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OPTIMIZING RETURNS IN A CHALLENGING MARKET: AN APPLICATION OF THE MEAN-VARIANCE MODEL ON THE INDONESIAN LQ45 INDEX

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Abstract

The rapid growth of retail investors in Indonesia, from 2.48 million in 2019 to over 20 million by 2025, underscores an urgent need for empirically grounded portfolio optimization frameworks adoptable into practical tools such as robo-advisory systems. This study applies the Markowitz Mean-Variance model to construct and evaluate an optimal stock portfolio from the LQ45 index over January 2022 to December 2025, a post-pandemic period characterized by predominantly adverse risk-adjusted returns. Using daily closing price data for 27 consistently listed LQ45 stocks (958 trading days) from the Indonesia Stock Exchange (IDX), with sample consistency verified through official BEI constituent evaluation announcements, this study constitutes an ex-post empirical analysis designed to isolate the mathematical efficacy of the Mean-Variance model under adverse market conditions. The analysis encompasses individual return and risk profiling, construction of a 27x27 covariance matrix, efficient frontier derivation via constrained quadratic optimization using Microsoft Excel Solver (GRG Nonlinear), and Sharpe ratio-based performance evaluation against a risk-free rate of 5.3281% per annum (average BI Rate 2022-2025). The core finding is that 19 of 27 sample stocks (70.4%) generated negative Sharpe ratios, confirming the inadequacy of undiversified single-stock strategies in adverse markets. In contrast, the tangency portfolio achieved a Sharpe ratio that materially surpasses all 27 individual stocks, establishing that quantitative portfolio optimization delivers superior risk-adjusted outcomes precisely when markets are most challenging. These results validate the enduring relevance of Modern Portfolio Theory in Indonesia's capital market and provide a transparent, replicable framework for investors and practitioners.

Keywords: Portfolio Optimization, Mean-Variance Model, LQ45, Sharpe Ratio, Efficient Frontier

INTRODUCTION

The Indonesian capital market has undergone a remarkable transformation over the past six years. Data from PT Kustodian Sentral Efek Indonesia (KSEI) records that the number of registered investors surged from approximately 2.48 million at end-2019 to over 20 million by mid-2025, an eightfold increase in just six years. This surge has been driven by the proliferation of user-friendly trading applications, streamlined investor registration, and aggressive financial literacy campaigns targeting millennials and Generation Z.

Behind this positive trend, the Indonesian capital market experienced heightened volatility throughout 2022-2025. The period was marked by the post-COVID recovery trajectory, the European energy crisis triggered by Russia's invasion of Ukraine (which selectively boosted commodity prices), aggressive global interest rate tightening, and structural weakening of domestic purchasing power across multiple sectors. These dynamics created an asymmetric return environment: while energy and petrochemical stocks surged, large portions of the market delivered sub-risk-free-rate returns. Empirically, 19 of the 27 consistently listed LQ45 stocks

examined in this study recorded negative Sharpe ratios during this period, confirming the challenging nature of the investment landscape.

Modern Portfolio Theory (MPT), developed by Harry Markowitz (1952), provides the formal mathematical framework to navigate such complexity. MPT demonstrates that by combining assets whose returns are imperfectly correlated, an investor can reduce total portfolio risk without proportionally sacrificing returns. Crucially, while MPT was originally conceived for sophisticated institutional investors, the proliferation of computing tools and robo-advisory platforms means its underlying optimization logic is increasingly deployable at the retail level, making its empirical validation in the Indonesian context both timely and practically relevant. The LQ45 Index, administered by the Indonesia Stock Exchange (IDX), comprises 45 stocks with the highest liquidity and largest market capitalization, and is evaluated quarterly since April 2024 (previously semi-annually).

This study contributes to the literature in three ways. First, it provides an ex-post empirical analysis of the 2022-2025 post-pandemic period in which the majority of LQ45 blue-chip stocks delivered risk-adjusted returns below the risk-free rate. This adversarial setting constitutes the core selling point of the study: demonstrating that MPT remains efficacious precisely when markets are most challenging, a finding with direct implications for the adoption of quantitative optimization in robo-advisory and algorithmic investment systems. Second, the 27-stock sample was constructed through purposive sampling with consistency verified through direct inspection of official BEI constituent evaluation announcements. Third, the full analytical procedure is implemented using Microsoft Excel Solver (GRG Nonlinear), making it transparent, auditable, and directly replicable by practitioners without specialized programming tools.

