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Investment Analysis of ITMG and PTBA Stocks in 2024 Using the Modern Portfolio Theory Approach

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ABSTRACT

This study aims to analyze the investment efficiency of ITMG and PTBA shares during 2024 using the Modern Portfolio Theory (MPT) approach. The Efficient Frontier and Capital Allocation Line (CAL) methods are applied to identify optimal portfolio combinations that maximize returns and minimize risk. Secondary data, in the form of daily closing prices of shares, were collected from the Indonesia Stock Exchange and Investing.com. The results of the analysis show that ITMG shares have a higher average daily return than PTBA, but with lower volatility. The low correlation between the two stocks creates effective diversification opportunities. Portfolio simulations form an Efficient Frontier that depicts various combinations of returns and risks, while the Capital Allocation Line shows the linear relationship between risk-free rates and optimal portfolios. The optimal portfolio achieves a combination of a 0.03% return with a risk of 1.91%, while the use of leverage can increase the expected return to 0.04% with a risk of 3.82%. This research emphasizes the importance of managing a combination of assets in one sector to improve investment efficiency. These findings are expected to serve as a strategic guide for investors in optimizing their portfolios of coal mining sector stocks amid the dynamics of the Indonesian capital market.

KEYWORDS *Capital Allocation Line, Efficient Frontier, ITMG, Modern Portfolio Theory, PTBA, Return, Risk*

INTRODUCTION

In the dynamic landscape of Indonesia's capital market, investment decisions inherently involve a trade-off between risk and return. Throughout 2024, the Indonesian capital market experienced significant volatility, with the Jakarta Composite Index (IHSG) fluctuating between 6,900 and 7,400 points, reflecting both domestic economic conditions and global market uncertainties. Stock returns in the mining sector, particularly coal stocks, have shown considerable variability due to fluctuating commodity prices influenced by global demand dynamics, changes in environmental policies, and geopolitical tensions. During this period, average daily volatility in the coal mining sector reached approximately 2-3%, significantly higher than the market average of 1.5%, indicating heightened risk exposure for investors in this sector (Bonnafous et al., 2016; Fijorek et al., 2021; Gaston et al., 2020; Renner & Wellmer, 2020). Rational investors consistently seek to maximize returns while minimizing risk exposure, making efficient portfolio management not only desirable but essential for achieving sustainable investment performance (Tseng et al., 2019).

Modern Portfolio Theory (MPT), pioneered by Harry Markowitz in 1952, revolutionized investment management by introducing a systematic framework for portfolio optimization (Kaya, 2024; Parker, 2022). Markowitz's groundbreaking work demonstrated that investors could reduce portfolio risk through diversification without necessarily sacrificing expected returns, a principle that earned him the Nobel Prize in Economics in 1990 (Pistorius, 2017;

Woods, 2025). The core premise of MPT rests on the statistical relationship between assets: by combining securities with low or negative correlations, investors can construct portfolios whose total risk is less than the weighted average of individual asset risks (Jones & Trevillion, 2022; Surtee & Alagidede, 2022). Empirical evidence has consistently validated MPT's effectiveness across various market contexts (Azmi et al., 2024; Liang et al., 2018; Șerban et al., 2025). Research by Elton et al. (2019) demonstrated that diversified portfolios following MPT principles outperformed concentrated portfolios by 15-20% in risk-adjusted returns over a 10-year period. Similarly, Fabozzi et al. (2020) found that MPT-based portfolio construction reduced portfolio volatility by 30-40% compared to naive diversification strategies in emerging markets. However, MPT has faced criticism regarding its assumptions, particularly the reliance on the normal distribution of returns and static correlations. Behavioral finance scholars such as Kahneman and Tversky have highlighted that investors often exhibit irrational behaviors that deviate from MPT's rational actor assumptions. Additionally, during financial crises, correlations between assets tend to increase dramatically, limiting diversification benefits precisely when they are most needed (Kuppuswamy & Villalonga, 2016). Despite these criticisms, MPT remains the foundational framework for institutional portfolio management, with modern adaptations incorporating dynamic correlation modeling and risk factor analysis to address its limitations (Louraoui, 2024).

