com/MTDL/PT-Metrodata-Electronics-Tbk

IDNFinancials. (2025). PT. Megapolitan Developments Tbk [EMDE]. Retrieved June 1, 2026, from https://www.idnfinancials.com/id/EMDE/PT-Megapolitan-Developments-Tbk

Jeleskovic, V., Latini, C., Younas, Z. I., & Al-Faryan, M. A. S. (2024). Cryptocurrency portfolio optimization: Utilizing a GARCH-copula model within the Markowitz framework. *Journal of Corporate Accounting & Finance*, *35*(4), 139–155. https://doi.org/10.1002/jcaf.22721

Lee, K. S., & Karim, Z. A. (2025). Monetary policy and sectoral stock market in Malaysia. *Economic Journal of Emerging Markets*, *17*(2), 157–177. https://doi.org/10.20885/ejem.vol17.iss2.art4

Lesmana, A. S., Ganefi, H. S., & Muttaqien, D. D. (2025). A Hybrid Model for Stock Portfolio Selection: Mean-Value-at-Risk with Ant Colony Optimization. *Indonesian Journal of Business and Economics*, *8*(1), 1037–1051. https://doi.org/https://doi.org/10.25134/a3r24789

Lesmana, A. S., & Maulana, Y. (2025). Analisis Portofolio Saham. *WORKSHEET : Jurnal Akuntansi*, *4*(2), 249–261. https://doi.org/https://doi.org/10.46576/wjs.v4i2.6275

Lesmana, A. S., Wiharno, H., Maulana, Y., Supriatna, O., & Rahmantya, Y. E. K. (2024). Prediktor Kinerja IHSG dengan Pendekatan Error Correction Model. *Equilibrium: Jurnal Penelitian Pendidikan Dan Ekonomi*, *21*(01), 113–124. Retrieved from https://journal.uniku.ac.id/index.php/Equilibrium

Levine, R. (1997). Financial Development and Economic Growth: Views and Agenda. *Journal of Economic Literature*, *35*(2), 688–726.

Lolic, M. (2024). Practical Improvements to Mean-Variance Optimization for Multi-Asset Class Portfolios. *Journal of Risk and Financial Management*, *17*(5), 1–11. https://doi.org/10.3390/jrfm17050183

Mandal, P. K., & Thakur, M. (2024). Higher-order moments in portfolio selection problems: A comprehensive literature review. *Expert Systems with Applications*, *238*, 121625. https://doi.org/10.1016/j.eswa.2023.121625

Markowitz, H. (1952). PORTFOLIO SELECTION. *The Journal of Finance*, *7*(1), 77–91. https://doi.org/10.1111/j.1540-6261.1952.tb01525.x

Nabila, A., Lorenza, A., Az-Zahra, F. G., & Yusmaniarti, Y. (2025). Efisiensi Portofolio dengan Teori Markowitz: Studi pada Saham Blue Chip Indonesia. *Journal of Islamic Economics and Finance (JoIEaF)*, *2*(2), 331–342. https://doi.org/https://doi.org/10.70248/joieaf.v2i2.3323

Ridwanudin, O., & Sari, M. (2023). Penerapan Model Markowitz dalam Memperoleh Portofolio Optimal di Pasar Saham IDX30. *Image : Jurnal Riset Manajemen*, *11*(1), 118–129. https://doi.org/10.17509/image.2023.011

Sequeira, J. M. (2021). Monetary policy surprises, stock returns, and financial and liquidity constraints, in an exchange rate monetary policy system. *The Quarterly Review of Economics and Finance*, *81*, 226–236. https://doi.org/10.1016/j.qref.2021.06.005

Shkolnik, A., Kercheval, A., Gurdogan, H., Goldberg, L. R., & Bar, H. (2025). Portfolio selection revisited. *Annals of Operations Research*, *346*(1), 137–155. https://doi.org/10.1007/s10479-024-06340-7

Waluyo, D. E., Ramasamy, S., & Jamilah, S. F. (2025). Portfolio optimization using mean-variance model and single index model: Evidence from Indonesian and Malaysian

capital markets. *Asian Economic and Financial Review*, *15*(11), 1731–1747. https://doi.org/10.55493/5002.v15i11.5662

Wu, Z., Xie, G., Ge, Z., & Simone, V. De. (2024). Nonconvex multi-period mean-variance portfolio optimization. *Annals of Operations Research*, *332*(1–3), 617–644. https://doi.org/10.1007/s10479-023-05524-x

Yusan, B. O., & Riyadi, S. (2024). Portfolio Optimization: Application and Comparison of Markowitz Model and Single Index Model on LQ45 Stocks in Indonesia Stock Exchange. *International Journal of Management Science and Application*, *3*(1), 57–85. https://doi.org/10.58291/ijmsa.v3i1.210