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Investment Portfolio Optimization Model Using The Markowitz Model

Emmanuel Parulian Sirait[1], Yasir Salih[2*], Rizki Apriva Hidayana[3]

[1]*Mathematics Undergraduate Study Program, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran, Jatinangor, Indonesia*
[2]*Department of Mathematics, Faculty of Education, Red Sea University, Sudan*
[3]*Master's Program of Mathematics, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran, Jatinangor, Indonesia*

**Corresponding author email: yasirsalih2015@gmail.com*

Abstract

The stock portfolio is related to how someone allocates several shares in various types of investments so that the results achieve maximum profit. By implementing a diversification system or portfolio optimization on several stocks, investors can reduce the level of risk and simultaneously optimize the expected rate of return. This study aims to determine which stocks listed on the Indonesia Stock Exchange (IDX) and included in the portfolio for the 2021-2022 period are eligible to be included in the optimal portfolio and to determine the proportion of funds for each share in the formation of the optimal portfolio. The population in this study are all shares included in the Indonesia Stock Exchange (IDX) listed on the Indonesia Stock Exchange (IDX) for the 2021-2022 period. The sample of this research is five stocks that are candidate portfolios. The sampling method uses a purposive sampling method with the criteria of 5 stocks with the highest positive ratio. The population in this study was all 30 companies included in the IDX30, while the samples were five companies. Data were analyzed using a mean-variant optimization model with a research duration between May 2021 and May 2022. Based on the results of the investment portfolio optimization analysis on the 5 (five) selected stocks, this study shows that, out of 23 stocks, five stocks are eligible to enter the optimal portfolio with their respective proportions, namely PT Adaro Energy Indonesia Tbk (ADRO) 20%, PT Astra International Tbk (ASII) 26%, PT Merdeka Copper Gold Tbk (MDKA) 10%, PT XL Axiata Tbk (EXCL) 19%, PT Bukit Asam Tbk (PTBA) 25%. The portfolio of these stocks generates an expected return of 0.00217 at a risk level of 0.00022. It is hoped that this research can be helpful to add to the literature on investment optimization models, especially the concentration of Mathematics in Finance, and serve as an additional reference for further research, as well as an alternative for investors in optimizing investment portfolios.

Keywords: Mathematics, instructions for authors, manuscript template

1. Introduction

Investment is the activity of investing some funds with the hope of getting profits in the future. The most fundamental thing in the investment process is understanding the expected returns and the risks that will occur in the future. All investors certainly want to have a goal to benefit from their equity participation in the company (Tandelilin, 2010). To achieve this goal, investors must analyze the shares to be purchased. A good investor will focus on 1) the highest rate of return with a certain level of risk and 2) a certain level of return with low risk. Both of these conditions indicate investment in optimal conditions.

In the world of investment, known as stock diversification. The formation of an efficient and optimal portfolio is the goal of stock diversification, namely placing several funds in various investment alternatives so that the funds can generate optimal returns. The placement and merging of several shares are then referred to as a portfolio (Sulistianingsih & Rosadi, 2021).

The obstacle in forming an optimal portfolio is not knowing precisely the optimal proportion of funds for each stock in the portfolio. Efficient portfolio analysis needs to be done to solve the problem (Bai et al., 2009). The discussion of this paper aims to show the analysis of the Mean-Variance investment portfolio optimization model without risk-free assets. The analysis of portfolio risk and return calculations are then used to determine the composition of the weight (proportion) of fund allocation in each of the assets that make up the optimum portfolio. The investment portfolio optimization method will be carried out using the Markowitz model. The results of this study are expected to be beneficial for interested parties, especially investors, as they can be used as a guide in analyzing shares to be traded on the capital market and determining the optimal portfolio as reflected in the realization of the frequency of stock trading transactions on the Indonesia Stock Exchange (IDX) or investment policy to be taken by investors.