LITERATURE REVIEW AND HYPOTHESIS FORMULATION

Capital Markets and Investment

Capital markets serve as intermediaries connecting investors with surplus funds and issuers in need of capital, facilitating the trading of long-term financial instruments (Tandelilin, 2017). Market efficiency, as outlined by Husnan (2015), requires that security prices reflect all available information rapidly and accurately. Hartono (2022) classifies investment into real assets and financial securities, the latter including equities traded on exchanges such as the IDX.

Stock Returns and Risk

The daily logarithmic return of an individual stock is defined as:

$$R_{i,t} = \ln(P_{i,t} / P_{i,t-1}) \quad (1)$$

Where Pi,t is the closing price of stock i on day t. The annualized expected return E(Ri) equals the mean daily log return multiplied by 252 trading days. Annualized standard deviation (sigma_i) equals the daily standard deviation multiplied by sqrt(252). A higher standard deviation denotes greater return uncertainty (Elton et al., 2014).

Modern Portfolio Theory and the Mean-Variance Model

Markowitz (1952) demonstrated that rational portfolio construction should focus not on individual asset risk, but on each asset's marginal contribution to portfolio risk. The expected portfolio return is:

$$E(R_p) = \Sigma (w_i \times E(R_i)) \quad (2)$$

Portfolio variance, capturing both individual variances and pairwise covariances, is expressed as:

$$\sigma^2_p = \Sigma_i \Sigma_j (wi \times wj \times \sigma_{ij}) = w^T \Sigma w \quad (3)$$

Where the covariance sigma_ij relates to the Pearson correlation rho_ij by:

$$\sigma_{ij} = \rho_{ij} \times \sigma_i \times \sigma_j \quad (4)$$

Diversification benefits increase as rho_ij approaches zero or negative values. Merton (1972) confirmed analytically that the set of efficient portfolios forms a hyperbola in the return-standard deviation space.

The Efficient Frontier and Portfolio Selection

The efficient frontier is obtained by solving the constrained quadratic program:

$$\text{Min } \sigma^2_p = w^T \Sigma w$$
$$\text{Subject to: } E(Rp) = \mu^*, \quad \Sigma wi = 1, \quad wi \geq 0 \text{ for all } i \quad (5)$$

The Sharpe Ratio

Sharpe (1966, 1994) proposed the ratio of excess return per unit of total risk:

$$S = [E(Rp) - Rf] / \sigma_p \quad (6)$$

Where Rf is the risk-free rate, proxied by the average BI Rate of 5.3281% per annum. A higher Sharpe ratio indicates superior risk-adjusted performance (Bodie et al., 2021).

Prior Research and Research Gap

Hasbiah, Anwar, and Bado (2022) applied the Markowitz model to LQ45 stocks (2017-2021) and confirmed that optimized portfolios outperform individual stock investments. Putra and Dana (2020) compared the Single Index Model with the Markowitz model on LQ45 stocks (2017-2020). Meliala and Sukarno (2023) applied the Markowitz model during COVID-19 and achieved a maximum Sharpe ratio of 31.57%, reflecting the post-shock recovery environment of 2020-2021. Nasution and Al-khowarizmi (2025) integrated K-Means clustering with Mean-Variance Optimization using LQ45 data and confirmed that cross-cluster diversification enhances portfolio efficiency. Oktavianus Yusan and Riyadi (2024) compared Markowitz with the Single Index Model on LQ45 data (2016-2021) and found the Markowitz portfolio outperformed both the JCI and LQ45 indices in 2022.

The critical gap in the existing literature is not merely a temporal one. Prior studies have predominantly tested MPT during neutral or recovery market conditions, leaving an open empirical question: does MPT retain its superiority when the majority of blue-chip constituents themselves underperform the risk-free rate? The 2022-2025 post-pandemic period, in which 19 of 27 LQ45 blue-chip stocks generated negative Sharpe ratios, provides precisely this stress-test environment.

Research Proposition

Given the theoretical underpinnings of Modern Portfolio Theory and the empirical evidence from prior studies, this study advances the following research proposition:

P1: A Mean-Variance optimized portfolio constructed from consistently listed LQ45 stocks will generate a higher Sharpe ratio than any individual constituent stock over the period January 2022-December 2025.

