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Designing Optimal Green Investment Portfolio Using Markowirtz Model

Muhammad M. Hakim[1], **Nurhayati**[2], **Joko Setiawan**[3]
[1] University of Dr. Soetomo, Indonesia
[2] University of Dr. Soetomo, Indonesia
[3]STIE GICI Business School, Indonesia

Corresponding Author: muhammad.mhakim3@gmail.com[1]

Abstract: *This research aims to create an optimal portfolio that is not only profitable from a financial perspective, but also takes into account the concept of natural and social environmental sustainability (green investment). Trends and public attention towards sustainability concepts are not only limited to consumption patterns but have also expanded to investment behavior. In other words, people are not only considering the financial returns of their investments, but also their contributions to the natural environment, the economy, and social welfare. The chosen research approach was quantitative, with analysis based on the Markowitz Model. The Markowitz Model was used to construct a stock portfolio from stocks included in the SRI-Kehati index during the period of 2020-2023. The data that has been collected was then analyzed using the Solver Add-ins in Microsoft Excel. The study findings indicated that out of 12 stocks tested, there were 4 stocks that are ideal to include in the optimal portfolio, consisting of BBCA (with a weight of 37.59%), KLBF (with a weight of 30.44%), SIDO (with a weight of 21.67%), and TLKM (with a weight of 10.30%). From these four stocks, the expected return from the investment portfolio is 0.00522211, and the portfolio risk is 0.0391. This study was expected to help investors determine optimal portfolio diversification, while being sustainable not only from a financial perspective, but also ecologically and socially.*

Keyword: Optimal Portfolio, Green Investment, Markowitz model, SRI-Kehati Index

INTRODUCTION

In recent years, the trend of eco-friendly products has increased and become a major concern (Pangkong et al., 2020). People as consumers currently prefer products that are free from environmental issues (Khachatryan et al., 2023), such as climate change and pollution, and tend to choose companies that have reduced their carbon footprint in their production processes (Darsyah et al., 2024). The reason for this trend is because sustainable products are considered a way to

minimize the negative impacts of human activities on the environment (Han, 2021; Kim & Lee, 2023). Second, currently there is an increase in consumer awareness regarding the use of hazardous chemicals and toxins in many conventional products (Alamsyah & Muhammed, 2018; Cam, 2023). Furthermore, the trend of using eco-friendly products is currently becoming increasingly popular because consumers are starting to realize the long-term benefits of making environmentally conscious choices (Alamsyah & Muhammed, 2018). By choosing eco-friendly products, consumers can not only reduce their environmental impact but also save money in the long run. For example, energy-efficient appliances can help lower utility bills, while organic products can improve health and reduce the risk of pesticide exposure.

Similar to consumption trends, in investment activities there is also a trend of increasing investor awareness to choose to invest their capital in issuers with a positive reputation (Rounok et al., 2023). Climate change, depletion of natural resources, and pollution are causing significant damage to the earth, and increasing awareness of society to take action to address these issues is one of the highest factors causing investment in green companies (Ye & Dela, 2023). By investing in companies that are committed to reducing their carbon footprint, conserving resources, and promoting renewable energy, individuals can play a role in contributing to a more sustainable future. Moreover, someone invests in a company that prioritizes the concept of sustainability are also related to the potential for financial gain (Van Zanten & Rein, 2023). Research has shown that companies with strong environmental, social, and governance (ESG) practices tend to outperform their competitors financially in the long run. This is because sustainable practices can result in cost savings, increased efficiency, and improved brand reputation, all of which can result in competitive advantage and increased profitability for companies (Tarnovskaya, 2023; Gómez-Bezares et al., 2017).

In addition, as consumer preferences shift to more environmentally friendly products and services, companies that fail to adapt to implementing sustainable practices risk losing market share and facing reputational damage (Santoso, 2024). By investing in companies that are in line with changing consumer preferences and sustainable trends, investors can position themselves to gain more benefits from the opportunities presented by existing trends. However, the next question that arises is *"what are the best considerations needed in choosing sustainable investments?"*. This question arises as a result of the fact that companies that prioritize the concept of sustainability cannot always maintain their financial performance well. In other words, investors cannot only consider the concept of sustainability carried out by a company, but they also need to consider the sustainability of the benefits of the investment itself. This is because one of the main goals of someone making an investment is to obtain profits and control rights over the company from the investment mechanism (Luong & Ha, 2011). For this purpose, investments are made in order to obtain income or income from each share they invest in the company, which is referred to as dividends (Leković, 2018).

