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The formation of optimal stocks portfolio using Markowitz, single index, and Capital Asset Pricing Models on LQ45 Index of 2016-2020 period

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Abstract. This research aims to create an optimal portfolio using the Markowitz, Single Index, and Capital Asset Pricing Models. The sample consists of 27 LQ45 Stocks Index consistently recorded between 2016 and 2020. According to the study's findings, the optimal portfolio formation of the Markowitz Model consists of 10 stocks (BBCA, UNVR, ICBP, TLKM, GGRM, UNTR, JSMR, ADRO, PTBA, and SRIL) with an expected portfolio return of 1.06 percent per month and portfolio risk of 3.68 percent per month. The optimal portfolio of the Single Index Model consists of six stocks (BBCA, PTBA, ADRO, INCO, UNTR, and ICBP) with a monthly return of 2.16 percent and a portfolio risk of 2.98 percent. Meanwhile, the Capital Asset Pricing Model's optimal portfolio formation consists of seven stocks (BBCA, ICBP, KLBF, UNTR, ADRO, PTBA, and ASII) with an expected monthly portfolio return and portfolio risk of 1.51 and 4.14 percent. Based on portfolio performance evaluations using the Sharpe Ratio, Treynor Ratio, and Jensen's Alpha shows the portfolio performance of the Single Index Model outperforms the Markowitz and Capital Asset Pricing Models. The comparison gives information for the investor when choosing the best portfolio shares of LQ45 based on data in the period of 2016-2020.

Keywords. Markowitz Model, Single Index Model, Capital Asset Pricing Model, Portfolio Optimal, LQ45 Stocks Index

1. Introduction

Investing is an option for people who want to increase their wealth. Investing can be done in the capital market, including stock instruments. Shares are evidence that the person who owns the shares becomes part of the owner of the company and indicates that shareholders have rights to the company's income. Investment activities in stocks in Indonesia are growing and according to data quoted from www.ksei.co.id there is an increase in the number of stock investors in the capital market every year as shown in Figure 1.

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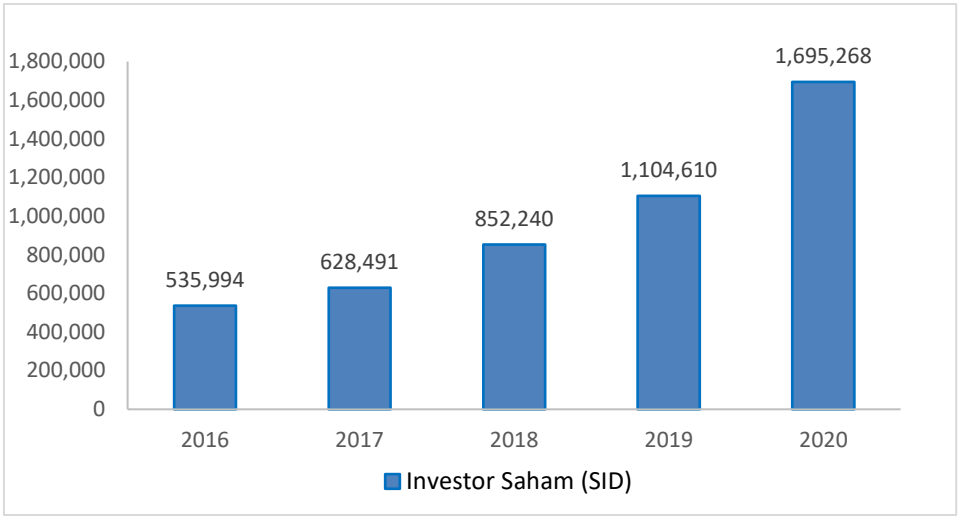

Source: www.ksei.co.id

Figure 1. The Number of Stock Investors at Indonesia Stock Exchange in 2016 – 2020

Figure 1. explains an increase in the number of stock investors by 216% in 2020 compared to 2016. It triggers by the digitalization process of the capital market in Indonesia (www.idx.co.id, 2020). LQ45 stocks index is the one preferred by investors. The LQ45 index contains 45 company shares with good fundamentals as well as have high capitalization and liquidity. LQ45 index is updated every six months. However, stocks in LQ45 still contain risks such as uncertainty of the return, as indicated by fluctuating or negative returns (Table 1). Investors need to anticipate the investment risk, e.g. by diversifying the shares, namely by forming an optimal portfolio. Finding an optimal portfolio of stocks can help investors determine the best investment based on the return and risk of each share (Siahaan & Siagian, 2018). The optimal portfolios can be formed using the Markowitz Model, Single Index Model, and Capital Asset Pricing Model.