2. Materials and Methods

2.1. Materials

The stock data analyzed in the object of this research is stock data traded on the capital market in Indonesia through the Indonesia Stock Exchange (IDX). Daily historical data of stocks included in the IDX30 index list. Daily historical data accessed through the website https://finance.yahoo.com/ consists of 30 (thirty) shares from May 12, 2021 – May 12, 2022. The selection of nominees from 30 shares is carried out by selecting shares continuously registered in each period. Based on IDX30 stock data for 1.5 years for the period May 12, 2021 – May 12, 2022, and permanently registered in 3 (three) study periods, it turns out that only 23 stocks were nominated, namely shares: ADRO, ANTM, ASII, BBCA, BBNI, BBRI , BBTN, BMRI, CPIN, EXCL, ICBP, INDF, INKP, KLBF, MDKA, PGAS, PTBA, SMGR, TBIG, TLKM, TOWR, UNTR, UNVR.

2.2. Methods

For the selection of an efficient portfolio, for the example given a p portfolio with a weight vector w referring to Panjer et al. (1998); Ruppert (2004); Kubilay & Bayrakdaroglu (2016); Grable (2008), it is done by finding the maximum value $2\tau\mu_p - \sigma_p^2$, the condition $\Sigma_{i=1}^{N} w_i = 1$ and $\tau \geq 0$, parameter τ is called risk tolerance. Using the Markowitz model approach, the optimization problem has several advantages: (i) The risk tolerance τ must be determined, and (ii) The first-moment μ_i and the second-moment σ_{ij} are required from the return on assets.

2.2.1. Mean-Variance Investment Portfolio Optimization Without Risk Free Assets

Suppose there are N risk-free assets with returns $r_1, \dots, r_n$. Assuming that the first and second moments of $r_1, \dots, r_n$ exist, the transposed vector of the expected return value is expressed as $\mu^T = (\mu_1, \dots, \mu_N)$ with $\mu_i = E[r_i], i = 1, \dots, N$ and matrix covariance is expressed as: $\Sigma = (\sigma_{ij})$ with $(\sigma_{ij}) = Cov(r_i, r_j), i, j = 1, \dots, N$. If the portfolio return is r_p with the transpose weight vector $w^T = (w_1, \dots, w_n)$, and the condition is $\Sigma_{i=1}^{N} w_i = 1$, then the expected portfolio return using vector notation can be expressed as:

$$\mu_p = E[r_p] = \mu^T w = w^T \mu \tag{1}$$

and the portfolio variance can be expressed as:

$$\sigma_p^2 = Var(r_p) = w^T \Sigma w \tag{2}$$

In Mean-Variance optimization, the efficient portfolio is defined as follows.
Definition: A portfolio p^* is called (Mean-Variance) efficient if there is no portfolio p with $\mu_p \geq \mu_{p^*}$ and $\sigma_p^2 < \sigma_{p^*}^2$ (Panjer et al., 1998; Ruppert, 2004).

To get an efficient portfolio, it means that you have to solve the portfolio optimization problem as follows:

$$\text{Maximize } \{2\tau\mu^T w - w^T \Sigma w\}, \tag{3}$$

$$\text{Condition } e^T w = 1 \tag{4}$$

with $e^T = (1, \dots, N)$, $\mu^T w = w^T \mu$, and $w^T e = e^T w$. The Lagrange function of equation (3) where λ is the substitute, can be expressed as follows:

$$L(w, \lambda) = (2\tau w^T \mu - w^T \Sigma w) + \lambda(w^T e - 1) \tag{5}$$

Equality (4) by using the necessary conditions of the Kuhn-Tucker theorem $\frac{\partial L}{\partial w} = 0$ and $\frac{\partial L}{\partial \lambda} = 0$, got:

$$\frac{\partial L}{\partial w} = 2\tau\mu - 2\Sigma w + \lambda e = 0 \tag{6}$$

$$\frac{\partial L}{\partial \lambda} = w^T e - 1 = 0 \tag{7}$$

Equality (5) multiply Σ^{-1} and state in w, then multiply the result e^T, after the solution is obtained:

$$w = \frac{1}{e^T \Sigma^{-1} e} \Sigma^{-1} e + \tau \left\{ \Sigma^{-1}\mu - \frac{e^T \Sigma^{-1} \mu}{e^T \Sigma^{-1} e} \Sigma^{-1} e \right\}; \tau \geq 0 \tag{8}$$