This proposition is grounded in Markowitz (1952) diversification theory, which mathematically demonstrates that combining assets with imperfect correlations reduces portfolio variance below the weighted average of individual variances. The proposition is evaluated empirically by comparing the Sharpe ratio of the tangency portfolio against the Sharpe ratios of all 27 individual stocks.

RESEARCH METHODS

Research Design

This study employs a quantitative descriptive-analytical approach. Secondary data obtained from the Indonesia Stock Exchange (IDX) are used to compute returns, risks, covariances, and optimal portfolio weights, with the results compared systematically across all instruments.

Population and Sample

The population comprises all stocks listed on the LQ45 index during the observation period (January 2022 to December 2025). The final sample was selected using purposive sampling based on three requirements: the stock must appear consistently in every LQ45 constituent evaluation throughout the entire observation period; complete daily closing price data must be available with no gaps; and the stock must not have undergone major corporate actions that disrupt price data continuity. Consistency of each stock was verified through direct inspection of all official BEI constituent evaluation announcements published during the observation period, covering all Mayor, Minor, and Fast Entry evaluations from February 2022 through January 2026. It is important to acknowledge that this sampling procedure yields an ex-post stable constituent set: an investor at the beginning of 2022 would not have known in advance which stocks would remain consistently listed throughout 2025. This study is therefore explicitly designed as a retrospective, in-sample analysis to test the mathematical efficacy of the Mean-Variance model on a stable constituent universe. Application of these requirements yielded 27 stocks as the final sample.

Data Sources and Collection

Daily closing price data for all 27 sample stocks from January 3, 2022 to December 30, 2025 (958 trading days) were obtained from the Indonesia Stock Exchange through its official data portal (idx.co.id). The closing prices used reflect adjustments for corporate actions occurring during the observation period. Monthly BI Rate data for the same period were obtained from Bank Indonesia (bi.go.id) to compute the average risk-free rate of 5.3281% per annum.

Operationalization of Variables and Assumptions

Individual stock return Ri,t is calculated per Equation (1). Annualized expected return E(Ri) equals mean daily log return multiplied by 252. Annualized standard deviation (sigma_i) equals daily standard deviation multiplied by sqrt(252). The covariance matrix (Sigma) is annualized by multiplying the daily sample covariance matrix by 252, computed using Excel's COVARIANCE.S function. The risk-free rate Rf is the arithmetic average of monthly BI Rate observations from January 2022 through December 2025 (48 months), yielding 5.3281% per annum (Bank Indonesia, 2025). The Sharpe ratio S is computed per Equation (6). The Mean-Variance model assumes that investors make decisions based on the mean and variance of returns. While daily log returns typically exhibit slight excess kurtosis relative to the normal distribution, this assumption is widely accepted in the empirical portfolio optimization literature (Elton et al., 2014; Bodie et al., 2021).

Data Analysis Procedure

The analysis proceeds in six steps: (1) Data preparation, daily closing prices obtained from the IDX official portal are filtered to exclude non-trading days and verified for completeness across all 27 stocks; (2) Computation of daily log returns per Equation (1) and annualized statistics using Microsoft Excel; (3) Construction of the 27x27 annualized covariance matrix using Excel's COVARIANCE.S function multiplied by 252; (4) Derivation of the efficient frontier by solving Equation (5) for 16 evenly-spaced target return levels spanning the range from the minimum-variance return to 90% of the highest individual stock return, a sufficient number of points to capture a smooth, granular efficient frontier curve for both visual and statistical representation; (5) Identification of the tangency portfolio by configuring Solver to maximize the Sharpe ratio objective function with no target return constraint, using multiple starting weight configurations to reduce sensitivity to local optima; (6) Systematic comparison of the tangency portfolio Sharpe ratio against the Minimum Variance Portfolio and all 27 individual stocks.

RESULTS AND DISCUSSION

Description of the Research Sample

Following the application of purposive sampling requirements verified through official BEI evaluation announcements, 27 stocks were identified as consistently present throughout all LQ45 evaluation periods from January 2022 to December 2025. Table 1 presents the complete sample.