Table 1. Rate of Return of LQ45 Index in 2016-2020

	2016	2017	2018	2019	2020
Rate Return of LQ45 (%)	11,7%	22,0%	-9,0%	3,2%	-7,8%

Source: www.yahoo.finance.com

2. Literature Review

a. Efficient and Optimal Portfolio

According to Halim (2020:54), "a portfolio is a combination of real assets and financial assets owned by investors. The essence of portfolio formation is to reduce risk by allocating some funds to various investment alternatives that are negatively correlated. Meanwhile, Hartono (2019:6)explains that "a portfolio is a collection of financial assets in a unit that is held or managed by investors, investment companies, or financial institutions." Based on this understanding, we can conclude that a portfolio is a collection of a combination of financial securities managed by investors to reduce investment risk.

Harry Markowitz introduced a portfolio theory in 1952 in his article "Portfolio Selection," published in the "Journal of Finance." His book has released in 1959 entitled "Portfolio

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Selection: Efficient Diversification of Investment." Markowitz has statistically proved that combining several single assets in portfolio formats will reduce the risk.
An efficient portfolio is a portfolio that provides the highest expected return with the same level of risk or a portfolio that produces the lowest risk with the same expected rate of return (Hartono, 2019:147).
An efficient portfolio is not always the best portfolio share because it only considers the maximum return or the low risk. Therefore, to get the best portfolio, it is necessary to form an optimal portfolio. The optimal portfolio is the portfolio chosen by the investor's preferences regarding the returns and the risk of their investment policy (Tandelilin, 2017:164).

b. Markowitz Model

In his theory, Markowitz proved that the risk decrease by combining several assets in a portfolio. The Markowitz portfolio model emphasizes efforts to reduce portfolio risk. Investors should consider several factors when building a portfolio, such as a covariance and correlation coefficient.
The risk of an asset portfolio is the proportion of each asset's inherent risk to the portfolio, known as the covariance, not the sum of the risks in the portfolio assets. Investors need to choose different companies with different types of industries to get low covariance values. Diversify companies' securities from the same industry will result in higher covariance value.
In his model, Markowitz uses three assumptions, namely using a single investment period such as one year, there is no transaction cost, and investor's preference based upon their expected return and risk (Hartono, 2019:388).

c. Single Index Model

In 1963 William Sharpe introduced the Single Index Model, a simplified portfolio formation method of the Markowitz Model. The model has an assumption that the stock price is in line with the movement of the market index (Halim, 2020:64). A Single Index Model has two components in calculating the rate of return; the return component related to the company's uniqueness, symbolized by α_i and, the market rate of return, noted by β_i (Tandelilin, 2019:141)

d. Capital Asset Pricing Model

The Capital Asset Pricing Model is a method for estimating the relationship between the expected returns and the risk of assets in a balanced state of the capital market. In this model, the benchmark of the risk is explained by the beta variable (Kennedy & Yanis, 2019). As Markowitz model, the Capital Asset Pricing Model explains that every investor will diversify his portfolio and choose the optimal portfolio based on his preferences in its expected returns and risks.
The security market line for individual stocks explains a balanced market (equilibrium). The description of the relationship between expected return and the risk of the stocks portfolio is explained through the security market line when the capital market is in the balanced state (beta=1), as shown in Figure 2.

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Source: (Hartono, 2017:586)

Figure 2. Security Market Line

e. Sharpe Ratio

Sharpe Ratio proposed by William Sharpe measures portfolio performance by comparing the portfolio risk premium with the portfolio risk shown as standard deviation or total risk. Tandelilin (2017:500) states that the risk premium ((E(Rp)-Rf)/ σ_p) is the compensation for taking risks. Thus, the Sharpe Ratio is the ratio of compensation to total risk. Sharpe Ratio can be used to sort several portfolios based on their performance. A high Sharpe Ratio value means that the portfolio's performance is good.

f. Treynor Ratio

Treynor Ratio proposed by Jack Treynor is a ratio that uses the securities market line as a benchmark. A high Treynor Ratio value indicates that the portfolio's performance is good. There is an assumption in the Treynor Ratio that systematic risk or beta value is a relevant risk when the portfolio formed has gone through a proper diversification process. Treynor Ratio assesses portfolio performance by comparing the risk premium to a beta value (Kennedy & Yanis, 2019).

g. Jensen's Alpha

Jensen's Alpha--introduced by Michael C. Jensen-- is an index to show whether the realized return on a portfolio is different from the expected return when the portfolio lies on the security market line (Tandelilin, 2017:500). Jensen's Alpha measures excess returns that occur below or above the securities market line. Jensen's Alpha used to see the number of portfolios that can "beat the market." A portfolio found above the securities market line indicates that the portfolio has a higher realized return than the expected return. It also interpreted that the portfolio has a greater return at a portfolio systematic risk level and vice versa.

