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## PORTFOLIO OPTIMIZATION OF ESG STOCKS USING THE MARKOWITZ MODEL ON ALL GREEN INDEXES IN INDONESIA

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***ABSTRACT***

*ESG (Environmental, Social, and Governance) investments are becoming popular because they may provide competitive financial returns while promoting sustainable development. However, the uptake of ESG investments is limited due to barriers such as a lack of understanding and insufficient information. Indonesia has ESG-oriented indexes, such as SRI-KEHATI, ESG Leaders, ESG Sector Leaders IDX KEHATI, and ESG Quality 45 IDX KEHATI serve as a basis for ESG stock selection. This research uses the Markowitz model to optimize an ESG portfolio from four Indonesian green indices. The Markowitz model is employed to determine the optimal weights for establishing a portfolio on the efficient frontier. Using monthly adjusted closing prices from 2019 to 2024, the optimal portfolio suggested by four green indexes offers a balance of risk/return ratio. The optimal portfolio's performance comparison, which is measured by using the Treynor measure, Sharpe ratio, and Jensen's alpha is done to indicate which portfolio provides better risk-adjusted returns. The findings may provide optimal ESG portfolio choices to investor depending on their financial goals and risk tolerance. This research may also inspire other investors who have not yet invested in ESG companies to consider green investing, as ESG stocks provide investors with many benefits.*

## INTRODUCTION

The ESG performance of companies has become relevant to investors. The increasing significance of ESG elements necessitates awareness of including ESG components in investing choices (Nekhili, Nagati, Chtioui, & Rebolledo, 2017). BlackRock's Global Sustainable Investing Survey (2020) found that 88% of respondents consider ESG parameters when making investing decisions. ESG factors can help investors assess the management quality and the possible resilience of their portfolio firms in the face of future challenges. Lins et al. (2017) discovered that during the 2008-2009 financial crisis, firms with high levels of corporate social responsibility (CSR) had greater stock returns than those with low levels of CSR. This is because companies with strong CSR tend to have competent management and ethical business practices, which improves their stability and resistance to the financial crisis.

ESG investors are driven by plenty of factors, including a desire to achieve desirable social and environmental outcomes and the need to maximize financial performance. Investors pursuing ESG goals are frequently motivated by a desire to help achieve beneficial social, environmental, and governance outcomes. These investors feel that their investments have a greater influence beyond financial returns. Many ESG investors are driven by personal/institutional values or a desire to support company practices that promote sustainability, such as renewable energy, sustainable agriculture, and green technology. On the other hand, some investors who prioritize risk/return ratio optimization are primarily concerned with attaining financial performance while also taking ESG considerations into their investing plan. ESG considerations are increasingly viewed as important to financial performance. Companies that engage in poor ESG practices may suffer penalties, reputational harm, and operational hazards, all of which can have a detrimental impact on financial performance. Companies that perform well in terms of ESG can be better managed, more robust, and more adaptable to changing market conditions and regulatory frameworks. Investors may benefit from integrating ESG factors, including better handling risks, identifying opportunities, and contributing to a more sustainable and fair future.

Indonesia has four ESG-compliant indexes. In December 2021, the SRI-KEHATI Index included two new ESG indices: the ESG Sector Leaders IDX KEHATI (ESGSKEHATI) and the ESG Quality 45 IDX KEHATI (ESGQKEHATI). The ESG Sector Leaders IDX KEHATI (ESGSKEHATI) includes companies with ESG performance ratings higher than the sector average and strong liquidity, with the sector categorization based on the IDX Industrial Classification (IDX-IC). The ESG Quality 45 IDX KEHATI (ESGQKEHATI) index rates the top 45 companies based on their ESG performance ratings and financial performance while guaranteeing enough liquidity (Mahardhika, 2021). These two indexes were established and administered in partnership with the Indonesian Biodiversity Foundation (KEHATI Foundation).

Prior to the publication of these two indices, the Indonesian Stock Exchange included two ESG-based indexes. First, on June 8th, 2009, the KEHATI Foundation and Indonesian Stock Exchange introduced the KEHATI Sustainable and Responsible Investment (SRI) index, which adheres to the United Nations Principles for Responsible Investment (PRI). According to the IDX's official website, the SRI-

KEHATI index assesses the share price performance of 25 publicly traded companies recognized for their commendable efforts to promote sustainable initiatives and raise awareness of environmental, social, and corporate governance (ESG) principles, also known as Sustainable and Responsible Investment (SRI). Second, the IDX ESG Leaders Index was released on December 14th, 2020. This index assesses the share price performance of firms with positive ESG ratings, which are rarely involved in major scandals and have strong transaction liquidity and financial performance. Sustainalytics, which specializes in analyzing the sustainability of listed firms based on their environmental, social, and corporate governance policies, conducts the ESG ratings and controversies (Indonesia Stock Exchange, n.d.).

Although the importance of environmental, social, and corporate governance factors in investing is becoming more widely acknowledged, insufficient knowledge of ESG investment and lack of clear information are becoming problems. These problems were supported by some global investing surveys. According to PwC Global Investor Survey (2021), 67% of investors were concerned about the quality and comparability of ESG information supplied by corporations, emphasizing the need for more transparent and consistent disclosures. In addition, based on the KPMG Sustainability Reporting Survey (2022), investors feel there is a lack of clear guidance on ESG reporting from companies (including Indonesia as one of the N100), resulting in a lack of investor knowledge and information. The pressure on firms to be more transparent in their ESG reporting is projected to increase. Investors believe firms that analyze and report on ESG risks are more likely to handle risks effectively and provide value in the long term.