However, economic reality will always be related to return and risk (Leković, 2018). In other words, profits obtained from dividends or capital gains may also be accompanied by the risk of loss. Based on this assumption, every investor needs to be rational, by estimating the future, analyzing the most potential investments and estimating the risks, while trying to identify certain investment alternatives. This is what is then referred to as investment diversification, which refers to a strategy in managing risk and maximizing potential profits in an investment portfolio (Sulastri et al., 2016). The concept of investment diversification refers to the practice of dividing investments into different types of assets, sectors, or geographic regions to reduce the negative impact of market fluctuations on the overall value of the portfolio (Leković, 2018). In other words, diversification aims to not put all "potential eggs" in one basket. This strategy is based on the

principle that different assets do not always move in the same direction at the same time, so that the bad movement of one asset can be offset by the positive performance of another asset (Page & Panariello, 2018). In short, this strategy aims to reduce the specific risk associated with a single investment. This risk, often referred to as idiosyncratic risk or unique risk, comes from factors that only affect one company or sector (Liu & Wang, 2021). For example, if an investor only invests in the shares of one technology company and that company experiences a decline in performance, then the entire investment portfolio could be affected. By diversifying investments into sectors such as energy, healthcare, and financials, and various types of assets such as stocks, bonds, and real estate, the risks faced are more spread out and not concentrated in one point.

However, it is important to note that diversification is not an absolute guarantee against losses. Although this strategy can reduce risk, no investment method is completely risk-free. Diversification can only reduce certain risks and help manage risk more effectively, not eliminate all possible losses (Chao, 2018). Therefore, investors must remain wise in choosing assets and continue to monitor and adjust their portfolios according to changes in market conditions and their investment goals. Including, one way to build an optimal investment portfolio can be done with the Markowitz model, developed by Harry Markowitz in 1952 (Hanif et al., 2021). This model emerged as an improvement on the efficient portfolio, which only considers the higher rate of return compared to other portfolios with the same level of risk, or which provides the smallest risk with the same expected rate of return (Halim, 2015). While the optimal portfolio also considers risk preferences and investment returns that match investors. In other words, an efficient portfolio is not always an optimal portfolio, while an optimal portfolio is definitely an efficient portfolio.

In determining the optimal portfolio, there is an assumption that all investors are "risk-averse", or prefer lower returns with minimal risk, compared to high returns with uncertain risk. This study was then conducted to determine the optimal portfolio that can be chosen by investors for companies that prioritize the concept of sustainability. This study can make it easier for investors to choose decisions and determine a green portfolio that is considered efficient and optimal, namely with a certain expected return with the lowest risk. The green portfolio in this study referred to the investment that will be created from issuers that have been proven to contribute to the development of the environment, society, and the economy of the community. Thus, the companies selected as data in this study refer to various companies included in the SRI-Kehati index, which is one of the stock market indexes in Indonesia designed to measure the performance of stocks that meet the criteria for sustainability and corporate social responsibility (Targanski & Murhadi, 2021). This index was launched in 2009 by the Kehati Foundation (Indonesian Biodiversity Foundation), a non-governmental institution that focuses on biodiversity conservation and sustainable development in Indonesia (Zulkafli et al., 2017).

The gap in this research lies in the fact that the Markowitz model used in previous studies only assumes that returns and risks can be measured by a normal distribution, where in this condition investors behave rationally. However, researchers in this case assumed that the distribution of market returns may not be normal, and investors often exhibit behavior that is not entirely rational or there are certain emotional considerations. In other words, in addition to including complex return distributions, human behavioral factors such as investor preferences need to be discussed. Moreover, based on the researchers' scientific research, until now there have been few studies that use the Markowitz Model and integrate it with social and environmental factors in forming an optimal portfolio. Thus, the novelty in this study is related to the fact that although there have been many studies that review the use of the Markowitz model in forming an optimal investment portfolio, previous studies only consider aspects of liquidity and company financial performance. While in this study, the Markowitz model also considers the selection of companies

that have credibility in terms of the Environment, Social, and Governance (ESG) Index, so that it is in accordance with investor preferences that prioritize investments that are not only sustainable in terms of finance, but also contribute to nature and society.