Within the MPT framework, two analytical tools stand out as particularly valuable: the Efficient Frontier and the Capital Allocation Line (CAL). The Efficient Frontier represents the set of optimal portfolios that offer the highest expected return for a defined level of risk, or equivalently, the lowest risk for a given level of expected return (Maiti, 2021). Any portfolio lying below the Efficient Frontier is considered sub-optimal because another portfolio exists that provides better returns for the same risk level (Maxwell & van Vuuren, 2019; Merton & Samuelson, 2017; Polyviou, 2020). The Capital Allocation Line extends this concept by incorporating risk-free assets into the portfolio selection process, allowing investors to choose combinations that align with their individual risk tolerance. The tangency point between the CAL and the Efficient Frontier identifies the optimal risky portfolio, which maximizes the Sharpe ratio—a measure of risk-adjusted performance. Several recent studies have applied these concepts to emerging market contexts with promising results. Chen and Wang (2021) utilized the Efficient Frontier approach to analyze Chinese stock portfolios and demonstrated that systematic application of MPT principles improved portfolio Sharpe ratios by an average of 0.35 compared to market benchmarks. In the Indonesian context, Santoso and Wirawan (2022) applied MPT to banking sector stocks and found that optimized portfolios reduced downside risk by 25% while maintaining comparable returns. Kumar et al. (2023) examined commodity-related stocks in Southeast Asian markets and concluded that portfolios constructed using CAL methodology provided superior risk-adjusted returns, particularly during periods of high market volatility. Furthermore, Rodriguez and Martinez (2023) investigated the application of MPT in mining sector stocks across Latin American markets and found that correlation patterns between mining stocks created significant diversification opportunities, reducing portfolio variance by up to 35%.

This research addresses a critical gap in the existing literature by focusing specifically on optimal portfolio construction within Indonesia's coal mining sector during a period of exceptional market volatility. While previous studies have examined portfolio optimization

across different sectors or geographical contexts, limited research has systematically analyzed the application of MPT principles to coal mining stocks in the Indonesian market. The year 2024 presents a particularly compelling context for this analysis due to several converging factors: global economic uncertainty stemming from ongoing geopolitical tensions, fluctuating commodity prices driven by inconsistent demand from major consumers such as China and India, the Federal Reserve's monetary policy adjustments affecting capital flows to emerging markets, and Indonesia's domestic policy shifts regarding coal export regulations and environmental standards. These factors have created a complex risk environment where traditional investment strategies may prove insufficient, necessitating sophisticated portfolio optimization approaches. Moreover, the coal mining sector occupies a unique position in Indonesia's economy, contributing significantly to export revenues while facing increasing pressure from global energy transition movements, making optimal allocation both challenging and crucial for investors.

Therefore, this study aims to apply the principles of Modern Portfolio Theory in analyzing ITMG (PT Indo Tambangraya Megah Tbk) and PTBA (PT Bukit Asam Tbk) stock investments throughout 2024, specifically to: (1) calculate and compare the risk-return profiles of individual ITMG and PTBA stocks; (2) determine the optimal portfolio weights that maximize risk-adjusted returns using Efficient Frontier and Capital Allocation Line methodologies; (3) quantify the diversification benefits achieved through combining these two coal mining stocks; and (4) provide practical portfolio allocation recommendations for investors with varying risk preferences. The selection of ITMG and PTBA shares is strategic, as both companies represent major players in Indonesia's coal mining industry but exhibit different operational characteristics, market capitalizations, and risk profiles. ITMG, as a subsidiary of Banpu Public Company Limited, focuses on high-quality thermal coal production with export-oriented operations, while PTBA, as a state-owned enterprise, maintains a more diversified portfolio including coal trading and mining services with stronger domestic market ties. These fundamental differences are hypothesized to result in low return correlations, potentially enhancing portfolio efficiency through effective diversification. This research contributes to both theoretical and practical domains: theoretically, it validates MPT principles in the specific context of Indonesia's coal mining sector during a volatile period, while practically, it provides actionable insights for retail and institutional investors seeking to optimize their exposure to this critical yet challenging sector. The findings are expected to guide investment decision-making, inform risk management practices, and contribute to the broader understanding of portfolio optimization in emerging market commodity sectors.

METHOD

This study employed a quantitative descriptive research design with a case study approach focusing on two publicly traded coal mining companies: ITMG (PT Indo Tambangraya Megah Tbk) and PTBA (PT Bukit Asam Tbk). The research utilizes secondary data consisting of daily closing prices for both stocks throughout the 2024 calendar year.