3. METHODS

a. Population and Sample

This research uses quantitative descriptive analysis, a systematic approach to produce answers to a problem and obtain an in-depth explanation of a phenomenon using a quantitative technique (Yusuf, 2014:62). The population of this study is corporate stocks in the LQ45 stocks index at the Indonesia Stocks Exchange of the 2016 - 2020 period. The sampling was using purposive sampling method with the criteria as follows:

• Companies that have conducted initial public offerings before 2015.
• Issuers consistently listed in the LQ 45 Index during the 2016-2020 period.

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• Full data on share prices listed on the Indonesia Stock Exchange until the end of 2020.
Of the 71 shares listed in the LQ45 stocks exchange in the 2016-2020 period, found 27 company shares met the criteria.

b. Technical Data Analysis

1) Optimal Portfolio-Markowitz Model

a) Calculating the return, variance, and standard deviation of individual stocks:

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

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

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

b) Calculating the variance-covariance matrix and correlation coefficient matrix:

$$\sigma_{RC\,.\,RD} = \sum_{t=1}^{n} \frac{[(R_{Ct} - E(R_C)) \,.\, (R_{Dt} - E(R_D)]}{n}$$

$$R_{AB} = \sigma_{AB} = \frac{Cov\,(R_A, R_B)}{\sigma_A . \sigma_B}$$

c) Calculating the expected return and the portfolio risk of the same weight:

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

$$\sigma_{p^2} = \sum_{i=1}^{n}\sum_{j=1}^{n} W_i W_j \sigma_{ij}$$

d) Calculating the proportion of funds with the help of *add-ins solver*.
e) Calculating the expected return and portfolio risk with different weights:

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

$$\sigma_{p^2} = \sum_{i=1}^{n}\sum_{j=1}^{n} W_i W_j \sigma_{ij}$$

2) Optimal Portfolio – Single Index Model

a) Calculating the market returns and risk-free returns:

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$$R_{mt} = \frac{IHSG_t - IHSG_{t-1}}{IHSG_{t-1}}$$

b) Calculating alpha and beta values:

$$\alpha i = E(Ri) - \beta i.E(Rm)$$
$$\beta_i = \frac{\sum_{t=1}^{n}(R_i - E(R_i)).(R_m - E(R_m))}{\sum_{t=1}^{n}(R_m - E(R_m))}$$

c) Calculating the variance residual error and excess return to beta (ERB):

$$\sigma ei^2 = \frac{\sum_{i1}^{n} Ri - \alpha i - (\beta i.Rm))^2}{n}$$
$$ERB_i = \frac{E(R_i) - RBR}{\beta_i}$$

d) Calculating the value of Ai, Bi, Ci, and C* for each stock:

$$A_i = \frac{E(R_i) - Rf.\beta i}{\sigma ei^2}$$
$$B_i = \frac{\beta i^2}{\sigma ei^2}$$
$$Ci = \frac{\sigma m^2 \sum_{i=1}^{i} \frac{(E(Ri) - RBR).\beta i}{\sigma ei^2}}{1 + \sigma m^2 \sum_{j=1}^{i} \left(\frac{\beta i^2}{\sigma ei^2}\right)}$$

e) Selecting the optimal portfolio candidate with the criteria that the ERB value is greater than the C* value.

f) Calculating the proportion of each stock, expected return and risk of optimal portfolio-Single Index Model:

$$Zi = \frac{\beta i}{\sigma ei^2}(ERB_i - C^*)$$
$$Wi = \frac{Zi}{\sum_{j=1}^{k} Zj}$$
$$E(R_P) = \alpha_p + \beta_p .E(R_m)$$
$$\sigma p^2 = \beta p^2.{\sigma_{rm}}^2 + (\sum_{t=1}^{n} W_i \sigma_{ei})^2$$

3) Optimal Portfolio - Capital Asset Pricing Model

a) Calculating the expected return of each stock with the principle of the Capital Asset Pricing Model.

$$E(Ri) = Rf + \beta_i[E(Rm) - Rf]$$

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b) Create a Security Market Line.

c) Selecting efficient stocks which have a value of R_i greater than $E(R_i)$.

d) Calculating the proportion of funds, expected return, and risk of optimal portfolio of Capital Asset Pricing Model with the same weight:

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

$$\sigma_{p^2} = \sum_{i=1}^{n} \sum_{j=1}^{n} W_i W_j \sigma_{ij}$$

e) Calculating the proportion of funds, expected return, and risk of optimal portfolio of Capital Asset Pricing Model with different weights with the help of *add-in solver*.