This study seeks to give investors insights on how to construct an optimal portfolio of ESG stocks. The Markowitz model, often known as modern portfolio theory (MPT), enables investors to optimize their portfolios. Using historical data on asset returns, variances, and covariances, the model computes the "efficient frontier" - a set of ideal portfolios that maximize expected returns for a given level of risk or minimize risk for a given level of return. This strategy aids in asset diversification, reduces unsystematic risk, and ensures that portfolios are tailored to individual risk tolerances and predicted returns. The Markowitz model emphasizes quantitative analysis and diversification, resulting in improved long-term performance.

Evaluating portfolio performance is also crucial for investors to understand how well their assets manage risk and achieve their financial objectives. The portfolio's performance is evaluated using key indicators such as the Treynor measure, Jensen's alpha, and Sharpe ratio. These measures give a complete picture of which optimal portfolio, suggested by each green index, is outperforming or underperforming.

## METHODS

Methodology is an important part of research since it gives specific directions on how to do the study. In the context of this study, an effective methodology guarantees that data collection, risk-return analysis, portfolio optimization, and portfolio performance evaluation are done in a systematic and responsible way. This study's approach includes multiple phases as follows.

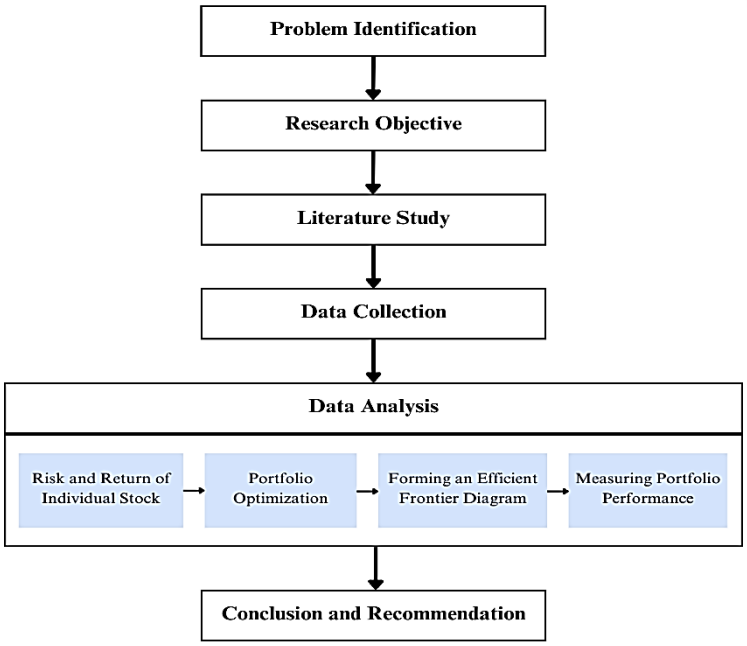


**Figure 1. Research Framework**

Many investors continue to experience considerable hurdles in implementing ESG-oriented investments. This knowledge and resource gap disrupts the widespread use of ESG investing and limits investors' capacity to achieve competitive financial returns while contributing to sustainable development. This issue emphasizes the significance of a systematic approach to developing optimum ESG portfolios and stock combinations of four Indonesian green indices that maximize return for a given level of risk or minimize risk for a specific return, and to comparing the performance of optimal ESG portfolios suggested by four Indonesian green indexes.

To address the problem and attain the aforementioned aims, the research requires extra literature that provides direction and suggestions on how to perform the research. The supporting literature mostly consists of book (Bodie et al.), several journals (The Journal of Finance, SSRN Electronic Journal, etc.), and several websites (Investopedia, Institute of Business & Finance, etc.).

The data utilized for the analysis is secondary data, which means it was acquired and released by a third party. The secondary data was gathered from online sources, including reports from public archives. The names of companies listed in SRI-KEHATI, ESG Leaders, ESG Sector Leaders IDX KEHATI, and ESG Quality 45 IDX KEHATI indexes were retrieved from the Indonesian Stock Exchange. This study uses monthly adjusted closing prices of stocks listed in four Indonesian green indexes from June 30$^{th}$, 2019, to June 30$^{th}$, 2024. These monthly adjusted closing prices were retrieved from historical data in Yahoo Finance.

To select the optimum ESG portfolio and generate an effective frontier chart, the researcher meticulously studies the data and information gathered in the data analysis part. This research needs numerous phases, including risk and return of individual stock, portfolio optimization, forming an efficient frontier diagram, and measuring portfolio performance.

In the last section, this research will determine the optimal ESG portfolios suggested by four green indices in Indonesia and analyze their performance using the Sharpe

ratio, Treynor measure, and Jensen's alpha. The recommendations will be given to assist investors in understanding what they should do after determining the optimal ESG portfolio. The recommendations will also be stated for further studies to have a wider scope of research.