Table 1. LQ45 Stock Samples Consistently Listed — January 2022 to December 2025 (27 Stocks)

No	Code	Company Name	Sector	LQ45 Status
1	ADRO	Adaro Energy Indonesia Tbk.	Energy	Consistent
2	AMRT	Sumber Alfaria Trijaya Tbk.	Consumer	Consistent
3	ANTM	Aneka Tambang Tbk.	Materials	Consistent
4	ASII	Astra International Tbk.	Industrials	Consistent
5	BBCA	Bank Central Asia Tbk.	Financials	Consistent
6	BBNI	Bank Negara Indonesia (Persero) Tbk.	Financials	Consistent
7	BBRI	Bank Rakyat Indonesia (Persero) Tbk.	Financials	Consistent
8	BBTN	Bank Tabungan Negara (Persero) Tbk.	Financials	Consistent
9	BMRI	Bank Mandiri (Persero) Tbk.	Financials	Consistent
10	BRPT	Barito Pacific Tbk.	Materials	Consistent
11	CPIN	Charoen Pokphand Indonesia Tbk.	Consumer	Consistent
12	EXCL	XL Axiata Tbk.	Communication	Consistent
13	ICBP	Indofood CBP Sukses Makmur Tbk.	Consumer	Consistent
14	INCO	Vale Indonesia Tbk.	Materials	Consistent
15	INDF	Indofood Sukses Makmur Tbk.	Consumer	Consistent
16	INKP	Indah Kiat Pulp & Paper Tbk.	Materials	Consistent
17	ITMG	Indo Tambangraya Megah Tbk.	Energy	Consistent
18	KLBF	Kalbe Farma Tbk.	Health Care	Consistent
19	MDKA	Merdeka Copper Gold Tbk.	Materials	Consistent
20	MEDC	Medco Energi Internasional Tbk.	Energy	Consistent
21	PGAS	Perusahaan Gas Negara Tbk.	Energy	Consistent
22	PTBA	Bukit Asam Tbk.	Energy	Consistent
23	SMGR	Semen Indonesia (Persero) Tbk.	Materials	Consistent
24	TLKM	Telkom Indonesia (Persero) Tbk.	Communication	Consistent
25	TOWR	Sarana Menara Nusantara Tbk.	Communication	Consistent
26	UNTR	United Tractors Tbk.	Industrials	Consistent
27	UNVR	Unilever Indonesia Tbk.	Consumer	Consistent

Source: IDX (idx.co.id); BEI official LQ45 constituent evaluation announcements (all Mayor, Minor, and Fast Entry evaluations, February 2022 to January 2026); author's processing.

Individual Stock Return and Risk Analysis

Table 2 presents the annualized return, standard deviation, and Sharpe ratio for each of the 27 sample stocks, calculated from 957 daily log return observations. The risk-free rate is 5.3281% per annum.

Table 2. Individual Stock Return and Risk Statistics (January 3, 2022 to December 30, 2025)

No	Code	Company Name	Daily E(Ri) (%)	Annual E(Ri) (%)	Annual σi (%)	Sharpe Ratio
1	ADRO	Adaro Energy Indonesia Tbk.	-0.0282	-7.0982	46.0638	-0.2698
2	AMRT	Sumber Alfaria Trijaya Tbk.	0.0495	12.4698	38.5382	0.1853
3	ANTM	Aneka Tambang Tbk.	0.0311	7.8273	42.7475	0.0585
4	ASII	Astra International Tbk.	0.0164	4.1411	27.6114	-0.0430
5	BBCA	Bank Central Asia Tbk.	0.0102	2.5669	23.3287	-0.1184
6	BBNI	Bank Negara Indonesia (Persero) Tbk.	0.0274	6.9011	30.0387	0.0524
7	BBRI	Bank Rakyat Indonesia (Persero) Tbk.	-0.0139	-3.4982	28.9011	-0.3054
8	BBTN	Bank Tabungan Negara (Persero) Tbk.	-0.0446	-11.2312	33.7848	-0.4901
9	BMRI	Bank Mandiri (Persero) Tbk.	0.0386	9.7261	30.2424	0.1454
10	BRPT	Barito Pacific Tbk.	0.1396	35.1697	57.8370	0.5160
11	CPIN	Charoen Pokphand Indonesia Tbk.	-0.0290	-7.2965	31.9369	-0.3953
12	EXCL	XL Axiata Tbk.	0.0179	4.5077	34.9406	-0.0235
13	ICBP	Indofood CBP Sukses Makmur Tbk.	-0.0053	-1.3306	26.6042	-0.2503
14	INCO	Vale Indonesia Tbk.	0.0087	2.2012	45.2712	-0.0691
15	INDF	Indofood Sukses Makmur Tbk.	0.0084	2.1239	23.3081	-0.1375
16	INKP	Indah Kiat Pulp & Paper Tbk.	0.0050	1.2693	38.7592	-0.1047
17	ITMG	Indo Tambangraya Megah Tbk.	0.0113	2.8581	31.9705	-0.0773
18	KLBF	Kalbe Farma Tbk.	-0.0309	-7.7930	33.5245	-0.3914
19	MDKA	Merdeka Copper Gold Tbk.	-0.0623	-15.7077	52.4056	-0.4014
20	MEDC	Medco Energi Internasional Tbk.	0.1117	28.1383	49.0587	0.4650
21	PGAS	Perusahaan Gas Negara Tbk.	0.0325	8.1796	32.0179	0.0891
22	PTBA	Bukit Asam Tbk.	-0.0151	-3.8137	33.9813	-0.2690