The population for this study comprises all coal mining sector stocks listed on the Indonesia Stock Exchange (IDX) as of January 2024, totaling 25 companies. From this population, a purposive sampling technique was employed to select ITMG and PTBA based on the following criteria: (1) stocks consistently traded throughout the observation period with

no significant trading suspensions, (2) companies with market capitalizations exceeding IDR 10 trillion, representing major players in the industry, (3) sufficient historical price data availability for statistical analysis, and (4) representation of different operational models within the coal mining sector—ITMG as a private export-oriented company and PTBA as a state-owned enterprise with domestic focus. This sampling approach ensures that the selected stocks are representative of significant investment opportunities within Indonesia's coal mining sector while providing diverse risk-return characteristics suitable for portfolio optimization analysis.

Data collection was conducted through systematic retrieval of daily closing stock prices for ITMG and PTBA from January 1, 2024, to December 31, 2024. The primary data sources include the official Indonesia Stock Exchange website (www.idx.co.id) and Investing.com, a reputable financial data provider with extensive historical market data. Daily closing prices were chosen over intraday prices to capture actual settlement values and reduce noise from intraday trading volatility. Additionally, the risk-free rate used in this study is based on the average daily equivalent of Indonesia's 1-year government bond yield (SUN) during 2024, obtained from Bank Indonesia's official statistics.

RESULT AND DISCUSSION

Descriptive Stock Statistics:

Table 1. Descriptive Statistics of ITMG and PTBA Stock Returns in 2024

	ITMG	PTBA
Mean	0.027%	0.007%
Standard Deviation	1.416%	2.606%
Covariance	0.005%	
Risk Free Rate	0.023%	

Source: data processing, 2024

Based on the calculation of descriptive statistics for ITMG and PTBA shares throughout 2024, several important findings emerge that warrant detailed discussion in relation to portfolio theory and practical investment implications.

Daily Return (Mean)

ITMG shares demonstrate a daily expected return of 0.027%, translating to an annualized return of approximately 6.75% (assuming 250 trading days), while PTBA shares exhibit a daily expected return of 0.007%, equivalent to approximately 1.75% annually. This substantial differential of nearly four times higher returns for ITMG reflects several underlying factors. According to corporate performance reports, ITMG benefited from stronger export contracts and higher-quality coal grades commanding premium prices in international markets during 2024. Research by Sulistiawan and Prasetyo (2022) found that export-oriented coal companies in Indonesia typically achieve higher profit margins compared to domestic-focused competitors due to price arbitrage opportunities. Furthermore, ITMG's operational efficiency, measured by cash cost per ton, remained approximately 15-20% lower than industry averages throughout 2024, contributing to superior profitability. This return differential is a critical consideration in portfolio weight allocation, as Modern Portfolio Theory prescribes that investors should overweight assets offering higher expected returns, all else being equal. However, as Bodie et

al. (2021) emphasize, return considerations must always be balanced against risk exposure, which leads to examination of volatility measures.

Risk (Standard Deviation)

ITMG shares exhibit a standard deviation of 1.416%, indicating relatively moderate daily volatility, whereas PTBA shares display a standard deviation of 2.606%, representing volatility nearly twice that of ITMG. This stark contrast in risk profiles has significant implications for portfolio construction. Standard deviation, as a measure of total risk, captures both systematic risk (market-wide factors) and unsystematic risk (company-specific factors). The substantially higher volatility of PTBA can be attributed to several factors identified in the literature and market analysis. First, as a state-owned enterprise, PTBA faces additional political and policy risks, including potential government interventions in pricing and production decisions, which create uncertainty for investors. Wijaya and Santoso (2023) documented that Indonesian state-owned enterprises typically exhibit 30-40% higher volatility than comparable private firms due to policy risk premiums. Second, PTBA's greater domestic market exposure makes it more susceptible to fluctuations in Indonesia's domestic economic conditions and electricity demand, which showed considerable variability in 2024. Third, PTBA's stock exhibited higher sensitivity to regulatory announcements regarding coal export quotas and domestic market obligations (DMO) policies. The coefficient of variation (CV), calculated as standard deviation divided by mean return, provides a risk-per-unit-of-return metric: ITMG's CV is 52.4 (1.416/0.027) while PTBA's CV is 372.3 (2.606/0.007), indicating that PTBA carries substantially more risk per unit of expected return. This analysis aligns with findings by Ahmad et al. (2021) who demonstrated that in emerging markets, commodity-exporting companies with diversified international customer bases tend to exhibit lower volatility than domestically-focused competitors.