When $\tau = 0$ it produces a minimum variance portfolio with weights:

$$w^{Min} = \frac{1}{e^T \Sigma^{-1} e} \Sigma^{-1} e$$

3. Results and Discussion

3.1. Stock data analysis

3.1.1. DX30 Stock Data

Stock data in the object of this study is data on shares traded on the capital market through the Indonesia Stock Exchange (IDX), which are included in the IDX30 index list. Daily historical data accessed through the website https://finance.yahoo.com/ consists of 30 (thirty) shares for May 12, 2021 – May 12, 2022. Out of these 30 shares, stocks were always listed in 3 (three) periods. Research turned out that only 23 shares were nominated, namely: ADRO, ANTM, ASII, BBCA, BBNI, BBRI, BBTN, BMRI, CPIN, EXCL, ICBP, INDF, INKP, KLBF, MDKA, PGAS, PTBA, SMGR, TBIG, TLKM, TOWR, UNTR, UNVR.

3.1.2. Selection of Share Nominations

Selection of nominees from 30 shares is carried out by selecting shares that are always registered in each period. Based on data on IDX30 shares for 2 (two) years for the period 12 May 2021 – 12 May 2022 and always registered for 1.5 research periods, it turns out that only 23 stocks were nominated, namely shares: ADRO, ANTM, ASII, BBCA, BBNI, BBRI, BBTN, BMRI, CPIN, EXCL, ICBP, INDF, INKP, KLBF, MDKA, PGAS, PTBA, SMGR, TBIG, TLKM, TOWR, UNTR, UNVR.

From the 23 stocks that were used as nominators in the portfolio formation, then searched for daily historical data on stocks for May 12, 2021 – May 12, 2022. These shares' historical contains data the opening, highest, lowest, and closing prices, respectively. For analysis purposes, the researcher only needs the stock's daily closing price. Of the 23 nominated stocks, the respective stock prices fluctuated up/strengthened and fell/weakened during the study period. The price graph of several stocks that are nominated is shown in Figure 1.

Figure 1: Nominated Share Price Chart

3.1.3. Distribution Estimation, Expectation, and Stock Return Variance

This section intends to estimate the distribution, expectation/mean, and stock return variance, as well as the ratio between stock return expectations and variance. It starts with determining the stock returns of 23 nominated stock prices, then estimates the distribution, expectations, and variances.

Determining Stock Return

To determine stock returns is done. From the stock return data, graphs are then made. An example of a return graph for several stocks is shown in Figure 2.