## RESULT AND DISCUSSION

### Data Collection

This research examines all firms listed in four Indonesian green indexes, except for a few companies. Several firms were excluded from this analysis because the amount of data did not fulfill the Markowitz model's standards of 60 observations. This study covered 5 years, from 2019 to 2024, and employed monthly data. Some firms, such as AVIA (IPO date 2021), BUKA (IPO date 2021), DRMA (IPO date 2021), GOTO (IPO date 2022), MTEL (IPO date 2021), PGEO (IPO date 2023), and TAPG (IPO date 2021), have not yet launched their shares available to the public (IPO/Initial Public Offering). Hence, no historical data can be accessed in 2019.

### Data Analysis

### Risk and Return of Individual Stock

R Studio is utilized in this study's computation to determine the optimal portfolio. Certain packages that must be installed in R Studio to run portfolio optimization are described below.

```
# Install the required packages if not already installed
install.packages(c("quantmod", "PerformanceAnalytics", "PortfolioAnalytics", "ROI",
"ROI.plugin.quadprog", "ROI.plugin.glpk"))

# Load the packages
library(quantmod)
library(PerformanceAnalytics)
library(PortfolioAnalytics)
library(ROI)
library(ROI.plugin.quadprog)
library(ROI.plugin.glpk)
```

The 'PerformanceAnalytics' package is used to get performance and risk analysis. To compute the portfolio optimization, the package required is called 'PortfolioAnalytics'. While the package of 'ROI' and related packages help to address optimization issues. By using the 'quantmod' package, the adjusted close price of the stocks can be obtained from Yahoo Finance, with a start date of June 30th, 2019, and an end date of June 30th, 2024. Adjusted close price refers to the actual price after being adjusted for splits, dividends, and/or capital gains distributions. Below is the R code used to fetch the data of stocks listed in the SRI-KEHATI index. To calculate the optimal portfolio of other indexes, the steps will be the same, only adjusting the listed stocks.

```
# Define the Indonesian assets and the period
assets <- c("ANTM.JK", "AUTO.JK", "BBCA.JK", "BBNI.JK", "BBRI.JK", "BBTN.JK", "BMRI.JK",
"DSNG.JK", "EMTK.JK", "ICBP.JK", "INCO.JK", "INDF.JK", "INTP.JK", "JPFA.JK", "JSMR.JK",
"KLBF.JK", "SCMA.JK", "SIDO.JK", "SMGR.JK", "SMSM.JK", "SSMS.JK", "TLKM.JK", "UNTR.JK",
"UNVR.JK")
start_date <- as.Date("2019-06-30")
end_date <- as.Date("2024-06-30")

# Get the data
getSymbols(assets, src = 'yahoo', from = start_date, to = end_date)

# Extract the adjusted closing prices and convert to monthly
monthly_prices <- do.call(merge, lapply(assets, function(x) Ad(to.monthly(get(x), indexAt =
'lastof', drop.time = TRUE))))

# Print the monthly prices
print(monthly_prices)
```

After getting the monthly adjusted close price of stock, the next step is to calculate the monthly returns of each stock. The R code used is described below.

```
# Calculate monthly returns
monthly_returns <- na.omit(ROC(monthly_prices, type = "discrete"))

# Print monthly returns
print(monthly_returns)
```

The ‘ROC’ stands for "Rate of Change" which is used to calculate the returns over a given period. The ‘type = "discrete"’ indicates that we want to calculate discrete returns. Discrete returns are calculated as the difference between the price of one month and the price of the previous month, divided by the price of the previous month. While the ‘na.omit’ function removes ‘NA’ (missing) values from the data frame. In the case of financial data, the first value in the ‘ROC’ calculation will be ‘NA’ because there is no previous month to compare with the first month.

After acquiring the monthly returns of each stock, the following step is to calculate the arithmetic average return and the standard deviation (risk) for individual stocks. This research uses the R code as follows.

```
# Define the arithmetic mean function
arithmetic_means <- colMeans(monthly_returns)

# Print the arithmetic means
print(arithmetic_means)

# Calculate the standard deviation (risk) for individual assets
risks <- apply(monthly_returns, 2, sd)

# Print the risks
print(risks)
```

The ‘colMeans’ function in R is used to compute the mean (average) of each column in a matrix or a data frame. This function is particularly useful when a data set is organized in a tabular format where each column represents a different asset. The ‘sd’ is the function to be applied to each column of the returns data frame. It calculates the standard deviation of a numeric vector. The average return and risk of stocks listed in the four green indexes are as follows.

**Table 1. Average Return and Risk of Stocks Listed in SRI-KEHATI Index**

| Stock | Average Return | Risk |
|---|---|---|
| ANTM | 1.89% | 16.18% |
| AUTO | 1.47% | 10.53% |
| BBCA | 1.12% | 5.27% |
| BBNI | 1.04% | 10.86% |
| BBRI | 0.92% | 8.24% |
| BBTN | 0.33% | 14.93% |
| BMRI | 1.52% | 8.52% |
| DSNG | 1.70% | 9.73% |
| EMTK | 0.42% | 17.79% |
| ICBP | 0.31% | 6.80% |
| INCO | 1.37% | 12.22% |
| INDF | 0.19% | 5.93% |
| INTP | -1.21% | 8.92% |
| JPFA | 0.61% | 11.18% |
| JSMR | 0.34% | 10.39% |
| KLBF | 0.40% | 5.96% |
| SCMA | -0.28% | 13.25% |
| SIDO | 1.47% | 8.49% |
| SMGR | -1.29% | 10.86% |
| SMSM | 1.12% | 8.77% |
| SSMS | 1.20% | 14.42% |
| TLKM | 0.07% | 6.60% |
| UNTR | 1.15% | 10.70% |
| UNVR | -1.27% | 7.36% |