METHOD

This study used a quantitative approach, with secondary data types obtained from the Indonesia Stock Exchange (IDX). The data used is a list of closing stock prices from issuers included in the SRI-Kehati index. The inclusion criteria used were: a) issuers or companies listed on the IDX during the 2020-2023 period; b) issuers are consecutively listed as companies in the SRI-Kehati index during the 2020-2023 period; c) issuers have attributable dividend profits and do not conduct stock splits during the 2020-2023 period; d) companies present dividend and stock value data consecutively during the 2020-2023 period. Of the total 25 companies listed in the SRI-Kehati index in 2023, 10 of them do not meet the second criterion because they are not consecutively listed in the SRI-Kehati index during the study period, and 3 of them do not meet the third criterion because they have negative profits so they do not have attributable dividend profits during the study period. Thus, the total number of companies used in this study were 12 companies, consisting of: Astra International Tbk (ASII); Bank Central Asia Tbk (BBCA); Bank Negara Indonesia (Persero) Tbk (BBNI); Bank Rakyat Indonesia (Persero) Tbk (BBRI); Bank Mandiri (Persero) Tbk (BMRI); Indofood Sukses Makmur Tbk (INDF); Kalbe Farma Tbk (KLBF); Sido Herbal Medicine and Pharmaceutical Industry Tbk (SIDO); Semen Indonesia (Persero) Tbk (SMGR); Telekomunikasi Indonesia (Persero) Tbk (TLKM); United Tractors Tbk (UNTR); Unilever Indonesia Tbk (UNVR). The data that has been collected was then analyzed using the Markowitz Model with the help of Microsoft Excel, with the stages described as follows.

1. Calculate the return of each stock, using the following formula.

   $$R_{it} = \frac{P_t - P_{t-1} + D_1}{P_{t-1}}$$

   .....(1)

   Informations:

   R_{it} = Return at expected time
   P_{t-1} = Stock price at the beginning of the period
   P_t = Stock price at the end of the period
   D_1 = Dividends distributed

   Source: Hartono (2013)

2. Calculate the expected return on each company's shares, using the following formula.

   $$E(R_{it}) = \sum_{t=1}^{n} (P_j \times R_{it})$$

   .....(2)

   Informations:

   $E(R_i)$ = Expected return of the issuer at time i
   n = Number of possible returns
   P_j = Probability of return occurrence at time j for issuer i

   Source: Hartono (2013)

3. Calculate the risk (variance and standard deviation) for n < 30, using the following formula.

$$\sigma_i^2 = \frac{\sum_{j=1}^{n}(P_j)[R_{ij}-E(R_{ij})]^2}{n-1}$$

.....(3)

and with:

$$\sigma = \sqrt{\frac{\sum_{j=1}^{n}(P_j)[R_{ij}-E(R_{ij})]^2}{n-1}}$$

.....(4)

Informations:

σ^2 = Variance of return
σ = Standard deviation or risk
R_{ij} = Return at time j for issuer i
n = Number of possible returns

Source: Husnan (2001)

4. Calculate the correlation coefficient of stock prices between companies, using the following formula.

$$R_{AB} = \frac{\sigma_{AB}}{\sigma_A \, x \, \sigma_A}$$

.....(5)

Informations:

R_{AB} = Correlation between return of stock A and return of stock B
σ_A = Standard deviation or risk of stock A
σ_B = Standard deviation or risk of stock B

Source: Hartono (2013)

5. Calculate the covariance between two stocks in a portfolio, using the following formula.

$$Cov\,(R_A.R_B) = \sigma_{RA.RB}$$

.(6)

with:

$$\sigma_{RA.RB} = \sum_{i=1}^{n} \frac{[(R_{Ai}-E(R_A)].[(R_{Bi}-E(R_B)]}{n}$$

.....(7)

Informations:

$Cov(R_A.R_B)$ = Covariance of stock A with stock B
R_{Ai} = Future return of stock A at time condition i
R_{Bi} = Future return of stock B at time condition i
$E(R_A)$ = Expected return of stock A
$E(R_B)$ = Expected return of stock B

Source: Hartono (2013)

6. Using Microsoft Excel Solver to minimize ratios and optimize stock proportions.
7. Determining optimal portfolio investment decisions.
8. Calculating the expected return of the optimal portfolio.