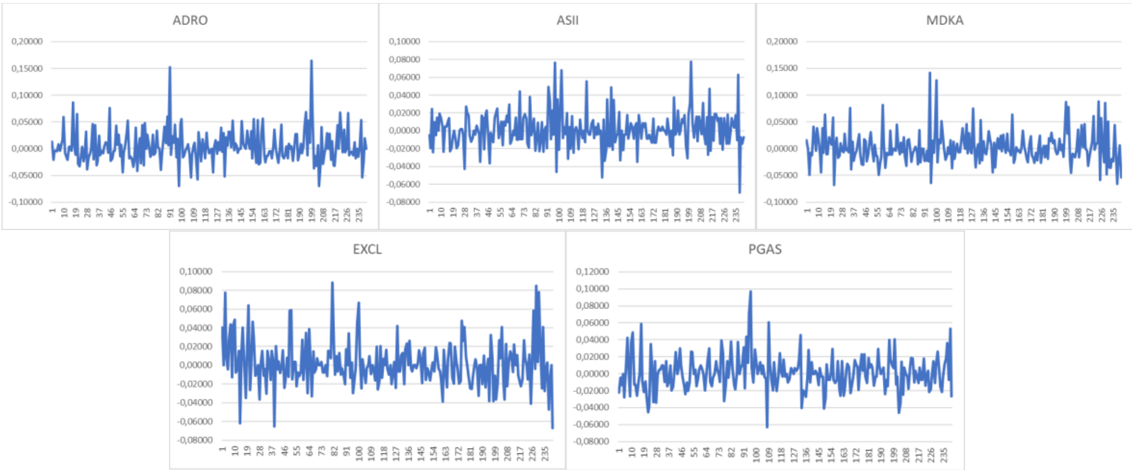

Figure 2: Graph of Nominated Stock Returns

Observing the sample stock return graph in Figure 2, some of the characteristics of stock returns that are nominated can be explained. Stock returns fluctuate around a certain value in certain periods. Sometimes, they go up high, and sometimes down sharply. Graphs above a certain value show an increase from the previous period's return, while graphs below a certain value show a decrease from the previous period's return. The returns of the 23 (twenty) nominated shares are then used to estimate expectations and variances, as done in section 3.2.

3.2. Formation of Mean-Variance Investment Portfolio Optimization Without Risk Free Assets

This section intends to estimate the distribution, expectations, and variance of stock returns. The distribution model is identified by looking at the histogram of stock returns. An example of a histogram of several stock returns is shown in Figure 3.

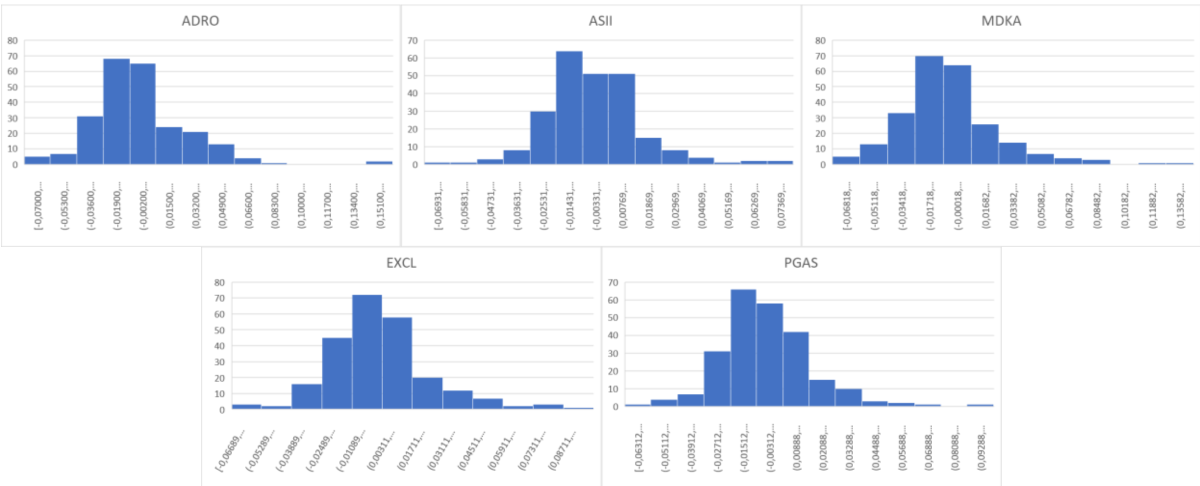

Figure 3: Nominated Stock Return Histogram

Looking at the histograms of several stock returns in Figure 3, it can be explained that, in general, the histograms are similar to a bell shape, so it can be assumed that the return distribution follows the normal distribution. Based on the identification, then using the help of Excel software, the expected return vector, unit vector e, covariance matrix Σ, and inverse covariance matrix Σ^{-1} will be formed. The results of the expectation estimation of the return variance are summarized in Table 1.

