

Optimization of the Technology Sector Stock Portfolio during the Covid-19 Pandemic Using the Markowitz Model

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ARTICLE INFO

Keywords: Stock Portfolio Optimization, Markowitz Model, Technology Sector, Covid-19 Pandemic

Received : 29 September

Revised : 10 October

Accepted: 19 October

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ABSTRACT

Stock investment in Indonesia has grown quite rapidly in recent years and has attracted the attention of many people . When investing, analysis is needed to get future profits by minimizing stock risk. One of the ways that can be used to minimize risk is to form an optimal portfolio using the Markowitz model. The technology sector is one of the stock sectors that has progressed because of the high public interest in technology-related matters during the Covid-19 pandemic. In this study , the optimal portfolio is a portfolio containing EMTK with a weight of 63% and TFAS with a weight of 37% which produces an expected return value of 0.007488 (0.7488%) and a risk value of 0.035000 (3.5%).

INTRODUCTION

Stock investment in Indonesia in recent years has developed quite rapidly and has attracted the attention of many parties. Based on data released by PT Kustodian Sentral Efek Indonesia (Sadono et al., 2021) , although the Covid-19 pandemic is still ongoing, the performance of the Jakarta Composite Index (JCI) on December 29, 2021 has reached the level of 6,600.68, the number increased by 10.4% of the position in December 2020, this shows that many people continue to invest amidst the uncertainty of the Covid-19 pandemic.

The Covid-19 pandemic was first discovered in Indonesia in early March 2020. This condition has changed many things, such as how to study, work, worship, socialize, and other things. One of the areas that has experienced a major impact due to the Covid-19 pandemic is the economic sector, this also affects investment activities so that investors need to adapt and rearrange optimal portfolios in investing because in the midst of the Covid-19 pandemic, the state of the stock market is changing and investors need to be careful (Nugroho et al., 2021) . There are several sectors in the stock, including the property industry sector and the technology industry sector. Based on previous research conducted by Saraswati (Saraswati, 2020) it was found that the share of the property industry sector experienced a high decline due to low public interest in buying property during the Covid-19 pandemic, in contrast to the technology industry sector which experienced rapid progress due to the high interest in the needs of the public. related to technology during the pandemic due to restrictions on activities.

In investing, analysis is needed to obtain future profits, because there are risks that cannot be eliminated but can be minimized. The risk in investing can be minimized by forming a portfolio that maximizes profits and minimizes risk or in other words provides optimal results (State et al., 2020) . Determining the optimal portfolio can use various models, one of which is the Markowitz model which emphasizes efforts to maximize the expected return and minimize risk to develop an optimal portfolio. The Markowitz model is also referred to as *the mean-variance model*, which means that when forming an optimal portfolio, a quantitative approach is used that relates the risk measured using standard deviation or variance with the expected return (NP Hartono et al., 2021) .

This study will examine the Markowitz model to optimize the stock portfolio of the technology sector on the Indonesia Stock Exchange (IDX) during the Covid-19 pandemic using data from the first year of the Covid-19 pandemic entering Indonesia, which is in the period March 2020 - February 2021. This research was conducted to help investors form an optimal portfolio so that they get maximum profit even though they invest during the Covid-19 pandemic.

IMPLEMENTATION AND METHODS

Data

The data used in this study is data on closing stock prices of the technology sector listed on the Indonesia Stock Exchange from March 2020 - February 2021. The

source of company data is obtained from the website www.idx.co.id which is the official website of the Indonesia Stock Exchange and price data daily closings can be accessed on the website www.finance.yahoo.com which is part of the Yahoo! which provides official stock data.

Step Analysis

The analysis in this study was carried out using the python programming language on Google Colab. Some general steps used to determine the optimal portfolio using the Markowitz model are as follows:

1. Collect closing stock price data

Closing stock price data collected in the form of daily data for each technology sector stock listed on the Indonesia Stock Exchange and can be accessed through the www.finance.yahoo.com page for the period March 2020 – February 2021.