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

$$\sigma_{p^2} = \sum_{i=1}^{n} \sum_{j=1}^{n} W_i W_j \sigma_{ij}$$

4) Assessment of Optimal Portfolio Performance Using Sharpe Ratio, Treynor Ratio, Jensen's Alpha.

$$Sharpe\ Ratio = \frac{E(R_p) - R_f}{\sigma_p}$$

$$Treynor\ Ratio_p = \frac{E(R_p) - R_f}{\beta_p}$$

$$Jensen\ Alpha_p = E(R_p) - \left[R_f + \beta_p(E(R_m) - R_f\right]$$

4. Result and Discussion

a. Optimal Portfolio-Markowitz Model

1) Expected Return, Variance, and Standard Deviation

Table 2 describes the results of Expected Return, Variance, and Standard Deviation of Stocks using the Markowitz model. That shows 25 of the 27 stocks have a positive expected return value, which explains that those stocks expect to generate profits for investors. Among these stocks, PTBA shares have the highest expected return value (0.0328).

Table 2. Expected Return, Variance, and Standard Deviation

No.	Code	E(Ri)	σ^2	σ	No.	Code	E(Ri)	σ^2	σ
1	ADRO	0,0288	0,0014	0,1182	15	JSMR	0,005	0,0110	0,1048
2	AKRA	-0,0057	0,0099	0,0993	16	KLBF	0,0057	0,0044	0,0666
3	ASII	0,006	0,0070	0,0838	17	MNCN	0,0053	0,0251	0,1585
4	BBCA	0,0181	0,0027	0,0518	18	PGAS	0,0074	0,0258	0,1607
5	BBNI	0,0124	0,0106	0,1031	19	PTBA	0,0328	0,0149	0,1222

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6	BBRI	0,0157	0,0055	0,0742	20	PTPP	0,005	0,0273	0,1652
7	BBTN	0,0179	0,0229	0,1514	21	SCMA	0,0039	0,0134	0,1156
8	BMRI	0,0113	0,0056	0,0751	22	SMGR	0,0087	0,0112	0,1060
9	BSDE	-0,0015	0,0093	0,0964	23	SRIL	0,0023	0,0161	0,1270
10	GGRM	0,0002	0,0052	0,0721	24	TLKM	0,005	0,0042	0,0652
11	ICBP	0,0096	0,0036	0,0600	25	UNTR	0,0149	0,0085	0,0921
12	INCO	0,0292	0,0208	0,1443	26	UNVR	0,0035	0,0038	0,0617
13	INDF	0,0102	0,0058	0,0761	27	WIKA	0,0099	0,0215	0,1465
14	INTP	0,0009	0,0099	0,0993					

Source: Own calculation

The results show that PTPP shares have the highest variance and standard deviation, namely 0.0273 and 0.1652, while BBCA stock has the lowest variance and standard deviation, i.e., 0.0027 and 0.0518. The data explains that PTPP shares have the highest risk because the higher the variance and standard deviation, the higher the risk of the stock, and the lower values of variance and standard deviation indicate the lower risk.

The correlation coefficient shows the relationship of the return variable between two stocks to the risk. The results show that the stocks of PTPP and WIKA have the highest correlation coefficient value of 0.86078, while ADRO and ICBP have the lowest correlation value of -0.13673.

A positive correlation coefficient value indicates that the risk diversification of those stocks is not a good choice; if one of the stocks experiences a decrease in return, then the other will decrease as well. On the other hand, the negative correlation coefficient value indicates that the risk diversification of those stocks is the better choice; a decline in one of the stocks' returns will not decrease the other one. Then, the lower the correlation coefficient value, the lower the risk.

2) Expected Return and Risk of Portfolio with Equal Weight

The previous calculations show that 25 company stocks have a positive expected return. Therefore, those stocks become a candidate for an optimal portfolio composition. Furthermore, a comparison needs to be conducted on the expected return and risk generated by the optimal portfolio on the Markowitz Model. With as much as 25 of the number of optimal portfolio composition shares, then the weight of each share is 4%. The calculation result is shown in Table 3.