No	Code	Company Name	Daily E(Ri) (%)	Annual E(Ri) (%)	Annual σi (%)	Sharpe Ratio
23	SMGR	Semen Indonesia (Persero) Tbk.	-0.1059	-26.6921	38.1720	-0.8388
24	TLKM	Telkom Indonesia (Persero) Tbk.	-0.0192	-4.8262	28.8443	-0.3520
25	TOWR	Sarana Menara Nusantara Tbk.	-0.0693	-17.4524	34.7368	-0.6558
26	UNTR	United Tractors Tbk.	0.0315	7.9348	32.3198	0.0807
27	UNVR	Unilever Indonesia Tbk.	-0.0509	-12.8157	40.6779	-0.4460
Annual Risk-Free Rate (Rf) — Avg. BI Rate Jan 2022 to Dec 2025:					5.3281%	

Source: IDX (idx.co.id); Bank Indonesia (2025); author's calculations using Microsoft Excel. Green = Sharpe ≥ 0.30; Red = Sharpe < 0.

Table 2 reveals a starkly heterogeneous return environment during the 2022-2025 period. Only 8 of 27 stocks (29.6%) generated positive Sharpe ratios, while 19 (70.4%) failed to compensate investors adequately for the risk taken relative to the BI Rate of 5.3281%. The three best-performing stocks on a risk-adjusted basis were BRPT (Sharpe 0.5160, return 35.17%), MEDC (Sharpe 0.4650, return 28.14%), and AMRT (Sharpe 0.1853, return 12.47%). BRPT's exceptional return reflects its position in the petrochemical sector, which benefited from elevated naphtha prices and rapid expansion in downstream industries. MEDC outperformed due to high global oil and gas prices during the 2022-2023 energy crisis. At the other extreme, SMGR recorded the worst Sharpe ratio (-0.8388) and an annual return of -26.69%, reflecting elevated energy costs in cement production, demand compression, and intensifying domestic competition.

Efficient Frontier and Optimal Portfolio

The efficient frontier was derived through constrained quadratic optimization using the Microsoft Excel Solver add-in (GRG Nonlinear method, long-only constraint) by solving Equation (5) across 16 evenly-spaced target return levels. Figure 1 visualizes the resulting efficient frontier, with all 27 individual stocks plotted as reference points. Table 3 presents the numerical coordinates of the representative frontier points.

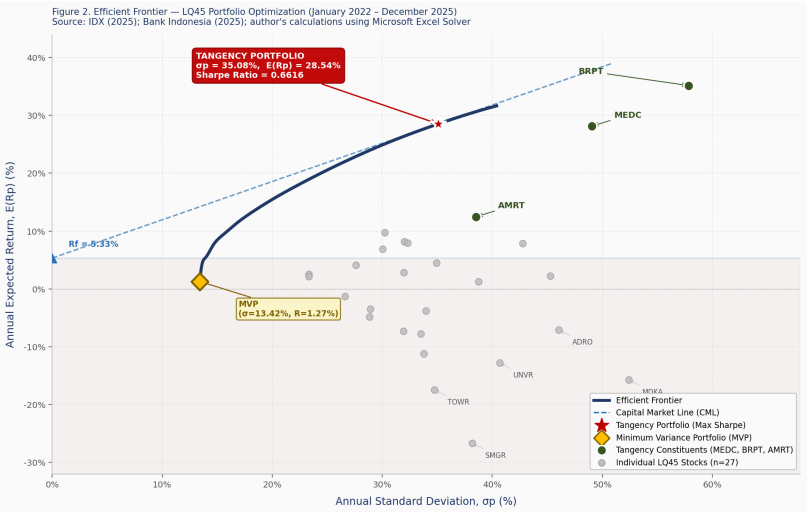

Figure 1. Efficient Frontier — LQ45 Portfolio Optimization (January 2022 to December 2025)