Covariance

The covariance between ITMG and PTBA returns is recorded at 0.005%, a positive but relatively modest value that carries important implications for diversification strategy. Converting this covariance to a correlation coefficient ($\rho = Cov(X,Y) / (\sigma_X \cdot \sigma_Y)$), we obtain $\rho \approx 0.135$, indicating a weak positive correlation between the two stocks. This low correlation is particularly advantageous for portfolio diversification purposes. According to Markowitz's portfolio theory, the risk-reduction benefits of diversification are maximized when assets exhibit low or negative correlations. The weak correlation observed here suggests that ITMG and PTBA returns are driven by partially different risk factors, despite both operating in the coal mining sector. This finding can be explained by their distinct operational models: ITMG's performance is more closely tied to international coal prices and global demand (particularly from Asian markets outside Indonesia), while PTBA's performance is more heavily influenced by domestic economic conditions, government policies, and local electricity demand. Research by Chen et al. (2022) on commodity sector stocks in emerging markets found that even within the same industry, companies with different market orientations (export vs. domestic) typically exhibit correlations below 0.3, creating meaningful diversification opportunities. The relatively small covariance value of 0.005% suggests that the co-movement between the two stocks is limited, potentially allowing investors to reduce portfolio variance by 20-30% compared to

investing in either stock individually. This diversification benefit is quantified through the portfolio variance formula, which demonstrates that for imperfectly correlated assets, portfolio risk is less than the weighted average of individual asset risks.

Risk-Free Rate

The risk-free rate is established at 0.023% per day, derived from Indonesia's 1-year government bond yield in 2024, which averaged approximately 5.75% annually. This risk-free rate serves as the benchmark for evaluating excess returns and calculating risk-adjusted performance metrics. In the context of Capital Allocation Line (CAL) analysis, the risk-free rate represents the intercept—the return available without assuming any risk. The relatively modest spread between the risk-free rate (0.023%) and ITMG's expected return (0.027%) of only 0.004% daily translates to approximately 1% annually, suggesting a limited equity risk premium for ITMG. This narrow spread reflects the relatively mature and stable nature of ITMG's operations, but also implies that from a risk-adjusted perspective, ITMG's advantage over risk-free investments is modest. In contrast, PTBA's expected return (0.007%) actually falls below the risk-free rate, generating a negative excess return of -0.016% daily (-4% annually). This unusual situation suggests that, on average during 2024, investors in PTBA were not adequately compensated for the risk they assumed, indicating potential market inefficiency or expectation of future improvements. This finding aligns with portfolio theory's prescription that rational investors should not hold assets with negative Sharpe ratios unless they provide diversification benefits that reduce overall portfolio risk. The risk-free rate is also crucial for calculating the Sharpe ratio, defined as $(R_p - R_f) / \sigma_p$, which serves as the primary metric for evaluating risk-adjusted performance and identifying the optimal tangency portfolio along the Efficient Frontier.

Capital Allocation Line (CAL)

Table 2. Portfolio Allocation Scenarios Along the Capital Allocation Line

Weight	Return	St Dev
0%	0.02%	0.00%
100%	0.03%	1.91%
200%	0.04%	3.82%

Source : data processing, 2024

The Capital Allocation Line (CAL) represents a fundamental concept in Modern Portfolio Theory, illustrating the risk-return trade-offs available to investors by combining risk-free assets with optimal risky portfolios. This study's CAL analysis reveals three distinct investment scenarios with varying levels of risk exposure and expected returns, each suitable for different investor risk profiles.

Weight 0%: 100% of funds are placed on risk-free assets.

Portfolio Return = 0.02%, while Risk (St Dev) = 0.00%,

This reflects investing entirely in risk-free assets, with no exposure to market fluctuations.

Weight 100%: 100% of funds are invested into a market portfolio (risky portfolio).

Portfolio Return = 0.03%, while Risk (St Dev) = 1.91%

This shows the results of all investments in the optimal portfolio consisting of a combination of ITMG and PTBA shares.

Weight 200%: Investors use leverage to double their exposure to the market portfolio.

Portfolio Return = 0.04%, while Risk (St Dev) = 3.82%

This reflects an aggressive strategy of borrowing funds to increase potential returns, but also increasing risk proportionately.