The table above displays the average returns for various stocks listed in the SRI-KEHATI index over the last five-year period, which is from June 30th, 2019, to June 30th, 2024, ANTM earned the highest average return of 1.89%, showing that it was the most successful investment in this index during this period. While, SMGR had the highest loss, with an average return of -1.29%, making it the least profitable firm on the list. However, it is important to remember that each stock carries its own amount of risk along with these returns. EMTK has the most risk among listed stocks, with a standard deviation of 17.79%, indicating extreme volatility in its returns over the previous five years. While, BBCA has the lowest risk with a standard deviation of 5.27%, implying greater consistency in return over the same time period.

**Table 2. Average Return and Risk of Stocks Listed in ESG Leaders Index**

| Stock | Average Return | Risk |
|---|---|---|
| MNCN | -1.89% | 10.62% |
| AUTO | 1.47% | 10.53% |
| JSMR | 0.34% | 10.39% |
| BMTR | -0.30% | 11.70% |
| ERAA | 1.05% | 13.94% |
| BSDE | -0.28% | 8.69% |
| MPMX | 2.23% | 11.95% |
| BBNI | 1.04% | 10.86% |
| PWON | -0.57% | 9.95% |
| BFIN | 2.18% | 14.49% |
| BMRI | 1.52% | 8.52% |
| CTRA | 0.79% | 11.93% |

| | | |
|---|---|---|
| TOWR | 0.63% | 9.80% |
| AKRA | 2.18% | 10.53% |
| BBRI | 0.92% | 8.24% |
| TLKM | 0.07% | 6.60% |
| MAPI | 1.64% | 13.08% |
| ACES | -0.58% | 9.94% |
| SCMA | -0.28% | 13.25% |
| SIDO | 1.47% | 8.49% |
| UNVR | -1.27% | 7.36% |
| BBCA | 1.12% | **5.27%** |
| ASSA | 1.22% | 18.20% |
| TBIG | 2.19% | 12.07% |
| MIKA | 1.06% | 7.65% |
| EMTK | 0.42% | 17.79% |
| TPIA | 4.52% | 18.73% |
| BRPT | 1.88% | 19.13% |

Based on the table above, the average returns of the stocks featured in the ESG Leaders Index for the last five years, from June 30th, 2019, to June 30th, 2024. TPIA had the greatest average return, 4.52%. MNCN, on the other side, had the lowest average return (-1.89%). The table above also reveals that BRPT has the greatest risk among the listed stocks, with a standard deviation of 19.13% over the previous five years. BBCA, on the other hand, had the lowest risk in this index, with a standard deviation of 5.27%.

**Table 3. Average Return and Risk of Stocks Listed in ESGSKEHATI Index**

| Stock | Average Return | Risk |
|---|---|---|
| ACES | -0.58% | 9.94% |
| AKRA | 2.18% | 10.53% |
| ANTM | 1.89% | 16.18% |
| ASGR | -0.13% | 5.95% |
| ASII | 0.14% | 8.93% |
| ASRI | -0.84% | 13.10% |
| ASSA | 1.22% | 18.20% |
| AUTO | 1.47% | 10.53% |
| BBCA | 1.12% | 5.27% |
| BBNI | 1.04% | 10.86% |
| BBRI | 0.92% | 8.24% |
| BBTN | 0.33% | 14.93% |
| BEST | -1.45% | 10.77% |
| BIRD | 0.17% | 12.89% |
| BJBR | 0.30% | 9.68% |
| BJTM | 0.73% | 7.83% |
| BMRI | 1.52% | 8.52% |
| BSDE | -0.28% | 8.69% |
| BTPS | -0.70% | 12.08% |
| CTRA | 0.79% | 11.93% |
| DSNG | 1.70% | 9.73% |
| ELSA | 1.47% | 11.82% |
| EMTK | 0.42% | 17.79% |
| HEAL | 1.76% | 9.65% |
| ICBP | 0.31% | 6.80% |
| INCO | 1.37% | 12.22% |
| INDF | 0.19% | 5.93% |

| | | |
|---|---|---|
| INTP | -1.21% | 8.92% |
| JPFA | 0.61% | 11.18% |
| JSMR | 0.34% | 10.39% |
| KLBF | 0.40% | 5.96% |
| MPMX | 2.23% | 11.95% |
| NISP | 1.07% | 6.00% |
| PNBN | 0.42% | 12.64% |
| POWR | 0.48% | 7.02% |
| PRDA | 0.52% | 14.06% |
| PTPP | -1.80% | 16.89% |
| PWON | -0.57% | 9.95% |
| SCMA | -0.28% | 13.25% |
| SIDO | 1.47% | 8.49% |

According to the table above, MPMX had the greatest average return of any company in the ESG Sector Leaders IDX KEHATI Index for the last five years, from June 30th, 2019, to June 30th, 2024, with an average return of 2.23%. PTPP, conversely, had the lowest average return (-1.80%). In addition, the table shows that ASSA has the greatest risk of any company listed in this index, with a standard deviation of 18.20% over the previous five years. BBCA, on the other hand, poses the lowest risk, with a standard deviation of 5.27%.