$E(R_P) = \sum_{i=1}^{n} Xi \times E(R_i)$ .....(8)

Informations:

$E(R_p)$ = Expected return of portfolio

X_i = Proportion of funds invested in stock i

$E(R_i)$ = Expected return of stock i

Source: Husnan (2001)

9. Calculate the risk (variance and standard deviation) of the optimal portfolio.

$\sigma_p{}^2 = X_A{}^2.\sigma_A{}^2 + X_B{}^2.\sigma_B{}^2 + 2X_AX_B\sigma_{AB}$.....(9)

If expressed as a standard deviation, then portfolio risk can be expressed using the following formula:

$\sigma_P = \sqrt{X_A{}^2.\sigma_A{}^2 + X_B{}^2.\sigma_B{}^2 + 2X_AX_B\sigma_{AB}}$

.....(10)

Informations:

$\sigma_p{}^2$ = Portfolio variance

σ_P = Portfolio standard deviation (risk)

X_A = Proportion of investment for stock A

X_B = Proportion of investment for stock B

$\sigma_A{}^2$ = Variance of stock returns for stock A

$\sigma_B{}^2$ = Variance of stock returns for stock B

σ_{AB} = Covariance of stock returns A and stock returns B

Source: Hartono (2013)

In general, this research consists of a flow which is described as follows.

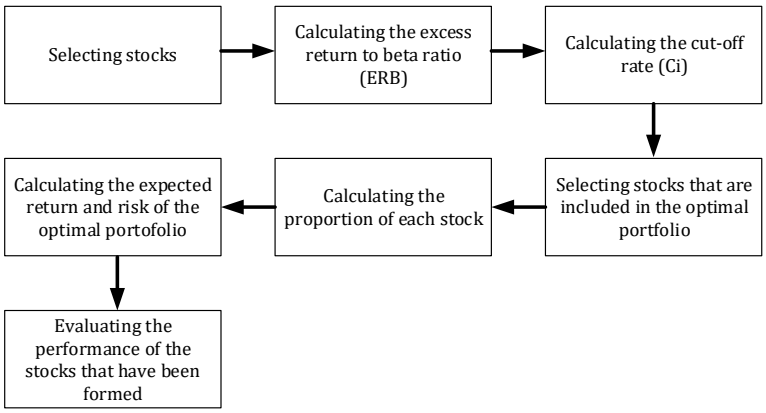

Figure 1. Research Flow

RESULTS AND DISCUSSION

The data used in this study comes from the closing price data of shares of companies included in the SRI-Kehati index in 2020-2023, which is presented in the following figure.

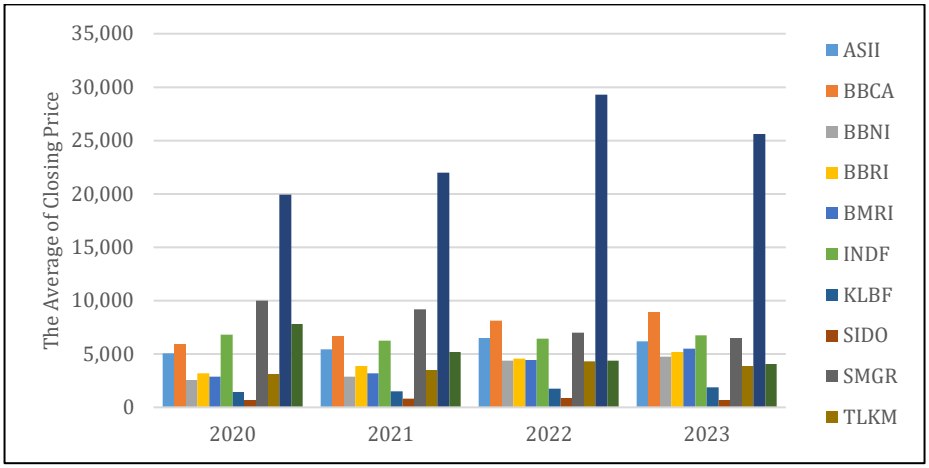

Figure 2. Average Shares of Sample Companies

Based on the figure, it can be said that all companies have closing stock prices that always change from year to year. All companies have an average (mean) closing price that fluctuates and there is no pattern of always going up or down during the period 2020 to 2023. Overall, for the research period from 2020 to 2023, UNTR has the highest mean closing price compared to other sample companies, with the highest mean closing price obtained in 2022.