Table 1: Distribution Estimates, Expectations, and Stock Return Variances

No	Code	Distribution Estimator	Expectation/average μ	The variance of σ^2	Ratio μ/σ^2
1	ADRO	Normal	0.00453	0.00095	4.76067
2	ANTM	Normal	0.00010	0.00085	0.12297
3	ASII	Normal	0.00136	0.00041	3.36368
4	BBCA	Normal	0.00057	0.00021	2.73867
5	BBNI	Normal	0.00187	0.00042	4.40312
6	BBRI	Normal	0.00060	0.00034	1.74088
7	BBTN	Normal	0.00033	0.00044	0.75645
8	BMRI	Normal	0.00134	0.00032	4.18153
9	CPIN	Normal	-0.00096	0.00040	-2.43033
10	EXCL	Normal	0.00171	0.00059	2.92025
11	ICBP	Normal	0.00002	0.00028	0.08595
12	INDF	Normal	0.00015	0.00023	0.63913
13	INKP	Normal	-0.00074	0.00074	-1.00210
14	KLBF	Normal	0.00050	0.00034	1.46001
15	MDKA	Normal	0.00283	0.00091	3.11510
16	PGAS	Normal	0.00125	0.00043	2.89878
17	PTBA	Normal	0.01640	0.00049	33.31298
18	SMGR	Normal	-0.00154	0.00057	-2.69659
19	TBIG	Normal	0.00094	0.00052	1.82452
20	TLKM	Normal	0.00139	0.00031	4.47321
21	TOWR	Normal	-0.00044	0.00047	-0.94463
22	UNTR	Normal	0.00159	0.00059	2.71042
23	UNVR	Normal	-0.00044	0.00061	-0.71451

For example, investors will form an investment portfolio, consisting of the 5 (five) best stocks that are randomly selected based on a positive ratio value. The five selected stocks are summarized in Table 2.

Table 2: Five Selected Stocks

Code	Expectation/average μ	Variance of σ^2	Ratio μ/σ^2
ADRO	0.00453	0.00095	4.76067
ASII	0.00136	0.00041	3.36368
MDKA	0.00283	0.00091	3.11503
EXCL	0.00171	0.00059	2.92025
PGAS	0.00125	0.00043	2.89878

Furthermore, the 5 selected stocks using the help of Excel software determined the estimated value of covariance and correlation between stocks, as was done in section 3.3.

3.3. Covariance and Correlation Estimation

This section intends to explain the determination of the estimated covariance between the five selected stocks. Estimation is carried out by referring to equation (7) with the help of excel software, and the results are given in Table 3.

Table 3: Covariance Estimator of 5 Selected Stocks

No	Code	ADRO	ASII	MDKA	EXCL	PGAS
1	ADRO	0.00095	0.00013	0.00030	0.00017	0.00017
2	ASII	0.00013	0.00041	0.00016	0.00008	0.00005
3	MDKA	0.00030	0.00016	0.00091	0.00018	0.00008
4	EXCL	0.00017	0.00008	0.00018	0.00059	0.00005
5	PGAS	0.00017	0.00005	0.00008	0.00005	0.00043

Using the covariance estimator in Table 3, it is possible to estimate the correlation between the returns of 5 stocks. Estimation is carried out by help of excel software, and the results are given in Table 4.

Table 4: Table of Correlation Between Returns of 5 Stocks

No	Code	ADRO	ASII	MDKA	EXCL	PGAS
1	ADRO	1.00000	0.21218	0.32216	0.22961	0.27141
2	ASII	0.21218	1.00000	0.25609	0.16742	0.12664
3	MDKA	0.32216	0.25609	1.00000	0.24009	0.13530
4	EXCL	0.22961	0.16742	0.24009	1.00000	0.09112
5	PGAS	0.27141	0.12664	0.13530	0.09112	1.00000

Looking at Table 4, it can be seen that the correlation between the 5 stock returns does not have a strong relationship and even tends to be weak (the correlation value is close to 0), meaning that the movement between stock returns does not influence each other.

Furthermore, the estimator of the covariance value between returns of 5 stocks as shown in Table 4, is used to form the covariance matrix in the process of optimizing the investment portfolio, discussed in section 3.4.

3.4. Investment Portfolio Optimization Process

In this section, we will investigate the weight/proportion of optimum funds invested in each stock in forming a portfolio. The hope is to maximize the return rate and minimize the investment portfolio's risk level.