2. Calculating the return of each stock

Stock return is one of the things that motivates investors to invest because from the return investors can see the results of their investments. The formula used to calculate stock returns is (Assof et al., 2022) :

$$R_{it} = \frac{P_{it} - P_{i(t-1)}}{P_{i(t-1)}} \quad (1)$$

where,

R_{it} = return saham i pada periode t

P_{it} = harga saham i pada periode t

$P_{i(t-1)}$ = harga saham i pada periode t - 1

3. Calculating the expected return of each stock

Expected Return is the level of return or profit expected by investors on each company's stock in the future. The calculation of expected return is useful for making investment decisions. The expected return value is obtained by the following formula (Muis, 2008) :

$$E(R_{it}) = \frac{\sum_{t=1}^N R_{it}}{N} \quad (2)$$

where,

$E(R_i)$ = return yang diharapkan dari saham i

R_{it} = return saham i pada periode t

N = jumlah periode pengamatan

4. Calculating the risk of each stock

Stock risk is a measure of spread that aims to determine the possibility of deviations between returns and expected returns. Risk is calculated for each stock that has a positive expected return value using the standard deviation (σ) (Lestari and Erdiana, 2021) . The formula used to calculate the risk of each stock is as follows (Country et al., 2020) :

$$\sigma_i = \sqrt{\frac{\sum_{t=1}^N [R_{it} - E(R_i)]^2}{N}} \quad (3)$$

where,

σ_i = risiko/standar deviasi saham i

$E(R_i)$ = return yang diharapkan dari saham i

R_{it} = return saham i pada periode t

N = jumlah periode pengamatan

5. Determining the stocks that are candidates for the portfolio
Determination of candidate portfolios is done by taking into account the expected return value. If the expected return is positive and not equal to zero, then the stock is included in the candidate portfolio.
6. Determine the number of portfolios that can be formed
Determination of the number of portfolios that can be formed using the following combination calculations (A, 2017) :

$$C_{(r,n)} = \frac{n!}{r!(n-r)!} \quad (4)$$

where,

$C_{(r,n)}$ = Kombinasi tingkat r dari n saham

$n!$ = faktorial jumlah saham

$r!$ = faktorial jumlah saham yang dikombinasi

7. Calculating the covariance between stocks in a portfolio
Covariance is a measurement to show the direction of movement of two variables. A negative covariance value of a portfolio means that an increase in the return of one stock is influenced by a decrease in the other stock, so this shows that both stocks can be diversified. The formula used to calculate the covariance value is as follows (Assof et al., 2022) :

$$\sigma_{ij} = \frac{\sum_{t=1}^N [(R_{it} - E(R_i)) \cdot (R_{jt} - E(R_j))]}{N} \quad (5)$$

where,

σ_{ij} = kovarian return antara saham i dan saham j

R_{it} = return saham i pada periode t

R_{jt} = return saham j pada periode t

$E(R_i)$ = return yang diharapkan dari saham i

$E(R_j)$ = return yang diharapkan dari saham j

N = jumlah periode pengamatan

8. Calculating the correlation coefficient between stocks
Correlation is useful to show the relationship of a stock with other stocks in the portfolio. If two stocks have returns with a correlation coefficient value of +1 (perfectly positive), then all risks cannot be diversified, whereas if two stocks have returns with a correlation coefficient value of -1 (perfect negative), then all risks can be diversified. To calculate the

correlation coefficient, the following formula is used (Muthohiroh et al., 2021) :

$$\rho_{ij} = \frac{N \sum_{i=1, j=1}^N R_{it} R_{jt} - \sum_{i=1}^N R_{it} \sum_{j=1}^N R_{jt}}{\sqrt{[N \sum_{i=1}^N R_{it}^2 - (\sum_{i=1}^N R_{it})^2][N \sum_{j=1}^N R_{jt}^2 - (\sum_{j=1}^N R_{jt})^2]}} \quad (6)$$

where,

ρ_{ij} = koefisien korelasi antara saham i dan saham j

R_{it} = return saham i pada periode t

R_{jt} = return saham j pada periode t

N = jumlah periode pengamatan

9. Define an efficient portfolio

An efficient portfolio is determined based on the calculation of covariance and correlation coefficient, if the value of covariance and correlation coefficient of a portfolio is negative, it means that both stocks can be diversified and included in an efficient portfolio.