Table 3. Expected Return and Risk in Portfolio with Equal Weight

$E(R_i)$	0,0108
σ_p	0,0628

Source: Own calculation

Table 3 explains that an optimal portfolio with the same weight produces an expected portfolio return of 0.0108 or 1.08% per month with a risk level of 0.0628 or 6.28% per month.

3) Portfolio with Different Weight

In determining the stocks that form the optimal portfolio of the Markowitz Model uses an 'add-in solver' program. The result is shown in Table 4.

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Table 4. Expected Return and Risk of Portfolio with Different Weight

Code	W_i (%)
BBCA	32,44%
UNVR	21,38%
ICBP	20,08%
TLKM	8,92%
GGRM	7,59%
UNTR	5,35%
JSMR	1,31%
ADRO	1,24%
PTBA	0,97%
SRIL	0,73%
Expected Return of Portfolio	1,06%
Risk of Portfolio	3,68%

Source: Own calculation

The results show that the optimal portfolio builder with different weights is ten stocks with the percentage of funds shown in Table 4. The expected return and risk of the portfolio formed are 0.0106 or 1.06% and 0.0368 or 3.68% per month, respectively.
In terms of returns, a portfolio with different weights produces returns (1.06%) lower than a portfolio with the same weight (1.08%). However, in terms of risk, a portfolio with the same weight (6.28%) is higher than a portfolio with different weights (3.68%). It is in line with the concept of high risk-high return.

b. Optimal Portfolio – Single Index Model

An optimal portfolio of the Single Index Model needs market return and risk-free returns data. The calculation obtained that the expected market return value is positive, namely 0.0053 or 0.53% per month, with a risk of 0.0017 or 0.17% per month. It means that the capital market can generate returns to investors.
In this study, the risk-free return uses monthly data. Since a five-year Indonesian bond yield (from January 2016 to December 2020) is 6.86%, therefore, the monthly risk-free return is 6.86% divided by 12, which is 0.57% per month.

1) The Calculation of Beta, Alpha, and Variance of Residual Error

A Beta is a risk measurement tool used to determine the diversification of a stock. If the beta value is high, then the systematic risk is also high. A Beta is the slope value of data. It was obtained by calculating the data using Ms. Excel program. Alpha shows the expected return of the market return measured using Ms. Excel with the intercept formula.

Table 5. The Value of Beta, Alpha, and Variance of Residual Error

Code	βi	αi	σei²	Code	βi	αi	σei²
ADRO	1,3827	0,0215	0,0108	JSMR	1,5635	-0,0033	0,0033

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AKRA	1,6889	-0,0146	0,0051	KLBF	0,7993	0,0015	0,0074
ASII	1,4604	-0,0017	0,0012	MNCN	1,8904	-0,0047	0,0034
BBCA	0,9490	0,0131	0,0039	PGAS	2,5229	-0,0059	0,011
BBNI	2,0133	0,0018	0,014	PTBA	1,1961	0,0265	0,0035
BBRI	1,3892	0,0083	0,0023	PTPP	3,1593	-0,0117	0,0023
BBTN	2,3127	0,0057	0,0046	SCMA	1,8694	-0,0059	0,0036
BMRI	1,4181	0,0038	0,0166	SMGR	1,6546	-0,0000	0,0034
BSDE	1,6740	-0,0103	0,0069	SRIL	1,2921	-0,0045	0,005
GGRM	0,9937	-0,0050	0,0192	TLKM	0,7682	0,0009	0,0067
ICBP	0,3634	0,0077	0,0152	UNTR	0,8054	0,0106	0,0034
INCO	1,5964	0,0208	0,0126	UNVR	0,4678	0,0011	0,0075
INDF	0,6832	0,0066	0,0106	WIKA	2,5046	-0,0033	0,0133
INTP	1,3769	-0,0064	0,0067				

Source: Own calculation

Table 5 shows 19 stocks that have a Beta value of more than one which, means that the stock is very vulnerable to changes in market conditions. PTPP share has the highest of beta value, namely 3.1593, while ICBP share has the smallest beta value of 0.3634.
PTBA share is the stock with the highest Alpha value, which is 0.0265, while stocks with the smallest Alpha value is AKRA share, which is -0.0146.

2) The Calculation of ERB, Ci, and C*

The ERB value determines whether the return of the stock is more than its systematic risk. The cut-off point (Ci) is needed to limit the selection of the shares that make up the portfolio. The cut-off point value is the value with the highest cut-off rate. To select stocks that make up the optimal portfolio, the ERB value of the stock must be greater than the cut-off point value.