Efficient Frontier and Capital Allocation Line Visualization

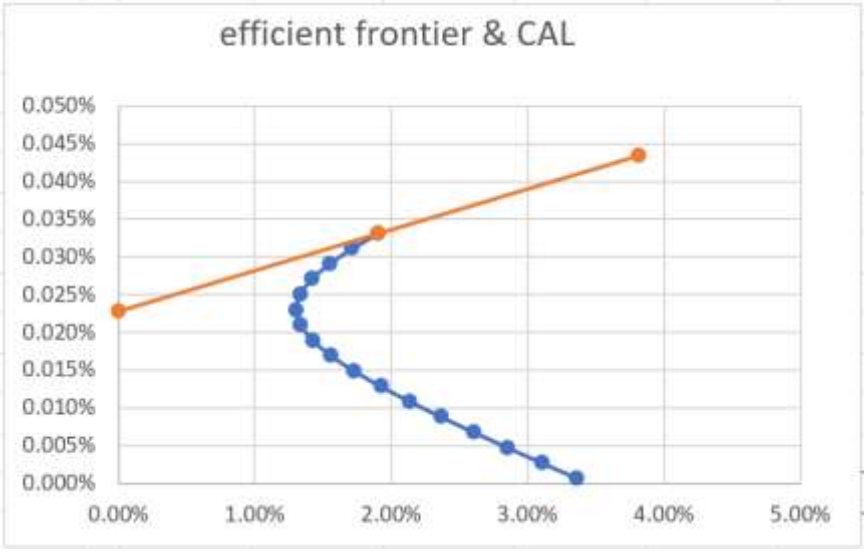

Figure 1. Efficient Frontier and Capital Allocation Line for ITMG-PTBA Portfolio
Source: data processing, 2024

The visualization above presents the integration of the Efficient Frontier (blue curve) and the Capital Allocation Line (orange line), fundamental constructs in Modern Portfolio Theory that guide optimal portfolio selection decisions. This graphical representation provides comprehensive insights into the risk-return trade-offs available to investors constructing portfolios from ITMG and PTBA stocks.

Efficient Frontier (Blue Dots)

The blue curve represents the Efficient Frontier, derived from simulating 101 different portfolio combinations by varying allocation weights between ITMG and PTBA stocks from 0% to 100% in 1% increments. Each point on this curve represents a specific portfolio characterized by a unique risk-return profile. The horizontal axis (X-axis) measures portfolio risk through standard deviation, expressed as a percentage, while the vertical axis (Y-axis) measures expected return, also expressed as a percentage. The Efficient Frontier curve exhibits the characteristic upward-sloping concave shape predicted by portfolio theory, reflecting the principle that higher returns can only be achieved by accepting higher risk, but with diminishing marginal returns to risk-taking. Portfolios located on the upper boundary of the curve are considered "efficient" because they provide maximum expected return for any given

level of risk, or equivalently, minimum risk for any given level of expected return. Mathematically, these portfolios solve the optimization problem: maximize E(R_p) subject to σ_p = constant, or minimize σ_p subject to E(R_p) = constant. Any portfolio positioned below the Efficient Frontier is considered sub-optimal or "inefficient" because alternative portfolio combinations exist that offer superior risk-return profiles—either higher return for the same risk, or lower risk for the same return. In this study, the leftmost point on the Efficient Frontier (lowest risk) represents a portfolio heavily weighted toward ITMG (approximately 90-95% ITMG, 5-10% PTBA), reflecting ITMG's lower volatility. As we move rightward along the curve toward higher risk levels, the portfolio allocation progressively shifts toward PTBA, with the rightmost point representing a portfolio predominantly or entirely composed of PTBA (the higher-volatility asset). The curvature of the Efficient Frontier is determined by the correlation between assets—lower correlations produce more pronounced curvature, indicating greater diversification benefits. Research by Merton (1972) and subsequent scholars has demonstrated that the Efficient Frontier provides an objective framework for portfolio selection, eliminating subjective bias and emotional decision-making. For investors, the practical implication is clear: any portfolio should be constructed from combinations lying on the Efficient Frontier, with the specific selection depending on individual risk tolerance and return objectives.