10. Determine the proportion of funds per share

Determination of the proportion of funds to be given to each stock in the selected efficient portfolio is calculated using the Lagrange method with the following steps (Afriana et al., 2017) :

$$L(w) = w^T \Sigma w + \lambda_1 (\mu_p - w^T \mu) + \lambda_2 (1 - w^T 1_N) \quad (7)$$

The Lagrange function $L(W)$ is derived from the first derivative $L'(W) = 0$, so that the value w can be determined by the following formula:

$$w = \frac{\sum^{-1} 1_n}{1_n^T \sum^{-1} 1_n} \quad (8)$$

where,

w = proporsi dana tiap saham

\sum^{-1} = invers matriks varian - kovarian

n = jumlah saham dalam portofolio

$$1_n = \begin{bmatrix} 1 \\ 1 \\ \vdots \\ n \end{bmatrix}$$

11. Calculating the expected return of the portfolio

Expected return portfolio is the average level of expected return of each stock in the portfolio that has been formed. This calculation is carried out using the following formula (NP Hartono et al., 2021) :

$$E(R_p) = \sum_{i=1}^n w_i E(R_i) \quad (9)$$

where,

$E(R_p)$ = return yang diharapkan dari portofolio

$E(R_i)$ = return yang diharapkan dari saham i

w_i = proporsidana pada saham i

n = jumlah saham pada portofolio

12. Calculating portfolio risk

Calculation of risk for each selected efficient portfolio is based on the Markowitz model which minimizes portfolio variance. This calculation can be written in the form of a matrix multiplication between the variance-covariance matrix and the proportion of funds per share matrix (J. Hartono, 2022) . Finding the portfolio variance for a portfolio containing n-shares in matrix multiplication is expressed as follows:

$$\sigma_p^2 = [w_1 \quad w_2 \quad \dots \quad w_n] \begin{bmatrix} \sigma_1^2 & \sigma_{12} & \dots & \sigma_{1n} \\ \sigma_{21} & \sigma_2^2 & \dots & \sigma_{2n} \\ \vdots & \vdots & \dots & \vdots \\ \sigma_{n1} & \sigma_{n2} & \dots & \sigma_n^2 \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} \tag{10}$$

In this study, each portfolio contains two stocks, then the portfolio variance based on the matrix (10) can be expressed as follows,

$$\begin{aligned} \sigma_p^2 &= [w_1 \quad w_2] \begin{bmatrix} \sigma_1^2 & \sigma_{12} \\ \sigma_{21} & \sigma_2^2 \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \end{bmatrix} \tag{11} \\ &= [w_1\sigma_1^2 + w_1\sigma_{21} \quad w_2\sigma_{12} + w_2\sigma_2^2] \begin{bmatrix} w_1 \\ w_2 \end{bmatrix} \\ &= [w_1^2\sigma_1^2 + w_1w_2\sigma_{21} \quad w_1w_2\sigma_{12} + w_2^2\sigma_2^2] \\ &= w_1^2\sigma_1^2 + w_1w_2\sigma_{21} + w_1w_2\sigma_{12} + w_2^2\sigma_2^2 \\ \sigma_p^2 &= w_1^2\sigma_1^2 + w_2^2\sigma_2^2 + 2(w_1w_2\sigma_{12}) \end{aligned} \tag{12}$$

From the formula obtained, the portfolio risk can be calculated by finding the standard deviation of the portfolio by rooting the variance of the portfolio. So the formula to get the risk value of a portfolio of two stocks is as follows,

$$\sigma_p = \sqrt{w_1^2\sigma_1^2 + w_2^2\sigma_2^2 + 2(w_1w_2\sigma_{12})} \tag{13}$$

where,

σ_p = portfolio risk/standard deviation.

13. Determining the optimal portfolio

The optimal portfolio is determined based on the relationship between the expected return and risk of each portfolio by calculating the value of the

Coefficient of Variation (CV) of each portfolio with the following formula (Mercangöz, 2021) :

$$CV = \frac{\sigma_p}{E(R_p)} \quad (14)$$

where,

CV = *Coefficient of Variation* (Koefisien Variasi)

σ_p = risiko/standar deviasi portofolio

$E(R_p)$ = *return yang diharapkan dari portofolio*

14. Draw a conclusion

The conclusion is drawn by presenting the selected optimal portfolio data in the form of the proportion of funds per share in the portfolio as well as the return and portfolio risk values obtained from several efficient portfolios that have been formed.