Table 3. Representative Points on the Efficient Frontier

No	Annual E(Rp) (%)	Annual σp (%)	Sharpe Ratio	Description
1	1.2700	13.4200	-0.3024	Minimum Variance Portfolio (MVP)
2	3.3000	13.5300	-0.1503	
3	5.3200	13.9000	-0.0005	
4	7.3500	14.5600	0.1386	
5	9.3700	15.5400	0.2603	
6	11.4000	16.8000	0.3613	
7	13.4200	18.2900	0.4425	
8	15.4500	19.9900	0.5063	
9	17.4700	21.8700	0.5555	
10	19.5000	23.9000	0.5930	
11	21.5300	26.0600	0.6215	
12	23.5500	28.3700	0.6423	
13	25.5800	30.8900	0.6555	
14	27.6000	33.7000	0.6610	
15	28.5400	35.0800	0.6616	**Tangency Portfolio (Max Sharpe Ratio)**
16	29.6300	36.8100	0.6601	

Source: Author's calculations using Microsoft Excel Solver (GRG Nonlinear; long-only constraint). Green row = Tangency Portfolio; Yellow row = MVP.

Table 3 demonstrates a well-formed efficient frontier. The Sharpe ratio increases monotonically from -0.3024 at the Minimum Variance Portfolio (MVP: return 1.27%, sigma_p 13.42%) through the tangency point at 28.5351% return and 35.0794% standard deviation, where it peaks at 0.6616. A notable characteristic of this frontier is that the MVP itself carries a negative Sharpe ratio (-0.3024), meaning its return of 1.27% lies below the risk-free rate of 5.3281%. This underscores the severity of the 2022-2025 market conditions across the LQ45 universe.

Optimal Portfolio Weights (Tangency Portfolio)

The tangency portfolio was identified through Sharpe ratio maximization. Only three of the 27 sample stocks received positive weights; the remaining 24 were assigned zero weight, a well-documented characteristic of long-only Mean-Variance optimization in adversarial markets (Elton et al., 2014). Table 4 details the optimal composition.

Table 4. Tangency Portfolio — Optimal Weights and Contribution to Return

No	Code	Company Name	Weight (wi) %	Annual E(Ri) %	Annual σi %	Return Contrib.
1	MEDC	Medco Energi Internasional Tbk.	42.8899%	28.1383%	49.0587%	12.0700%

No	Code	Company Name	Weight (wi) %	Annual E(Ri) %	Annual σi %	Return Contrib.
2	BRPT	Barito Pacific Tbk.	41.1681%	35.1697%	57.8370%	14.4800%
3	AMRT	Sumber Alfaria Trijaya Tbk.	15.9420%	12.4698%	38.5382%	1.9900%
PORTFOLIO TOTAL			**100.0000%**	**28.5351%**	**35.0794%**	**28.5351 %**
OPTIMAL PORTFOLIO SHARPE RATIO:						**0.6616**

Source: Author's calculations using Microsoft Excel Solver (GRG Nonlinear, maximize Sharpe ratio; long-only constraint; Σ wi = 1). Correlations among constituents: MEDC-BRPT ρ = 0.1376; MEDC -AMRT ρ = 0.0548; BRPT-AMRT ρ = 0.1063.

Table 4 reveals that the tangency portfolio is concentrated in energy and petrochemical sectors (MEDC 42.89% and BRPT 41.17%, totaling 84.06%) and retail consumer (AMRT 15.94%). The concentration of the optimal portfolio in only three stocks is a well-documented characteristic of Mean-Variance optimization under a long-only constraint when the investment opportunity set is limited by predominantly negative Sharpe ratios. When the majority of assets offer risk-adjusted returns below the risk-free rate, the optimizer rationally concentrates weights on the small subset that generates meaningful excess returns. This is sometimes referred to as a corner solution in the optimization literature (Elton et al., 2014). Mathematical verification: S = (28.5351% - 5.3281%) / 35.0794% = 0.6616, confirming the reported Sharpe ratio of 0.6616.