Meanwhile, the expected return level for each share can be seen in the following table.

Table 1. Expected Return of Each Stock

No.	Company	Expected Return or E(Ri)
1	ASII	0.204%
2	BBCA	0.950%
3	BBNI	1.590%
4	BBRI	1.096%
5	BMRI	1.418%
6	INDF	-0.222%
7	KLBF	0.413%
8	SIDO	0.033%
9	SMGR	-0.728%
10	TLKM	0.312%
11	UNTR	0.914%
12	UNVR	-1.470%

The expected return level is the average return for each stock in the period 2020 to 2023. Stocks that have an expected return with a positive sign indicate an implication that the stock can provide benefits to its shareholders. INDF, SMGR, and UNVR in the table 1 are known to have expected returns with a negative sign, which indicates a loss received by the shareholders. Thus, in the next stage INDF, SMGR, and UNVR will be eliminated because they cannot be used in forming an optimal portfolio.

Table 2. Individual Stock Risk

No.	Company	Risk
1	ASII	9.547%
2	BBCA	5.607%

3	BBNI	11.540%
4	BBRI	8.394%
5	BMRI	8.699%
6	KLBF	5.800%
7	SIDO	7.633%
8	TLKM	6.930%
9	UNTR	10.903%

After eliminating the negative expected stock returns, the next step is to calculate the investment risk for each stock. The common method for calculating risk in stocks is standard deviation or denoted as σ_i which assesses the absolute deviation of the realized return with its expected return. Return and risk in stocks have a correlation that is in the same direction, positive or directly proportional. In the sense that an investment that has a high rate of return also has the possibility of a high risk. The table 2 showed that the highest risk (standard deviation) is obtained in BBNI shares, which is 11.540%. While the lowest standard deviation is in BBCA at 5.607%. The higher the standard deviation, the higher the deviation between the actual return and the expected return. So investors are advised to choose stocks with the lowest investment standards among several other stocks in forming a portfolio.

Furthermore, it is very important in the concept of portfolio optimization to consider the correlation coefficient between issuers, where Markowitz suggested that forming a portfolio of stocks that have less than perfect positive coefficients result in a better level of diversification. Therefore, the covariance needs to be calculated first, where the results of the covariance calculation in this study are presented in the following table.

Table 3. Variance-Covariance Matrix between Stocks

	ASII	BBCA	BBNI	BBRI	BMRI	KLBF	SIDO	TLKM	UNTR
ASII	0.009114	0.003119	0.004640	0.003946	0,005418	0,001124	-0,000016	0,001466	0,002773
BBCA	0.003119	0.003143	0.003921	0.003137	0,003542	0,000604	-0,000021	0,001657	0,002230
BBNI	0.004640	0.003921	0.013317	0.006730	0,007394	0,001720	0,001800	0,004374	0,002201
BBRI	0.003946	0.003137	0.006730	0.007045	0,004793	0,000637	0,000232	0,002818	0,001867
BMRI	0.005418	0.003542	0.007394	0.004793	0,007567	0,001242	0,000019	0,001928	0,002424
KLBF	0.001124	0.000604	0.001720	0.000637	0,001242	0,003364	0,000780	0,001086	0,001321
SIDO	-0.000016	-0.000021	0.001800	0.000232	0,000019	0,000780	0,005826	0,000386	0,000394
TLKM	0.001466	0.001657	0.004374	0.002818	0,001928	0,001086	0,000386	0,004803	0,002239
UNTR	0.002773	0.002230	0.002201	0.001867	0,002424	0,001321	0,000394	0,002239	0,011887