RESULTS AND DISCUSSION

Research data

The data used in this study is based on data on closing stock prices of the technology sector listed on the Indonesia Stock Exchange. Stock data selection is done by recording all active technology sector stocks during the observation period March 2020 - February 2021 and can be accessed on the www.finance.yahoo.com page. The following is a list of technology sector stocks that are listed on the Indonesia Stock Exchange and have complete stock price closing data from March 2020 - February 2021:

Table 1. List of Technology Sector Stocks for the Period March 2020 - February 2021

Stock code	Company name
ATIC	Anabatic Technologies Tbk.
DIVA	Voucher Distribution Nusantara Tbk.
DMMX	Digital Mediatama Maxima Tbk.
EMTK	Eagle Mahkota Teknologi Tbk.
GLVA	Galva Technologies Tbk.
HDIT	Hensel Davest Indonesia Tbk.
STALL	Kioson Commercial Indonesia Tbk.
CREN	Kresna Graha Investama Tbk.
LMAS	Limas Indonesia Makmur Tbk.
LUCK	Sentral Mitra Informatika Tbk.
MCAS	M Cash Integration Tbk.
MLPT	Multipolar Technology Tbk.
MTDL	Metrodata Electronics Tbk.
NFCX	NFC Indonesia Tbk.
PGJO	Tourindo Guide Indonesia Tbk.
PTSN	Sat Nusapersada Tbk.

Process Analysis

1. Calculating the Return and Expected Return of Each Share

After the closing price of the shares is obtained, the return value of each share can be calculated using equation (1). Furthermore, if the return value has been obtained, then the expected return for each stock can be calculated based on equation (2). The results of the calculation of the expected return of each stock during the observation period are as follows:

Table 2. Expected Return of Each Share

Stock code	$E(R_i)$
ATIC	0.002296
DIVA	0.001525
DMMX	0.007129
EMTK	0.007024
GLVA	0.002216
HDIT	-0.003603
STALL	0.005964
CREN	-0.005924
LMAS	-0.000392
LUCK	0.001121
MCAS	0.004456
MLPT	0.006129
MTDL	0.000612
NFCX	-0.000069
PGJO	0.000023
PTSN	0.000845
TFAS	0.008277

In Table 2. it is shown that the highest stock return is TFAS stock with a value of 0.008277, while the stock with the lowest return is KREN stock. with a value of -0.005924.

2. Calculating the Risk of Each Share

In calculating the risk or standard deviation of each stock, (σ_i) it is necessary to first know the return value and expected return of each stock. Calculation of risk is based on equation (3). The results obtained from the calculation of the risk value of each share are as follows:

Table 3. Risk of Each Share

Stock code	σ_i
ATIC	0.063828
DIVA	0.049433
DMMX	0.057645
EMTK	0.044701
GLVA	0.044515

HDIT	0.039014
STALL	0.071581
CREN	0.061403
LMAS	0.033081
LUCK	0.059015
MCAS	0.043739
MLPT	0.051289
MTDL	0.028892
NFCX	0.043251
PGJO	0.050483
PTSN	0.042101
TFAS	0.059440

3. Determine the Portfolio Formed

Stocks that can be portfolio candidates are stocks that have a positive expected return value. Based on the results of the calculation of the expected return value in table 2, there are 13 stocks that have a positive expected return value and are candidates in the portfolio, namely ATIC, DIVA, DMMX, EMTK, GLVA, KIOS, LUCK, MCAS, MLPT, MTDL, PGJO, PTSN, and TFAS.

Based on the stocks that are candidate portfolios, the number of portfolios that can be formed provided that each portfolio contains two stocks can be calculated

using the formula $C_{(r,n)} = \frac{n!}{r!(n-r)!}$, resulting in:

$$C_{(13,2)} = \frac{13!}{2!(13-2)!} = 78$$

The results of the preparation of the 78 portfolios formed are:

Table 4. Stock Portfolio Formed

No.	Stock code	No.	Stock code	No.	Stock code
1	ATIC - DIVA	27	DMMX - LUCK	53	KIOSK - MLPT
2	ATIC - DMMX	28	DMMX - MCAS	54	KIOSK - MTDL
3	ATIC - EMTK	29	DMMX - MLPT	55	KIO - PGJO
4	ATIC - GLVA	30	DMMX - MTDL	56	KIOSK - PTSN
5	ATIC - KIOS	31	DMMX - PGJO	57	KIOSK - TFAS
6	ATIC - LUCK	32	DMMX - PTSN	58	LUCK - MCAS
7	ATIC - MCAS	33	DMMX - TFAS	59	LUCK - MLPT
8	ATIC - MLPT	34	EMTK - GLVA	60	LUCK - MTDL
9	ATIC - MTDL	35	EMTK - KIOSK	61	LUCK - PGJO
10	ATIC - PGJO	36	EMTK - LUCK	62	LUCK - PTSN
11	ATIC - PTSN	37	EMTK - MCAS	63	LUCK - TFAS
12	ATIC - TFAS	38	EMTK - MLPT	64	MCAS - MLPT
13	DIVA - DMMX	39	EMTK - MTDL	65	MCAS - MTDL
14	DIVA - EMTK	40	EMTK - PGJO	66	MCAS - PGJO