**Table 4. Average Return and Risk of Stocks Listed in ESGQKEHATI Index**

| Stock | Average Return | Risk |
|---|---|---|
| AKRA | 2.18% | 10.53% |
| ANTM | 1.89% | 16.18% |
| ASII | 0.14% | 8.93% |
| AUTO | 1.47% | 10.53% |
| BBCA | 1.12% | 5.27% |
| BBNI | 1.04% | 10.86% |
| BBRI | 0.91% | 8.24% |
| BBTN | 0.33% | 14.93% |
| BIRD | 0.17% | 12.89% |
| BJBR | 0.29% | 9.68% |
| BJTM | 0.73% | 7.83% |
| BMRI | 1.52% | 8.52% |
| BTPS | -0.70% | 12.08% |
| CTRA | 0.79% | 11.93% |
| DSNG | 1.70% | 9.73% |
| EMTK | 0.42% | 17.79% |
| EXCL | -0.005% | 10.53% |
| HEAL | 1.76% | 9.65% |
| ICBP | 0.31% | 6.80% |
| INCO | 1.37% | 12.22% |
| INDF | 0.19% | 5.93% |
| INTP | -1.21% | 8.92% |
| JPFA | 0.61% | 11.18% |
| JSMR | 0.34% | 10.39% |
| KLBF | 0.39% | 5.96% |
| MPMX | 2.23% | 11.95% |
| PNBN | 0.42% | 12.64% |
| POWR | 0.48% | 7.02% |
| PRDA | 0.52% | 14.06% |
| PWON | -0.57% | 9.95% |

| | | |
|---|---|---|
| SCMA | -0.28% | 13.25% |
| SIDO | 1.47% | 8.49% |
| SILO | 2.83% | 12.36% |
| SMGR | -1.29% | 10.86% |
| SMSM | 1.12% | 8.77% |
| SSMS | 1.20% | 14.42% |
| TBIG | 2.19% | 12.07% |
| TLKM | 0.07% | 6.60% |
| UNTR | 1.15% | 10.70% |
| UNVR | -1.27% | 7.36% |

Table 4 displays the mean of returns of the companies included in the ESG Quality 45 IDX KEHATI Index during the previous five years, from June 30th, 2019, to June 30th, 2024, with SILO having the greatest average return of 2.83%. In this index, investors who seek higher returns might choose stocks such as SILO, but they must be aware of the risks associated. On the other hand, SMGR had the lowest average return of -1.29%. Furthermore, the table above indicates that EMTK has the biggest risk among the listed stocks, with a standard deviation of 17.79% over the previous five years. While BBCA carried the lowest risk in this index, with a standard deviation of 5.27%. Stocks like BBCA may appeal to more risk-averse investors due to their stability.

**Portfolio Optimization**

Using the data from the previous part, the optimal portfolio from four green indexes could be generated. The R code used to generate the portfolio optimization is shown below.

```
# Define the portfolio specification
port_spec <- portfolio.spec(assets = colnames(monthly_returns))

# Add constraints: full investment and long only
port_spec <- add.constraint(portfolio = port_spec, type = "full_investment")
port_spec <- add.constraint(portfolio = port_spec, type = "long_only")
```

```
# Add objectives: maximize mean return and minimize standard deviation
port_spec <- add.objective(portfolio = port_spec, type = "return", name = "mean")
port_spec <- add.objective(portfolio = port_spec, type = "risk", name = "StdDev")

# Optimize the portfolio
opt_port <- optimize.portfolio(R = monthly_returns, portfolio = port_spec, optimize_method =
"ROI")

# Print the optimized portfolio
print(opt_port)

# Extract the optimal weights
optimal_weights <- extractWeights(opt_port)

# Print the optimal weights
print(optimal_weights)

# Extract risk and return of the optimal portfolio
optimal_measures <- extractObjectiveMeasures(opt_port)

# Print risk and return of the optimal portfolio
print(optimal_measures)
```

In this section, the function of 'portfolio.spec' is used to construct a portfolio specification object and generate it with asset names. The portfolio specification will be defined along with objectives and constraints. Below are the constraints added to the portfolio spectification.

1. 'full_investment': indicates that the total of all asset weights equals 1 (fully invested).

2. 'long_only': ensures that no weights are negative (no short selling).

The objectives of this portfolio specification are described below.

1. 'type = "return" and name = "mean"': aims to maximize the mean return.
2. 'type = "risk" and name = "StdDev"': aims to reduce risk as that is measured by standard deviation.

Lastly, the 'optimize.portfolio' function is used to optimize the portfolio based on the stated objectives and constraints, employing the 'ROI' (Risk-Return Optimization Interface) approach. Following these steps, the calculation of optimal weights and measures are obtained below.