Covariance indicates whether the assets in a portfolio move in the same direction. A positive covariance indicates that the assets generally move in the same direction, while a negative covariance indicates that the movement between assets is not in the same direction. For example, the covariance between ASII and SIDO has a negative sign (i.e. -0.000016), which therefore indicates the opposite movement of the stock. While the covariance between ASII and BBCA has a positive sign (i.e. 0.003119) which means that the stock has a movement in the same direction. In the table, it is known that the highest covariance is in BBNI with BMRI, which is 0.003542, both of which are in the same sector (finance). While the lowest covariance is in BBCA with SIDO, which is -0.000021, both of which are in different sectors (finance with health). And in building a portfolio, it is important to select assets that have negative or low covariance between one another, so that the overall risk can be suppressed.

However, covariance can only be used to measure the direction between two stocks being compared, not to indicate the strength of the relationship between one asset and another. Therefore, a correlation coefficient is also needed in portfolio diversification. It is important in forming a portfolio to consider the correlation between expected returns and expected volatility between investments or stocks. Correlation is calculated on a scale of -1.0 to 1.0. A correlation value of 1.0 indicates that one stock has a highly related return to another. For example, if an asset has a correlation of 1.0 with another asset, then the profit from each asset is 50% in the proportion consisting of the two assets. Likewise, if a loss occurs, both assets will experience losses in the same proportion. In short, the higher the correlation value between assets, the less likely diversification can be done in the portfolio. Thus, it is important for investors to consistently look for asset columns with low correlation values or close to zero in order to limit risk. In this study, the correlation coefficient matrix can be presented as follows.

Table 4. Correlation Coefficient Matrix between Stocks

	ASII	BBCA	BBNI	BBRI	BMRI	KLBF	SIDO	TLKM	UNTR
ASII	1.000000	0.753265	0.443250	0.591091	0.774675	-0.179524	-0.520823	0.062931	0.063871
BBCA	0.753265	1.000000	0.752323	0.864915	0.921418	-0.308795	-0.617155	0.437216	0.133652
BBNI	0.443250	0.752323	1.000000	0.857898	0.837758	-0.081646	-0.148863	0.624070	-0.196883
BBRI	0.591091	0.864915	0.857898	1.000000	0.850468	-0.304382	-0.416790	0.563734	-0.118860
BMRI	0.774675	0.921418	0.837758	0.850468	1.000000	-0.133917	-0.464435	0.354922	-0.041350
KLBF	-0.179524	-0.308795	-0.081646	-0.304382	-0.133917	1.000000	-0.083707	-0.091249	-0.032525
SIDO	-0.520823	-0.617155	-0.148863	-0.416790	-0.464435	-0.083707	1.000000	-0.332474	-0.300043
TLKM	0.062931	0.437216	0.624070	0.563734	0.354922	-0.091249	-0.332474	1.000000	0.081331
UNTR	0.063871	0.133652	-0.196883	-0.118860	-0.041350	-0.032525	-0.300043	0.081331	1.000000

The table showed that each column has its negative and positive correlation coefficient. This means that there is a possibility to optimize expected returns at a certain risk level with a combination of stocks tested. Because, with a negative correlation coefficient, it means that the tendency to lose value at the same time can be suppressed.

In determining the expected return and portfolio risk, the first step taken was to determine the proportion or weight of each stock. The proportion of stocks is determined by finding the stock variance using the MMULT function in Microsoft Excel, so that the Variance and Weight of each stock are obtained as follows.

Table 5. Variance and Weight of Portfolio

Stocks	Variance 1 (V1)	Variance 2 (V2)	Weight 1 (W1)	Weight 2 (W2)
ASII	-15.84368855	-1.971433227	-0.020269356	-0.665791632
BBCA	327.5615362	2.567623528	0.419060332	0.867136779
BBNI	-173.7215605	0.179950326	-0.222247751	0.060772751
BBRI	48.72454965	0.536522006	0.062334932	0.181193995
BMRI	61.15158074	1.57780736	0.078233244	0.532856463
KLBF	216.8482673	0.87041125	0.277421177	0.293954935
SIDO	186.67427	-0.09181083	0.238818582	-0.031006316
TLKM	150.4840381	-1.136207558	0.192519218	-0.383719557
UNTR	-20.22176714	0.428173502	-0.025870377	0.144602582

The next step was to calculate the expected return and risk of the portfolio with the alpha that has been determined as follows.