15	DIVA - GLVA	41	EMTK - PTSN	67	MCAS - PTSN
16	DIVA - KIOSSE	42	EMTK - TFAS	68	MCAS - TFAS
17	DIVA - LUCK	43	GLVA - KIOSK	69	MLPT - MTDL
18	DIVA - MCAS	44	GLVA - LUCK	70	MLPT - PGJO
19	DIVA - MLPT	45	GLVA - MCAS	71	MLPT - PTSN
20	DIVA - MTDL	46	GLVA - MLPT	72	MLPT - TFAS
21	DIVA - PGJO	47	GLVA - MTDL	73	MTDL - PGJO
22	DIVA - PTSN	48	GLVA - PGJO	74	MTDL - PTSN
23	DIVA - TFAS	49	GLVA - PTSN	75	MTDL - TFAS
24	DMMX - EMTK	50	GLVA - TFAS	76	PGJO - PTSN
25	DMMX - GLVA	51	KIO - LUCK	77	PGJO - TFAS
26	DMMX	- 52		78	
	KIOSK		KIOSK - MCAS		PTSN - TFAS

4. Calculating Covariance Between Stocks in Portfolio

The next step is to calculate the covariance value between stocks in the formed portfolio. The calculation of covariance is based on equation (5), which aims to show the direction of movement of the two stocks in the portfolio. Some of the results of the covariance between stocks can be seen as follows:

Table 5. Covariance between Stocks in Portfolio

Stock code	Covariance
ATIC - DIVA	0.000092
ATIC - DMMX	-0.000091
ATIC - EMTK	0.000213
⋮	⋮
PTSN - TFAS	0.000012

The covariance value can be in the form of positive or negative numbers, however, the expected condition is that the covariance is negative, because if it is negative then the two stocks in the portfolio move in opposite directions and can be diversified or combined.

5. Calculating the Correlation Coefficient Between Stocks

Correlation is useful for showing the relationship of a stock with other stocks in a portfolio. The expected condition in the correlation is the same as the covariance, i.e. the result is negative, because if the correlation coefficient is negative, then all the risks can be diversified. Some of the results of the calculation of the correlation coefficient of each stock in the portfolio based on equation (6) are as follows:

Table 6. Correlation Coefficient Between Stocks in Portfolio

Stock code	Correlation coefficient
ATIC - DIVA	0.028975
ATIC - DMMX	-0.024639
ATIC - EMTK	0.074255
⋮	⋮
PTSN - TFAS	0.004956

6. Define an Efficient Portfolio

Determination of an efficient portfolio is based on the results of the calculation of covariance and correlation coefficient of each portfolio that has been formed. Portfolios that have a covariance value and a negative correlation coefficient are included in the efficient portfolio. Based on the value of covariance and correlation coefficient, there are 28 portfolios that include efficient portfolios, namely:

Table 7. Efficient Portfolio

No.	Stock code	No.	Stock code
1	ATIC-DMMX	15	EMTK-TFAS
2	ATIC-GLVA	16	GLVA-Kiosk
3	ATIC-KIOS	17	GLVA-MLPT
4	ATIC-MCAS	18	GLVA-PGJO
5	ATIC-MLPT	19	GLVA-PTSN
6	DIVA-GLVA	20	KIOS-LUCK
7	DIVA-KOST	21	KIOS-MCAS
8	DIVA-PGJO	22	KIOS-MLPT
9	DMMX-EMTK	23	KIOS-MTDL
10	DMMX-Kiosk	24	LUCK-MTDL
11	DMMX-PGJO	25	LUCK-PTSN
12	EMTK-GLVA	26	MCAS-PGJO
13	EMTK-Kiosk	27	MLPT-PGJO
14	EMTK-MLPT	28	PGJO-TFAS