Table 6. The value of ERB, Ci, and C*

Code	ERB	Ci	Portfolio	Code	ERB	Ci	Porfolio
PTBA	0,0227	0,00362	Optimal	ASII	0,0002	0,00513	-
ADRO	0,0167	0,00622	Optimal	KLBF	-0,0000	0,00499	-
INCO	0,0147	0,00747	Optimal	MNCN	-0,0002	0,00487	-
BBCA	0,0131	0,00984	Optimal	PTPP	-0,0002	0,0043	-
UNTR	0,0113	0,00991	Optimal	JSMR	-0,0005	0,00411	-
ICBP	0,0107	0,00992	Optimal	TLKM	-0,0009	0,00401	-
BBRI	0,0072	0,00908	-	SCMA	-0,001	0,00377	-
INDF	0,0066	0,0090	-	SRIL	-0,0027	0,00368	-
BBTN	0,0053	0,00856	-	INTP	-0,0035	0,00348	-
BMRI	0,0039	0,00758	-	BSDE	-0,0043	0,00303	-
BBNI	0,0033	0,00672	-	UNVR	-0,0047	0,00299	-
SMGR	0,0018	0,00636	-	GGRM	-0,0055	0,00277	-

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WIKA	0,0017	0,00592	-	AKRA	-0,0068	0,0023	-
PGAS	0,0007	0,00559	-				

Source: Own calculation

Table 6 shows that PTBA share is the stock with the highest ERB value, 0.0227. Meanwhile, AKRA has the smallest ERB value, -0.0068. On the other hand, ICBP share becomes a cut-off point with the highest cut-off value (C*), 0.00992. By comparing the ERB value and the cut-off rate, it found six stocks that make up the optimal portfolio of the Single Index Model, namely PTBA, ADRO, INCO, BBCA, UNTR, and ICBP stocks.

3) The calculation of the Weighted Scale (Zi), Fund Proportion (Wi), Expected Return, and Risk of Optimal Portfolio

The results shown in Table 7. The proportion of funds starting from the highest of each stock making up the optimal portfolio is BBCA (55.0%), PTBA (13.4%), ADRO (12.3%), INCO (7.8%), UNTR (6.0 %), and ICBP (5.5%). Furthermore, the expected return of an optimal portfolio with the Single Index Model is 0.0216 or 2.16% per month and the portfolio risk of 0.298 or 2.98% per month.

Table 7. Weighted Scale (Zi), Fund Proportion (Wi), Expected Return, and Risk of Optimal Portfolio

Code	Zi	Wi (%)
PTBA	1,7778	13,4%
ADRO	1,6274	12,3%
INCO	1,0290	7,8%
BBCA	7,2744	55,0%
UNTR	0,7972	6,0%
ICBP	0,7210	5,5%
Expected Return of Portfolio		2,16%
Risk of Portfolio		2,98%

Source: Own calculation

c. Capital Asset Pricing Model

1) The Calculation of Expected Return of Capital Asset Pricing Model

The results explained in Table 8. The results show ICBP share has the highest expected return value of 0.0056, while the lowest is PTPP of 0.0043.

Table 8. Expected Return of Capital Asset Pricing Model

Code	βi	E(Rm)-Rf	E(Ri)	Code	βi	E(Rm)-Rf	E(Ri)
ICBP	0,3634	-0,0004	0,0056	ASII	1,4604	-0,0004	0,0051
UNVR	0,4678	-0,0004	0,0055	JSMR	1,5635	-0,0004	0,0050
INDF	0,6832	-0,0004	0,0054	INCO	1,5964	-0,0004	0,0050
TLKM	0,7682	-0,0004	0,0054	SMGR	1,6546	-0,0004	0,0050
KLBF	0,7993	-0,0004	0,0054	BSDE	1,6740	-0,0004	0,0050
UNTR	0,8054	-0,0004	0,0054	AKRA	1,6889	-0,0004	0,0050
BBCA	0,9490	-0,0004	0,0053	SCMA	1,8694	-0,0004	0,0049