3.5. Formation of Mean Vector, Unit Vector, and Covariance Matrix and Covariance Matrix Inverse

This section intends to construct the mean vector, unit vector, covariance matrix, and inverse return covariance matrix of 5 stocks. From the 5 (five) stocks selected in Table 1., the estimator of the average value $\mu_i, (i = 1, \dots, 5)$ is formed by the average transpose vector $\mu^T = (0.00453\ 0.00136\ 0.00283\ 0.00171\ 0.00125)$, then the unit transpose vector is formed $e^T = (1\ 1\ 1\ 1\ 1)$. Furthermore, from Table 2, the variance value $\sigma_i^2, (i = 1, \dots, 5)$ estimator together with the covariance estimator between stock returns is used to form the covariance matrix Σ. Using the help of excel software, the inverse covariance matrix Σ^{-1} can be determined. The covariance matrix Σ and the inverse covariance matrix Σ^{-1} is expressed as follows:

$$\Sigma = \begin{bmatrix} 0.00095 & 0.00013 & 0.00030 & 0.00017 & 0.00017 \\ 0.00013 & 0.00041 & 0.00016 & 0.00008 & 0.00005 \\ 0.00030 & 0.00016 & 0.00091 & 0.00018 & 0.00008 \\ 0.00017 & 0.00008 & 0.00018 & 0.00059 & 0.00005 \\ 0.00017 & 0.00005 & 0.00008 & 0.00005 & 0.00043 \end{bmatrix}$$

$$\Sigma^{-1} = \begin{bmatrix} 1293.43 & -202.29 & -309.91 & -225.19 & -412.03 \\ -202.29 & 2725.39 & -345.14 & -204.48 & -163.95 \\ -309.91 & -345.14 & 1316.83 & -249.66 & -64.78 \\ -225.19 & -204.48 & -249.66 & 1876.66 & -34.58 \\ -412.03 & -163.95 & -64.78 & -34.58 & 2526.68 \end{bmatrix}$$

Furthermore, the inverse covariance matrix Σ^{-1} is used for the process of calculating the composition of the efficient portfolio weight which is carried out based on the Mean-Variance portfolio optimization model or called the Marwitz model.

3.6. Mean-Variance Investment Portfolio Optimization Process Without Risk Free Assets

This section intends to carry out the process of optimizing the investment portfolio without risk-free assets in IDX30 shares. Portfolio optimization based on the Mean-Variance model aims to obtain an efficient portfolio weight composition by maximizing the average expectation/return and minimizing the level of risk as measured by the variance. The problem of optimizing the Mean-Variance portfolio without risk-free assets is compiled according to equation (3). Using the vectors μ^T and e^T and the matrix Σ^{-1}, the weight vector w is calculated using equation (7). The risk tolerance τ with the condition that $\tau \geq 0$ in the investment portfolio optimisation is simulated by taking several values that meet the requirements $e^T w = 1$.

Taking the risk tolerance value is stopped if for a risk tolerance value after being substituted into equation (7), it produces a weight $w_i\ (i = 1, \dots, 5)$ which is not a positive real number and satisfies $e^T w = 1$. To simplify the calculation, use the help of Excel software. As for taking the values of risk tolerance and the results of calculating the composition of the efficient portfolio weights are given in Table 5.

Table 5: The process of optimizing a Mean-Variance investment portfolio without risk-free assets on IDX30 shares