**Table 5. Weights, Return, and Risk for Each Optimal Portfolio**

| SRI-KEHATI | | ESG Leaders | | ESG Sector Leaders IDX KEHATI | | ESG Quality 45 IDX KEHATI | |
|---|---|---|---|---|---|---|---|
| **Stock** | **Weight** | **Stock** | **Weight** | **Stock** | **Weight** | **Stock** | **Weight** |
| ANTM | 7.96% | AUTO | 8.59% | AKRA | 31.11% | AKRA | 24.84% |
| AUTO | 9.46% | MPMX | 29.18% | DSNG | 15.73% | DSNG | 5.11% |
| BMRI | 24.89% | BFIN | 2.91% | HEAL | 12.79% | HEAL | 7.04% |
| DSNG | 22.39% | AKRA | 11.78% | MPMX | 26.17% | MPMX | 9.47% |
| SIDO | 33.05% | TBIG | 2.67% | SIDO | 14.20% | SILO | 40.82% |
| SSMS | 2.24% | TPIA | 44.87% | | | TBIG | 12.71% |
| **Total** | **100%** | **Total** | **100%** | **Total** | **100%** | **Total** | **100%** |
| **Return** | **Risk** | **Return** | **Risk** | **Return** | **Risk** | **Return** | **Risk** |
| 1.56% | 5.81% | 3.19% | 10.09% | 1.96% | 6.34% | 2.39% | 7.04% |

The optimal portfolio with the determined weighting focuses on stocks with a good risk/return ratio. The table above shows the top contributors of stocks in each portfolio. These stocks are expected to generate a good return for their risk. The rest of the stocks that are not mentioned in the table are the stocks that have low weightings or almost zero, indicating that they do not contribute much to the optimal portfolio. This makes them less appealing to include in the portfolio. By using these optimal weights, the portfolio generates the optimal expected return and risk as shown in the table above.

As seen in Table 5, the optimal portfolio of the ESG Leaders offers the highest returns while simultaneously carrying the most risk. This may be appropriate for those with a higher risk tolerance. The optimal portfolio of SRI-KEHATI provides the lowest return while also carrying the lowest risk, making it ideal for conservative investors looking for stability. The optimal portfolio of ESG Sector Leader IDX KEHATI and the ESG Quality 45 IDX KEHATI provide a balanced return and risk profile. They may appeal to investors seeking a well-balanced portfolio. Ultimately, these optimal portfolios will be chosen depending on the investor's risk tolerance and expected return.

After constructing the optimal portfolio suggested by four Indonesian green indices, a correlation matrix is carried out to bring considerable advantages to investors. This helps to understand the relationship between the portfolio's different assets, where assets move together or move independently. This understanding is critical for diversification since mixing assets with low or negative correlations can lower the total risk of the portfolio. The R code used to calculate the correlation matrix is described below.

```
# Calculate correlation matrix
cor_matrix <- cor(monthly_returns)

# Display the correlation matrix
print(cor_matrix)
```

**Table 6. Correlation Matrix of Optimal Portfolio in SRI-KEHATI**

| | ANTM | AUTO | BMRI | DSNG | SIDO | SSMS |
|---|---|---|---|---|---|---|
| **ANTM** | 1.00 | 0.12 | 0.30 | 0.21 | 0.17 | 0.39 |
| **AUTO** | 0.12 | 1.00 | 0.45 | 0.31 | 0.02 | -0.13 |
| **BMRI** | 0.30 | 0.45 | 1.00 | 0.42 | -0.05 | -0.02 |
| **DSNG** | 0.21 | 0.31 | 0.42 | 1.00 | 0.20 | -0.01 |
| **SIDO** | 0.17 | 0.02 | -0.05 | 0.20 | 1.00 | 0.17 |
| **SSMS** | 0.39 | -0.13 | -0.02 | -0.01 | 0.17 | 1.00 |

The table above shows that some of the stocks in the optimal portfolio of SRI-KEHATI have moderate to strong positive correlations (BMRI-AUTO, BMRI-DSNG, ANTM-SSMS, etc.), implying that they tend to move together, while others have weak or nearly zero correlations. A few negative correlations (AUTO-SSMS, SIDO-BMRI, BMRI-SSMS, etc.) indicate that certain stocks tend to move oppositely, even if the correlations are weak. These various correlations might be useful for diversification since they can reduce the overall risk in a diversified portfolio.

**Table 7. Correlation Matrix of Optimal Portfolio in ESG Leaders**

| | AUTO | MPMX | BFIN | AKRA | TBIG | TPIA |
|---|---|---|---|---|---|---|
| **AUTO** | 1.00 | 0.35 | 0.08 | 0.30 | -0.08 | -0.11 |
| **MPMX** | 0.35 | 1.00 | 0.27 | 0.25 | -0.01 | 0.04 |
| **BFIN** | 0.08 | 0.27 | 1.00 | 0.31 | 0.29 | 0.19 |
| **AKRA** | 0.30 | 0.25 | 0.31 | 1.00 | 0.22 | 0.28 |
| **TBIG** | -0.08 | -0.01 | 0.29 | 0.22 | 1.00 | 0.44 |
| **TPIA** | -0.11 | 0.04 | 0.19 | 0.28 | 0.44 | 1.00 |

Table 7 reveals that certain companies in the optimal portfolio of ESG Leaders have moderately positive correlations (AUTO-MPMX, TPIA-TBIG, BFIN-AKRA, etc.), implying that they tend to move together, but not significantly. However, a few negative correlations are low (AUTO-TPIA, AUTO-TBIG, and MPMX-TBIG), indicating that there is a minimal inverse relationship. This means the stocks have diversification potential because the movements are not strongly connected.