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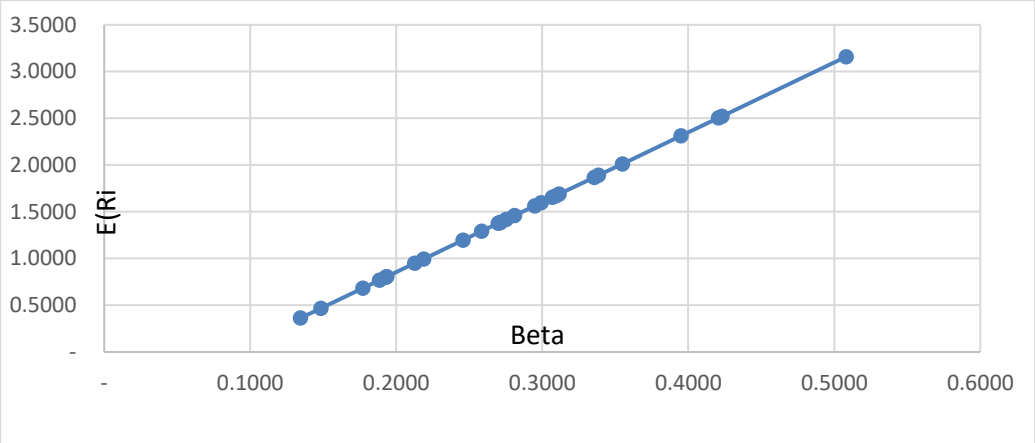
GGRM	0,9937	-0,0004	0,0053	MNCN	1,8904	-0,0004	0,0049
PTBA	1,1961	-0,0004	0,0052	BBNI	2,0133	-0,0004	0,0048
SRIL	1,2921	-0,0004	0,0051	BBTN	2,3127	-0,0004	0,0047
INTP	1,3769	-0,0004	0,0051	WIKA	2,5046	-0,0004	0,0046
ADRO	1,3827	-0,0004	0,0051	PGAS	2,5229	-0,0004	0,0046
BBRI	1,3892	-0,0004	0,0051	PTPP	3,1593	-0,0004	0,0043
BMRI	1,4181	-0,0004	0,0051				

Source: Own calculation

2) Security Market Line



Source: Own calculation

Gambar 3. Security Market Line

The securities market line in Figure 3. explains that the higher the beta value - the higher the expected return of the stocks. Conversely, the lower the beta value - the lower the expected return is.

3) Efficient Stock Selection

The calculation to determine efficient stocks, namely when the value of E(Ri) is greater than Ri, finds 18 efficient stocks, consisting of ICBP, INDF, KLBF, UNTR, BBCA, PTBA, ADRO, BBRI, BMRI, ASII, INCO, SMGR, MNCN, BBNI, BBTN, WIKA, PGAS, and PTPP, as shown in Table 9. These stocks are candidates that will enter into the formation of the optimal portfolio of the Capital Asset Pricing Model.

Table 9. Efficient Stocks

Code	Ri	E(Ri)	Efficient	Code	Ri	E(Ri)	Efficient
ICBP	0,0096	0,0056	Efficient	ASII	0,0060	0,0051	Efficient
UNVR	0,0035	0,0055	-	JSMR	0,0050	0,0050	-
INDF	0,0102	0,0054	Efficient	INCO	0,0292	0,0050	Efficient
TLKM	0,0050	0,0054	-	SMGR	0,0087	0,0050	Efficient
KLBF	0,0057	0,0054	Efficient	BSDE	-0,0015	0,0050	-
UNTR	0,0149	0,0054	Efficient	AKRA	-0,0057	0,0050	-
BBCA	0,0181	0,0053	Efficient	SCMA	0,0039	0,0049	-

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GGRM	0,0002	0,0053	-	MNCN	0,0053	0,0049	Efficient
PTBA	0,0328	0,0052	Efficient	BBNI	0,0124	0,0048	Efficient
SRIL	0,0023	0,0051	-	BBTN	0,0179	0,0047	Efficient
INTP	0,0009	0,0051	-	WIKA	0,0099	0,0046	Efficient
ADRO	0,0288	0,0051	Efficient	PGAS	0,0074	0,0046	Efficient
BBRI	0,0157	0,0051	Efficient	PTPP	0,0050	0,0043	Efficient
BMRI	0,0113	0,0051	Efficient	ASII	0,0060	0,0051	Efficient
ASII	0,0060	0,0051	Efficient				

Source: Own calculation

4) Optimal Portfolio of Capital Asset Pricing Model with Equal Weight

The weighting of each share is 5.56% of the 18 efficient shares. The calculation of the optimal portfolio with the same weight in the Capital Asset Pricing model produces nine stocks with a portfolio expected return of 1.38% and a risk of 6.87%.