Table 6. Risk and Expected Return of All Formed Portfolios

Alpha	Weights of Each Stocks									Expected Return of Portfolio	Variance of Portfolio	Risk
	ASII	BBCA	BBNI	BBRI	BMRI	KLBF	SIDO	TLKM	UNTR			
0.1	-0.6012	0.8223	0.0325	0.1693	0.4874	0.2923	-0.0040	-0.3261	0.1276	0.0172	0.0054	0.0732
0.2	-0.5367	0.7775	0.0042	0.1574	0.4419	0.2906	0.0230	-0.2685	0.1105	0.0157	0.0045	0.0671
0.3	-0.4721	0.7327	-0.0241	0.1455	0.3965	0.2890	0.0499	-0.2108	0.0935	0.0142	0.0037	0.0612
0.4	-0.4076	0.6879	-0.0524	0.1337	0.3510	0.2873	0.0769	-0.1532	0.0764	0.0127	0.0031	0.0556
0.5	-0.3430	0.6431	-0.0807	0.1218	0.3055	0.2857	0.1039	-0.0956	0.0594	0.0113	0.0025	0.0504
0.6	-0.2785	0.5983	-0.1090	0.1099	0.2601	0.2840	0.1309	-0.0380	0.0423	0.0098	0.0021	0.0457
0.7	-0.2139	0.5535	-0.1373	0.0980	0.2146	0.2824	0.1579	0.0196	0.0253	0.0083	0.0017	0.0416
0.8	-0.1494	0.5087	-0.1656	0.0861	0.1692	0.2807	0.1849	0.0773	0.0082	0.0068	0.0015	0.0385
0.9	-0.0848	0.4639	-0.1939	0.0742	0.1237	0.2791	0.2118	0.1349	-0.0088	0.0053	0.0013	0.0365

Based on the table, it is known that the smallest risk is obtained at alpha 0.9, with a risk of 0.0365 and an expected return of 0.0053. This risk is not a weighted average of each stock risk in the portfolio, but rather the risk of the portfolio as a whole.

The next step was to optimize the portfolio using Solver in Microsoft Excel, to eliminate stocks with negative weights, while reducing the level of portfolio risk. By using Solver in Microsoft Excel, the new expected return and risk are obtained at 0.00522211 and 0.0391, with the proportion of the portfolio considered the most optimal as follows.

Table 7. Proportion of Stocks in an Optimal Portfolio

Company	Proportion		Expected Return of Portfolio	Risk
ASII	0.0000	0.00%	0.00522211	0.0391
BBCA	0.3759	37.59%		
BBNI	0.0000	0.00%		
BBRI	0.0000	0.00%		
BMRI	0.0000	0.00%		
KLBF	0.3044	30.44%		
SIDO	0.2167	21.67%		
TLKM	0.1030	10.30%		
UNTR	0.0000	0.00%		
Total	**1.0000**	**100.00%**	0.00522211	0.0391

The table showed the proportion of each stock in the portfolio. Of the 12 stocks tested, there are 4 stocks that are most optimally combined in the portfolio. The 4 stocks, if sorted from the highest to the lowest proportion, include:

1) BBCA (Financial Sector), has a proportion of shares in the portfolio of 37.59%
2) KLBF (Health Sector), has a proportion of shares in the portfolio of 30.44%
3) SIDO (Health Sector), has a proportion of shares in the portfolio of 21.67%
4) TLKM (Technology Sector), has a proportion of shares in the portfolio of 10.33%

This confirmed that the highest proportion in the portfolio was in BBCA shares, and the lowest proportion was in TLKM. Then, the return for each share in the portfolio is as follows.