**Table 8. Correlation Matrix of Optimal Portfolio in ESGSKEHATI**

| | AKRA | DSNG | HEAL | MPMX | SIDO |
|---|---|---|---|---|---|
| **AKRA** | 1.00 | 0.21 | 0.23 | 0.25 | 0.17 |
| **DSNG** | 0.21 | 1.00 | 0.06 | 0.09 | 0.20 |
| **HEAL** | 0.23 | 0.06 | 1.00 | 0.37 | -0.10 |
| **MPMX** | 0.25 | 0.09 | 0.37 | 1.00 | -0.04 |
| **SIDO** | 0.17 | 0.20 | -0.10 | -0.04 | 1.00 |

This matrix demonstrates that several firms in the optimal portfolio of ESG Sector Leaders IDX KEHATI have some positive correlations (HEAL-MPMX, AKRA-MPMX, HEAL-AKRA, etc.), indicating that they tend to move together, although not substantially. Only a few firms (HEAL-SIDO and MPMX-SIDO) have negative correlations, indicating a modest inverse connection. This might provide strong diversification benefits for an investing portfolio.

**Table 9. Correlation Matrix of Optimal Portfolio in ESGQKEHATI**

| | AKRA | DSNG | HEAL | MPMX | SILO | TBIG |
|---|---|---|---|---|---|---|
| **AKRA** | 1,00 | 0,21 | 0,23 | 0,25 | 0,04 | 0,22 |
| **DSNG** | 0,21 | 1,00 | 0,06 | 0,09 | 0,07 | -0,01 |
| **HEAL** | 0,23 | 0,06 | 1,00 | 0,37 | -0,07 | 0,29 |
| **MPMX** | 0,25 | 0,09 | 0,37 | 1,00 | 0,28 | -0,01 |
| **SILO** | 0,04 | 0,07 | -0,07 | 0,28 | 1,00 | 0,19 |
| **TBIG** | 0,22 | -0,01 | 0,29 | -0,01 | 0,19 | 1,00 |

The table illustrates several firms in the optimal portfolio of ESG Quality 45 IDX KEHATI have numerous positive correlations (HEAL-MPMX, MPMX-AKRA, and so on), suggesting that they tend to move together. A few firms exhibit negative correlations (HEAL-SILO, TBIG-DSNG, etc.), indicating an inverse relationship. This implies diverse stocks, which provides diversification benefits to investors.

**Forming an Efficient Frontier Diagram**

The efficient frontier diagram of each optimal portfolio will be plotted in this part by using R Studio after determining the risk and return of the optimal portfolio. The R code used to form the efficient frontier diagram is described below.

```
# Define a grid of target returns
target_returns <- seq(min(colMeans(monthly_returns)), max(colMeans(monthly_returns)),
length.out = 100)

# Initialize a list to store the efficient frontier results
efficient_frontier <- list()

# Loop through each target return to optimize the portfolio for (target_return in
target_returns) {
        # Add the target return as an objective
        port_spec <- add.objective(portfolio = port_spec, type = "return", name = "mean",
        target = target_return)

        # Optimize the portfolio
        opt_port <- optimize.portfolio(R = monthly_returns, portfolio = port_spec,
        optimize_method = "ROI")

        # Store the results efficient_frontier[[length(efficient_frontier) + 1]] <- list(
                return = target_return,
                risk = extractObjectiveMeasures(opt_port)$StdDev,
                weights = extractWeights(opt_port
        )
}

# Extract returns and risks
efficient_returns <- sapply(efficient_frontier, function(x) x$return)
efficient_risks <- sapply(efficient_frontier, function(x) x$risk)

# Plot the efficient frontier
plot(efficient_risks, efficient_returns, type = "l", col = "blue",
     xlab = "Risk (Standard Deviation)", ylab = "Return",
     main = "Efficient Frontier")
points(efficient_risks, efficient_returns, pch = 16, col = "blue")

# Highlight the optimal portfolio
optimal_return <- colMeans(monthly_returns) %*% optimal_weights
optimal_risk <- sqrt(t(optimal_weights) %*% cov(monthly_returns) %*% optimal_weights)
points(optimal_risk, optimal_return, pch = 17, col = "green", cex = 1.5)
text(optimal_risk, optimal_return, labels = "Optimal Portfolio", pos = 3, cex = 0.8, col =
"green")
```

The 'optimal_risk' and 'optimal_return' in the R code show the coordinates of the optimal portfolio on the plot (risk on the x-axis and return on the y-axis). By applying the code that has been described before, the efficient frontier is generated below.