τ	ADRO	ASII	MDKA	EXCL	PGAS	$w^T e$	μ_p	σ_p^2	μ_p/σ_p^2
0	0.45230	0.15145	0.15974	0.13883	0.09768	1	0.00306	0.00036	8.40416
0.05	0.43104	0.16090	0.15502	0.14282	0.11021	1	0.00299	0.00035	8.60699
0.1	0.40978	0.17035	0.15030	0.14682	0.12274	1	0.00292	0.00033	8.80741
0.15	0.38852	0.17980	0.14558	0.15082	0.13527	1	0.00284	0.00032	9.00339
0.2	0.36726	0.18925	0.14086	0.15481	0.14781	1	0.00277	0.00030	9.19251
0.25	0.34600	0.19870	0.13614	0.15881	0.16034	1	0.00269	0.00029	9.37198
0.3	0.32474	0.20815	0.13143	0.16281	0.17287	1	0.00262	0.00027	9.53864
0.35	0.30348	0.21760	0.12671	0.16681	0.18540	1	0.00255	0.00026	9.68892
0.4	0.28222	0.22706	0.12199	0.17080	0.19794	1	0.00247	0.00025	9.81893
0.45	0.26096	0.23651	0.11727	0.17480	0.21047	1	0.00240	0.00024	9.92446
0.5	0.23970	0.24596	0.11255	0.17880	0.22300	1	0.00232	0.00023	10.00109
0.55	0.21844	0.25541	0.10783	0.18279	0.23553	1	0.00225	0.00022	10.04434
0.6	**0.19718**	**0.26486**	**0.10311**	**0.18679**	**0.24807**	**1**	**0.00217**	**0.00022**	**10.04979**
0.65	0.17592	0.27431	0.09839	0.19079	0.26060	1	0.00210	0.00021	10.01331
0.7	0.15466	0.28376	0.09367	0.19479	0.27313	1	0.00203	0.00020	9.93130
0.75	0.13340	0.29321	0.08895	0.19878	0.28566	1	0.00195	0.00020	9.80091
0.8	0.11214	0.30266	0.08423	0.20278	0.29820	1	0.00188	0.00020	9.62031
0.85	0.09088	0.31211	0.07951	0.20678	0.31073	1	0.00180	0.00019	9.38887
0.9	0.06961	0.32156	0.07479	0.21077	0.32326	1	0.00173	0.00019	9.10732
0.95	0.04835	0.33101	0.07007	0.21477	0.33579	1	0.00166	0.00019	8.77788
1	0.02709	0.34046	0.06535	0.21877	0.34833	1	0.00158	0.00019	8.40416
1.05	0.00583	0.34991	0.06063	0.22277	0.36086	1	0.00151	0.00019	7.99110
1.2	-0.05795	0.37826	0.04647	0.23476	0.39846	1	0.00128	0.00020	6.57993

Taking into account the results in Table 5, taking the risk tolerance value is only for a value of $0 \leq \tau \leq 1.05$. This is because the value of risk tolerance $\tau > 1.05$ produces a negative weight. After obtaining the weight vector of fund allocation in forming an efficient portfolio, the next step is to estimate the portfolio return expectations and calculate the portfolio variance. The portfolio return expectation value is μ_p, and the portfolio variance is σ_p^2 for risk tolerance $0 \leq \tau \leq 1.05$.

Looking at Table 5, it can be seen that with a risk tolerance of $\tau = 1.05$, a portfolio composition is obtained that produces a minimum variance of 0.00019 with a minimum expected portfolio return of 0.00151. A series of efficient portfolios are on the efficient frontier. The efficient frontier is an efficient surface on which portfolios are located and whose returns are commensurate with the risks. Based on the results of the calculation process in Table 5, the results show that efficient portfolios are located along the line with a risk tolerance of $0 \leq \tau \leq 1.05$, where the highest portfolio return expectation is 0.00306; and the minimum portfolio average return is 0.00151 as can be seen in Figure 4.

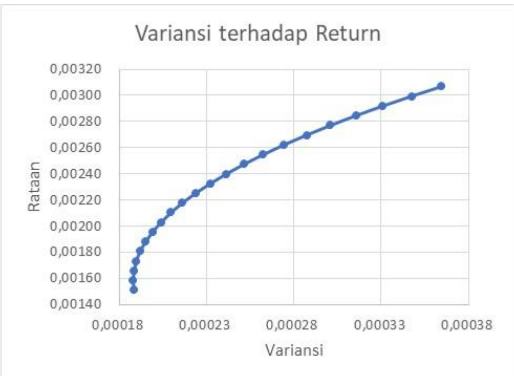

Figure 4: Efficient Frontier Mean-Variance Portfolio without Risk Free Assets on IDX30 Stocks

After obtaining a series of efficient portfolios, the next step is determining the optimum portfolio composition. Every investor wants a portfolio investment that can generate large returns but is accompanied by a small level of risk. Suppose it is assumed that investors' preferences are only based on the average return and risk of the portfolio. In that case, the selection of the optimal portfolio can be determined based on the composition of the efficient portfolio and produces the largest ratio between expected return and portfolio variance. The graph of the ratio between the average return and portfolio variance looks as given in Figure 5.