Table 10. Optimal Portfolio of Capital Asset Pricing Model with Equal Weight

Code	Wi
ADRO	5,56%
ASII	5,56%
BBCA	5,56%
BBNI	5,56%
BBRI	5,56%
BBTN	5,56%
BMRI	5,56%
ICBP	5,56%
INCO	5,56%
∑	100%
Portfolio Expected Return	1,38%
Portfolio Risk	6,87%

Source: Own calculation

5) Optimal Portfolio of Capital Asset Pricing Model with Different Weights

The formation of the Capital Asset Pricing Model portfolio with different weights was carried out with the help of an add-in solver program. Seven stocks became the composition of the optimal CAPM portfolio with the proportion of funds as shown in Table 11. These stocks yield an expected return portfolio of 1.39% with a risk of 4.06%.

Table 11. Optimal Portfolio of Capital Asset Pricing Model with Different Weights

Code	Wi
BBCA	40,21%
ICBP	33,78%
KLBF	12,92%
UNTR	8,15%
ADRO	3,48%
PTBA	1,07%
ASII	0,38%
∑	100%

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Portfolio Expected Return	1,39%
Portfolio Risk	4,06%

Source: Own calculation

In terms of returns, the optimal portfolio of CAPM with different weights yields slightly greater the expected returns than the optimal portfolio with the same weight. Meanwhile, in terms of risk, it has a lower risk than the optimal portfolio with the same weight.

6) Performance Assessment of Optimal Portfolio of Markowitz Model, Single Index Model, and Capital Asset Pricing Model

The performance of each optimal portfolio needs to be assessed to find out which one provides the best results for investors. The assessment uses Sharpe Ratio, Treynor Ratio, and Jensen's Alpha.

Table 12. Sharpe Ratio, Treynor Ratio, and Jensen's Alpha

	Markowitz Model	Single Index Model	CAPM
E(Ri)	1,06%	2,16%	1,39%
portfolio Risk	3,68%	2,98%	4,06%
Sharpe Ratio	13,2%	53,36%	20,04%
Treynor Ratio	0,7%	1,52%	1,10%
Jensen's Alpha	0,5%	1,64%	0,85%

Source: Own calculation

Table 12 explains that the order of the performance using Sharpe Ratio from the highest is the optimal portfolio of the Single Index Model (53.36%), the optimal portfolio of the CAPM (20.04%), and the optimal portfolio of the Markowitz Model (13.2%). That shows that the optimal portfolio of the Single Index Model is the best that will provide a greater expected return with lower risk than the other portfolio.

The portfolio measurements of the Treynor Ratio produce the same order as the Sharpe Ratio, with results of 1.52%, 1.10%, and 0.7%, respectively. Likewise, the performance order according to Jensen's Alpha, with the value of 1.64%, 0.85%, and 0.5%.

In terms of expected return, the optimal portfolio order that can produce the highest expected return is the optimal portfolio of the Single Index Model (2.16%), the Capital Asset Pricing Model (1.39%), and the Markowitz Model (1.06%). Meanwhile, in terms of risk, the optimal portfolio order with the lowest level of portfolio risk is the Single Index Model (2.98%), followed by the Markowitz Model (3.68%) and the Capital Asset Pricing Model (4.06%).

5. Conclusion

The Markowitz model produces ten stocks as the optimal portfolio composition, with the proportions of each share as follows: BBCA (32,44%), UNVR (21,38%), ICBP (20,08%), TLKM (8,92%), GGRM (7,59%), UNTR (5,35%), JSMR (1,31%), ADRO (1,24%), PTBA (0,97%), and SRIL (0,73%). The expected return result of the portfolio is 1.06%, with a risk of 3.68%.

The Single Index Model produces six stocks as the optimal portfolio composing. Those shares and its proportion are BBCA (55.0%), PTBA (13.4%), ADRO (12.3%), INCO (7.8%), UNTR (6.0%), and ICBP (5.5%), with the expected return value of 2.16% and 2.98% of the risk.

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The Capital Asset Pricing Model has seven shares that make up the optimal portfolio, namely BBCA (40.21%), ICBP (33.78%), KLBF (12.92%), UNTR (8.15 %), ADRO (3.48%), PTBA (1.07%), and ASCII (0.38%) with an expected return of 1.51% and portfolio risk of 4.14%.
Portfolio performance assessment using the Sharpe Ratio, Treynor Ratio, and Jensen's Alpha shows that the optimal portfolio of the Single Index Model has the best performance. Therefore, based on the data for the 2016-2020 period and using three selected optimal portfolio calculation models, it is concluded that the best portfolio shares performance of LQ45 is the shares resulting from the optimal portfolio calculation using the Single Index Model.
This study explains that the calculation of the optimal stock portfolio with various models provides information for investors in choosing well-performing shares.

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