Table 8. Return of Each Stock in the Optimal Portfolio

Company	Proportion	E(Ri)	Expected Return of Stock in Portfolio
BBCA	37.59%	0.009498	0.00357081
KLBF	30.44%	0.004135	0.00125852
SIDO	21.67%	0.000332	0.00007186
TLKM	10.30%	0.003117	0.00032092
Total Expected Return			**0.00522211**

DISCUSSION

Before the publication of Markowitz's article "Portfolio Selection" in 1952, investors only made asset selection by estimating their returns and risks from individual stocks, and then selecting the stocks that were considered most profitable to combine and form a portfolio. The investment decision process was only based on selecting issuers with higher returns or lower risks, and therefore forming a portfolio with weights consistent with the estimated returns and risks. In contrast, Markowitz dealt with portfolio formation on the basis of overall returns and risks, which is called portfolio diversification, meaning that portfolios are selected in aggregate, rather than selecting each separate security based on a specific evaluation of its risk and return. In detail, the expected return of the portfolio (E[rp]) can be considered as a measure of the return of this

investment, and so the standard deviation of the portfolio (σp) can be obtained to measure the risk of investment. The significance of this theory comes from the idea of diversification put forward by Markowitz, because it draws attention to the fact that considering the covariance between portfolio assets can be an important factor in estimating the overall risk of the portfolio, and then the selection decision itself. Included in this study, consideration of the covariance between each stock in the portfolio is also used to determine the portfolio that is considered optimal.

In this study, it is known that each asset or stock in the portfolio has its own positive and negative covariance to a particular stock. Covariance indicates whether the assets in a portfolio move in the same direction. Covariance with a positive sign indicates that the assets generally move in the same direction, while covariance with a negative sign indicates that the movement between assets is not in the same direction. And in building a portfolio, it is important to select assets that have negative covariance with each other so that the overall risk can be suppressed. After determining the covariance, the researchers then calculate the optimal portfolio value, by determining the weight or proportion of each stock.

In this study, the lowest risk level was at alpha 0.9, with a risk of 0.0365 and an expected return of 0.0053. Thus, the optimal portfolio was at the lowest risk level of 3.65% with an expected portfolio return of 0.53%, because as previously explained, the optimal portfolio can be determined by setting the lowest investment risk level and with a certain return level (due to the assumption that investors are risk averse). The next step was to optimize the portfolio using Solver in Microsoft Excel to minimize risk. By using Solver in Microsoft Excel, a new proportion was obtained which is considered as the most optimal, consisting of: BBCA (37.59%), KLBF (30.44%), SIDO (21.67%), and TLKM (10.30%) with a new risk of the portfolio of 0.0391 and an expected return of 0.00522211.

CONCLUSION

Sustainable investment or green investment, has become an increasingly important topic in today's global context, as awareness of climate change, environmental sustainability, and social responsibility increases. The Markowitz Model, known as modern portfolio theory, offers a mathematical method for optimizing investment portfolios with the aim of maximizing returns while minimizing risk. When applied to sustainable stocks, the Markowitz Model can help investors design portfolios that are not only financially profitable but also contribute to sustainability goals. For example, in this study, where the Markowitz Model is used to determine the optimal portfolio of stocks included in the SRI-Kehati index in Indonesia, for the period 2020 to 2023. Using Solver in Microsoft Excel, the research findings showed that there are 4 stocks that are ideal to be included in the optimal portfolio, consisting of BBCA (37.59%), KLBF (30.44%), SIDO (21.67%), and TLKM (10.30%). Of the four stocks, the expected return that may be obtained from the investment portfolio is 0.00522211 and the stock portfolio risk is 0.0391.

Although this research can be completed well, the researchers also realize that there are several limitations that may be improved in future research. First, this study used the Markowitz model, where parameter estimates such as expected return, variance, and covariance are based on historical data that may not be accurate for future projections. Moreover, the researchers used data in the form of monthly closing prices with fluctuations that are often not patterned, and not using daily closing price data. Thus, future research can focus on better estimation methods or data smoothing techniques to improve the accuracy of parameter estimates and their impact on optimal portfolios. In addition, research with the Markowitz model also does not consider external factors such as macroeconomics, global news, or market sentiment that can affect stock returns. Therefore, future researchers are advised to explore the integration of the Markowitz Model with other models

such as multifactor models or news-based models to improve accuracy and relevance in a broader market context. Also, the Markowitz Model needs to be done by calculating covariance and variance for many stocks so that it requires accurate data and sophisticated mathematical techniques, which can be complicated for inexperienced investors. Thus, future researchers can use other techniques that are considered accurate but at the same time considered easier to use as references by investors and practitioners.

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