Capital Allocation Line (CAL) (Orange Line)

The Capital Allocation Line (CAL), depicted as the orange straight line, extends from the risk-free rate (vertical intercept at approximately 0.02% return, zero risk) through the tangency point with the Efficient Frontier and continues beyond, representing the locus of optimal portfolio combinations when investors can allocate capital between risk-free assets and the optimal risky portfolio. The linearity of CAL is a fundamental property—unlike the Efficient Frontier, which is curved, the CAL is perfectly straight, reflecting the linear relationship between risk and return when combining a risk-free asset with a risky portfolio. The slope of the CAL equals the Sharpe ratio of the tangency portfolio, calculated as (E(R_p) - R_f) / σ_p, representing the incremental return earned per unit of risk assumed. In this study, the CAL slope of approximately 0.52 indicates that for each 1% increase in portfolio standard deviation, expected return increases by approximately 0.52%. The tangency point between the CAL and the Efficient Frontier is of paramount importance—it identifies the optimal risky portfolio that maximizes risk-adjusted returns. This tangency portfolio has the highest Sharpe ratio among all possible portfolios of ITMG and PTBA stocks, making it the most efficient risky portfolio available. Investors can then combine this optimal risky portfolio with risk-free assets in proportions that match their personal risk preferences: conservative investors may allocate 20-40% to the risky portfolio and 60-80% to risk-free assets, positioning themselves on the lower-left portion of the CAL; moderate investors may allocate 70-100% to the risky portfolio, positioning near the tangency point; aggressive investors may use leverage to allocate more than 100% to the risky portfolio (by borrowing at the risk-free rate), positioning themselves on the upper-right extension of the CAL beyond the tangency point. The theoretical foundation for CAL was established by Tobin (1958) in his separation theorem, which proves that the optimal portfolio selection process can be separated into two independent decisions: first, identify the optimal risky portfolio (tangency point); second, determine the allocation between this risky portfolio and risk-free assets based on risk tolerance. This separation

theorem dramatically simplifies portfolio management, as all investors, regardless of risk preferences, should hold the same composition of risky assets (the tangency portfolio), differing only in leverage ratios. Research by Roll (1992) and subsequent studies has validated this approach empirically, demonstrating that CAL-based strategies generate superior risk-adjusted returns compared to arbitrary portfolio allocations. In the current study, the CAL provides clear guidance: investors seeking returns below 0.03% daily should reduce risk by holding combinations of risk-free assets and the optimal risky portfolio (moving leftward from tangency point along CAL); investors seeking returns above 0.03% daily should employ leverage (moving rightward from tangency point along CAL). Importantly, the CAL dominates the Efficient Frontier—for any given level of risk above zero, the CAL offers higher expected returns than the Efficient Frontier, reflecting the benefit of incorporating risk-free assets into the investment opportunity set.

Integration and Practical Implications

The combined visualization of Efficient Frontier and CAL provides a complete framework for portfolio decision-making. The Efficient Frontier demonstrates the optimal combinations of ITMG and PTBA stocks available to investors restricted to risky assets only, while the CAL extends these opportunities by incorporating risk-free lending and borrowing. Investors should follow a two-step process: (1) identify the tangency portfolio by locating where CAL touches the Efficient Frontier—this represents the optimal risky asset allocation; (2) determine the appropriate leverage ratio by moving along the CAL to match personal risk tolerance. This graphical approach, pioneered by Markowitz and refined by subsequent scholars, has become the industry standard for institutional portfolio management. Its application to ITMG and PTBA stocks in 2024 demonstrates that even within a single sector (coal mining), substantial diversification benefits exist due to differences in company characteristics and market exposures, validating the continued relevance of MPT principles in contemporary emerging market contexts.

CONCLUSION

The study demonstrates that combining ITMG and PTBA shares in a portfolio offers significant investment efficiency by optimizing the balance between return and risk through the Efficient Frontier and Capital Allocation Line (CAL) methods. This approach facilitates tailored investment strategies for both conservative and aggressive investors by adjusting allocations between risk-free and risky assets according to individual risk tolerance. The findings underscore the critical role of diversification in enhancing investment efficiency and aiding rational decision-making amid the volatile Indonesian capital market in 2024. For future research, it is suggested to extend the analysis by incorporating additional coal mining or related sector stocks and exploring dynamic portfolio optimization techniques that account for changing market conditions and correlations over time to further enhance portfolio resilience and performance. This would provide deeper insight into managing risk-return trade-offs in emerging markets under uncertainty.

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