7. Determining the Proportion of Stock Funds in the Portfolio

Determination of the proportion of funds for each stock in an efficient portfolio is carried out to produce an optimal portfolio. The proportion of funds for each share in the portfolio is determined based on the Langrange method in equation (7). The results of the calculation of the proportion of funds per share in each portfolio are:

Table 8. Proportion of Equity Funds in Portfolio

Stock code	Proportion of Funds (w)
ATIC-DMMX	0.45 : 0.55
ATIC-GLVA	0.33 : 0.67
ATIC-KIOS	0.55 : 0.45
⋮	⋮
PGJO-TFAS	0.58 : 0.42

8. Determining Expected Return and Portfolio Risk

Expected return portfolio ($E(R_p)$) is the average level of the expected return of each stock in the portfolio associated with the proportion of funds per share in the portfolio formed. Equation (8) is the basis used to calculate the expected return of the portfolio ($E(R_p)$). While the calculation of portfolio risk (σ_p) is based on the Markowitz model in equation (8) which aims to minimize portfolio variance. the expected return and risk values of each efficient portfolio formed are as follows:

Table 9. Expected Return and Portfolio Risk

Stock code	$E(R_p)$	σ_p
ATIC-DMMX	0.004954	0.042251
ATIC-GLVA	0.002242	0.036117
ATIC-KIOS	0.003946	0.045568
⋮	⋮	⋮
PGJO-TFAS	0.003490	0.038116

9. Determining the Optimal Portfolio

The optimal portfolio is determined based on the relationship between expected return and risk for each portfolio formed by determining the value of the Coefficient of Variation (CV) according to equation (9). The portfolio with the smallest Coefficient of Variation (CV) is the best portfolio. The results obtained for the Coefficient of Variation (CV) portfolio are:

Table 10. Coefficient of Variation (CV) portfolio

Stock code	CV
ATIC-DMMX	8.528235
ATIC-GLVA	16.10597
ATIC-KIOS	11.54662
⋮	⋮
PGJO-TFAS	10.92229

The relationship between the expected return and risk of each portfolio adjusted for the smallest portfolio Coefficient of Variation (CV) value can be expressed in the form of a graph made using python, which produces the following graph:

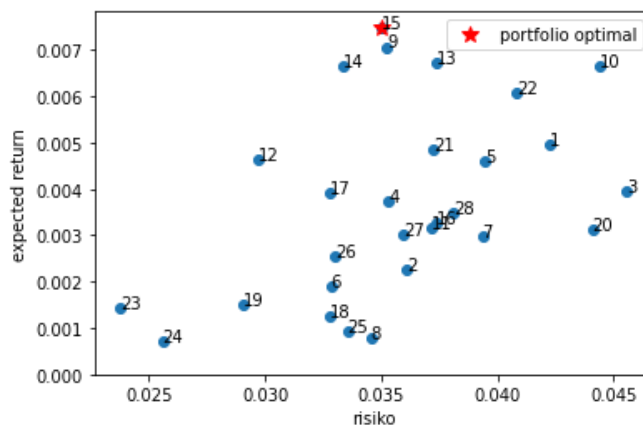


Figure 1. The relationship between expected return and portfolio risk

Based on Figure 1. it can be seen that the optimal portfolio is portfolio 15 because it produces the smallest portfolio Coefficient of Variation (CV) value, which is 4.674268. Portfolio 15 contains 63% EMTK (Elang Mahkota Teknologi Tbk.) shares and 37% TFAS (Telefast Indonesia Tbk.) shares with the highest expected return value compared to other portfolios, namely 0.007488 (0.7488%) and the risk value is not the smallest value compared to other portfolios. the other portfolio is 0.035000 (3.5%).

CONCLUSIONS AND RECOMMENDATIONS

The results showed that of the 28 available efficient portfolios, it was found that the optimal portfolio is a portfolio containing EMTK and TFAS shares with the proportion of funds for each share is 63% : 37%. In other words, investors must invest in EMTK (Elang Mahkota Teknologi Tbk.) companies with a share of 63% and in TFAS companies (Telefast Indonesia Tbk.) with a share of 37%. The *expected return* and risk resulting from the optimal portfolio formed by the Markowitz model are 0.007488 (0.7488%) and 0.035000 (3.5%). The risk value generated from the portfolio has a lower value than the risk value of individual stocks, where EMTK shares are worth 0.044701 (4.4701%) and TFAS shares are worth 0.059440 (5.9440%), so that with the diversification between EMTK and TFAS stocks, the risk value has been minimized. .

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