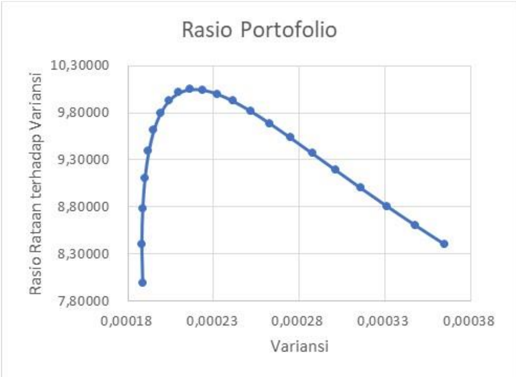

Figure 5: Plot of μ_p and σ_p^2 Ratio of Portfolio Mean-Variance without Risk Free Assets on IDX30 Stocks

From Figure 5, it can be seen that the ratio between the mean and the largest portfolio return variance is 10.04979 or is obtained when the risk tolerance is $\tau = 0.6$. The ratio between the mean and the variance of portfolio returns increased at the risk tolerance interval of $0 \leq \tau \leq 0.6$ and decreased at the risk tolerance interval of $0.6 < \tau \leq 1.05$. Complete numerical results are presented in Table 5.

In Table 5, it can also be seen that the optimal portfolio composed of 5 stocks is a portfolio with the composition of the weight vectors as follows:
$w^T = (0.19718\ 0.26486\ 0.10311\ 0.18679\ 0.24807)$, respectively, for ADRO, ASII, MDKA, EXCL and PGAS shares. This optimal portfolio composition produces an average return of 0.00217 and a variance of 0.00022.

3.7. Discussion: analysis of the results of forming an optimal investment portfolio

The calculation of the Markowitz model shows a balance between the return value and the risk. Calculations are performed with the help of Ms. software. Excel and the results are described as follows:

a. The risk tolerance for the Mean-Variance model without risk-free assets on IDX30 shares is around $0 \leq \tau \leq 1.05$.
b. The minimum portfolio for the Mean-Variance model without risk-free assets on IDX30 shares is an average return of 0.00151, a variance or risk of 0.00019, and a portfolio ratio of 7.99110.
c. The maximum portfolio for the Mean-Variance model without risk-free assets on IDX30 shares is an average return of 0.00306, a variance or risk of 0.00036, and a portfolio ratio of 9.40416.
d. The optimum portfolio for the Mean-Variance model without risk-free assets on IDX30 shares obtained an average return of 0.00217, a variance or risk of 0.00022, and a portfolio ratio of 10.04979.
e. Optimum portfolio weight for the Mean-Variance model without risk-free assets on IDX30 shares the proportion of shares ADRO=0.19718, ASII=0.26486, MDKA=0.10311, EXCL=0.18679, and PGAS=0.24807, with a value return of 0.00217, variance or risk of 0.00022, and portfolio ratio (return/risk) of 10.04979.

4. Conclussion

Based on the results of data analysis and discussion of this study, it can be concluded from this research as follows: 1) By using the Mean-Variance Portfolio Optimization Model, the optimal portfolio results are obtained, and the company included in the optimal portfolio is PT Adaro Energy Indonesia Tbk (ADRO)), PT Astra International Tbk (ASII), PT Merdeka Copper Gold Tbk (MDKA), PT XL Axiata Tbk (EXCL), PT Bukit Asam Tbk (PTBA). 2) The proportion of each share in the optimal portfolio, namely PT Adaro Energy Indonesia Tbk (ADRO) is 20%, PT Astra International Tbk (ASII) 26%, PT Merdeka Copper Gold Tbk (MDKA) 10%, PT XL Axiata Tbk (EXCL) 19%, PT Perusahaan Gas Negara (PGAS) 25% which will provide a portfolio return rate of 0.00217 and a risk of 0.00022.

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