The allocation logic is further supported by the correlation structure. Despite MEDC and BRPT both operating in energy-related sectors, their returns are driven by distinct drivers resulting in a low pairwise correlation of only rho_ij = 0.1376. AMRT's near-zero correlations with both energy stocks (MEDC: rho = 0.0548; BRPT: rho = 0.1063) provide additional diversification. The optimizer exploits this structure to achieve a portfolio standard deviation (sigma_p) of 35.08%, materially lower than a naive equal-weighted combination of the three stocks would yield.

Performance Comparison: Portfolio vs. Individual Stocks

Table 5 presents a comprehensive comparison of the Sharpe ratio of the tangency portfolio, the Minimum Variance Portfolio, and all 27 individual stocks, ranked from highest to lowest Sharpe ratio.

Table 5. Performance Comparison: Tangency Portfolio vs. Individual Stocks (Ranked by Sharpe Ratio)

Rank	Instrument	Annual E(R) %	Annual σ %	Sharpe Ratio	Category
1	TANGENCY PORTFOLIO (OPTIMAL)	28.5351	35.0794	0.6616	Best Risk-Adjusted
2	Minimum Variance Portfolio (MVP)	1.2695	13.4195	-0.3024	Lowest Risk
3	BRPT - Barito Pacific Tbk.	35.1697	57.8370	0.5160	Above Rf
4	MEDC - Medco Energi Internasional Tbk.	28.1383	49.0587	0.4650	Above Rf
5	AMRT - Sumber Alfaria Trijaya Tbk.	12.4698	38.5382	0.1853	Above Rf
6	BMRI - Bank Mandiri (Persero) Tbk.	9.7261	30.2424	0.1454	Above Rf

Rank	Instrument	Annual E(R) %	Annual σ %	Sharpe Ratio	Category
7	PGAS - Perusahaan Gas Negara Tbk.	8.1796	32.0179	0.0891	Above Rf
8	UNTR - United Tractors Tbk.	7.9348	32.3198	0.0807	Above Rf
9	ANTM - Aneka Tambang Tbk.	7.8273	42.7475	0.0585	Above Rf
10	BBNI - Bank Negara Indonesia (Persero) Tbk.	6.9011	30.0387	0.0524	Above Rf
11	EXCL - XL Axiata Tbk.	4.5077	34.9406	-0.0235	Below Rf
12	ASII - Astra International Tbk.	4.1411	27.6114	-0.0430	Below Rf
13	INCO - Vale Indonesia Tbk.	2.2012	45.2712	-0.0691	Below Rf
14	ITMG - Indo Tambangraya Megah Tbk.	2.8581	31.9705	-0.0773	Below Rf
15	INKP - Indah Kiat Pulp & Paper Tbk.	1.2693	38.7592	-0.1047	Below Rf
16	BBCA - Bank Central Asia Tbk.	2.5669	23.3287	-0.1184	Below Rf
17	INDF - Indofood Sukses Makmur Tbk.	2.1239	23.3081	-0.1375	Below Rf
18	ICBP - Indofood CBP Sukses Makmur Tbk.	-1.3306	26.6042	-0.2503	Below Rf
19	PTBA - Bukit Asam Tbk.	-3.8137	33.9813	-0.2690	Below Rf
20	ADRO - Adaro Energy Indonesia Tbk.	-7.0982	46.0638	-0.2698	Below Rf
21	BBRI - Bank Rakyat Indonesia (Persero) Tbk.	-3.4982	28.9011	-0.3054	Below Rf
22	TLKM - Telkom Indonesia (Persero) Tbk.	-4.8262	28.8443	-0.3520	Below Rf
23	KLBF - Kalbe Farma Tbk.	-7.7930	33.5245	-0.3914	Below Rf
24	CPIN - Charoen Pokphand Indonesia Tbk.	-7.2965	31.9369	-0.3953	Below Rf
25	MDKA - Merdeka Copper Gold Tbk.	-15.7077	52.4056	-0.4014	Below Rf
26	UNVR - Unilever Indonesia Tbk.	-12.8157	40.6779	-0.4460	Below Rf
27	BBTN - Bank Tabungan Negara (Persero) Tbk.	-11.2312	33.7848	-0.4901	Below Rf
28	TOWR - Sarana Menara Nusantara Tbk.	-17.4524	34.7368	-0.6558	Below Rf
29	SMGR - Semen Indonesia (Persero) Tbk.	-26.6921	38.1720	-0.8388	Below Rf

Source: Author's calculations. IDX data January 2022 to December 2025. Risk-free rate (Rf) = 5.3281% p.a.

Green = Tangency; Yellow = MVP; Red = Sharpe < 0.

Table 5 provides definitive evidence of the tangency portfolio's superiority. The Sharpe ratio of 0.6616 exceeds the best individual stock (BRPT at 0.5160) by 28.2%, and surpasses all 27 individual stocks without exception. The finding that 19 of 27 stocks carried negative Sharpe ratios

documents the extent of market adversity during 2022-2025. These results are consistent with Hasbiah, Anwar, and Bado (2022), who found that Markowitz-optimized portfolios systematically identify superior return-risk combinations. The findings extend this conclusion to an adverse market environment, demonstrating that MPT's benefits are not limited to bull markets.

Compared with Meliala and Sukarno (2023), who reported a maximum Sharpe ratio of 31.57% during the post-COVID recovery, the lower Sharpe ratio obtained here (0.6616) reflects the more constrained opportunity set in a period dominated by heterogeneous sectoral stresses. This confirms research proposition P1: the Mean-Variance optimized portfolio generates a Sharpe ratio higher than any individual constituent stock over the 2022-2025 period.

Managerial Implications

The results carry direct implications for both retail and institutional investors. First, undiversified single-stock strategies within the LQ45 universe exposed investors to significant risk of return shortfalls relative to the risk-free rate during 2022-2025. Second, the tangency portfolio demonstrates that quantitative Mean-Variance optimization can identify superior risk-adjusted combinations even in a challenging market environment. Third, the low pairwise correlations between energy and consumer retail stocks confirm that cross-sector diversification using instruments from structurally unrelated economic drivers is the key mechanism underlying portfolio efficiency.

CONCLUSION

This study constructs and evaluates an optimal stock portfolio from the LQ45 index using the Markowitz Mean-Variance model for the period January 3, 2022 to December 30, 2025, using official daily closing price data from the Indonesia Stock Exchange (IDX). As an ex-post empirical analysis on a stable 27-stock constituent universe, the study is designed to isolate the mathematical efficacy of the Mean-Variance framework under post-pandemic market conditions. Four principal conclusions are drawn.

First, from the 27 consistently listed LQ45 stocks, the 2022-2025 period was characterized by broad market adversity. Annual returns ranged from -26.69% (SMGR) to +35.17% (BRPT), and 19 of 27 stocks (70.4%) recorded negative Sharpe ratios below the risk-free rate of 5.3281% per annum. The three best-performing individual stocks were BRPT (Sharpe 0.5160), MEDC (Sharpe 0.4650), and AMRT (Sharpe 0.1853).

Second, quadratic optimization produced a valid efficient frontier, with the Sharpe ratio rising monotonically from -0.3024 at the MVP (return 1.2695%, sigma 13.4195%) to a maximum of 0.6616 at the tangency portfolio. The MVP's negative Sharpe ratio reflects the difficulty of the market environment, in which even risk-minimizing strategies could not generate returns above the BI Rate on an absolute basis.

Third, the tangency portfolio allocates 42.89% to MEDC, 41.17% to BRPT, and 15.94% to AMRT, with near-zero pairwise correlations (maximum rho = 0.1376) providing structural diversification. The 24 remaining stocks received zero weights under the long-only constraint, representing a corner solution consistent with the adversarial market conditions.

Fourth, the tangency portfolio achieved an annual return of 28.5351%, standard deviation 35.0794%, and Sharpe ratio 0.6616, outperforming all 27 individual stocks. Mathematical verification: S = (28.5351% - 5.3281%) / 35.0794% = 0.6616. These results validate the practical applicability of Modern Portfolio Theory in Indonesia's capital market even under predominantly adverse conditions.

This study has several limitations. A fundamental consideration of all historical portfolio optimization studies is that the efficient frontier and optimal weights are derived from in-sample data. This means the reported Sharpe ratio of the tangency portfolio represents the best achievable outcome given knowledge of the 2022-2025 return distribution, and out-of-sample performance may differ. Further specific limitations include: the use of historical returns as proxies

for expected returns introduces estimation risk; the long-only constraint may be relaxed for institutional investors; transaction costs and taxes are not incorporated; and out-of-sample validation using post-December 2025 data would provide additional robustness. Future research should conduct rolling-window backtests and explore Ledoit-Wolf shrinkage estimators or the Black-Litterman model.

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