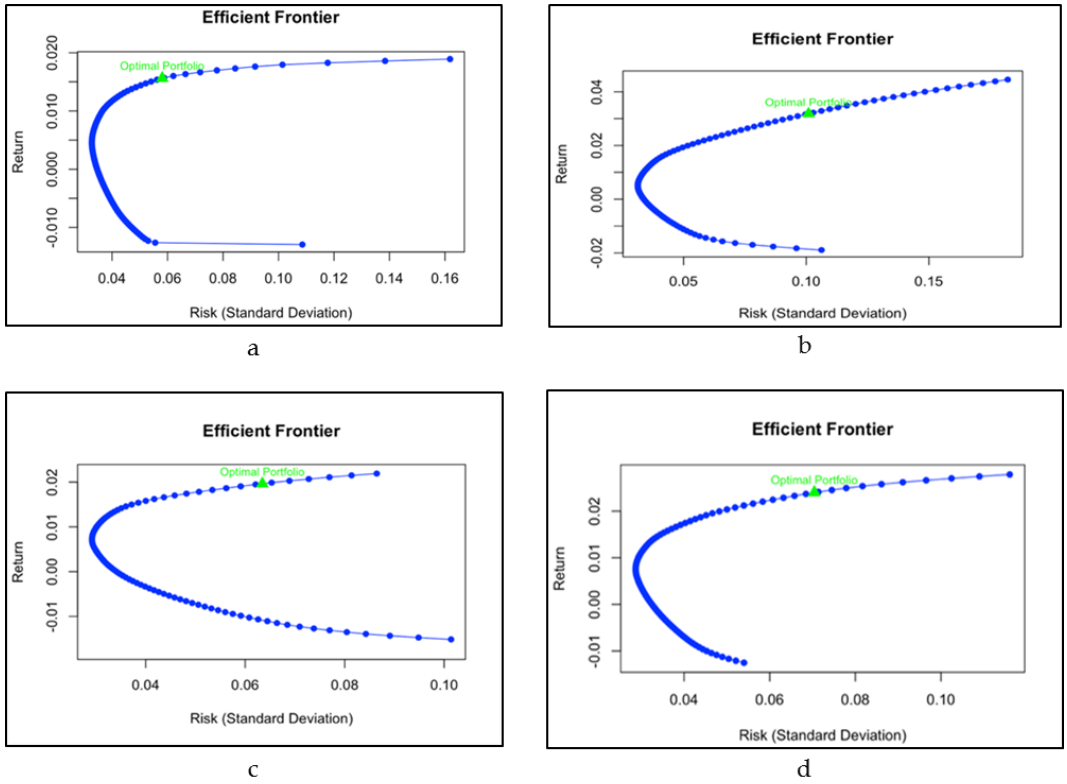


**Figure 2. (a) Efficient Frontier Diagram of Optimal Portfolio in SRI-KEHATI; (b) Efficient Frontier Diagram of Optimal Portfolio in ESG Leaders; (c) Efficient Frontier Diagram of Optimal Portfolio in ESGSKEHATI; (d) Efficient Frontier Diagram of Optimal Portfolio in ESGQKEHATI**

The figures above show that there is a blue curve and a green triangle in each diagram. The blue curve represents the efficient frontier. It is a collection of optimum portfolios that provide the greatest possible return for a given degree of risk. Portfolios on this curve are regarded as efficient because they provide the maximum expected return for a given level of risk. The green triangle denotes the ideal portfolio on the efficient frontier. This portfolio is the point on the efficient frontier which offers the best balance of risk and return depending on the optimization criteria (in this case, maximizing return while minimizing risk). The coordinates of the green dot in the figure reflect the precise return and risk values for the optimal portfolio.

The graphic shows investors may get a higher risk/return ratio by combining many stocks into a diversified portfolio to reduce the total risk of the portfolio while also achieving a larger return. Investors may pick an option along the efficient frontier based on their risk tolerance. The ideal portfolio, shown by the green triangle, has the largest possible return for a given degree of risk, making it a good choice for investors looking to optimize their investing strategy.

**Measuring Portfolio Performance**

The analysis for this section is carried out by a thorough examination of three metrics including Treynor measure, Sharpe ratio, and Jensen's alpha. Each metric offers various insights into risk-adjusted returns and the effectiveness of investment strategy.

The Treynor measure assesses a portfolio's performance regarding systematic market risk. The Sharpe ratio measures a portfolio's performance while adjusting for total risk (systematic and unsystematic). Jensen's alpha measures a portfolio's excess return above the expected return predicted by the Capital Asset Pricing Model (CAPM). The combination of these measures gives an extensive understanding of portfolio performance from many risk perspectives.

**Treynor Measure**

To get the Treynor measure, the calculation of portfolio return, risk-free rate, and beta are required. For the portfolio return, it has been calculated in the previous part. For the risk-free rate, this research used the BI Rate of 6.25% (updated on June 20th, 2024). To maintain consistency, the risk-free rate should be on the same frequency as returns for the portfolio. To convert it to a monthly rate, the BI rate will be divided into 12 months, which produces 0.52%.

While the beta of each stock calculates the covariance of stock return and market return divided by the variance of market return. In this research, the market index used is Jakarta Stock Exchange Composite (JKSE) Index. The steps to calculate the return of JKSE will be the same as the steps for computing the stock return in the beginning part. The R code to calculate market return and portfolio beta is described below.

```
# Get the market data (JKSE)
getSymbols("^JKSE", src = 'yahoo', from = start_date, to = end_date)

# Extract the adjusted closing prices for JKSE
monthly_market <- Ad(to.monthly(JKSE, indexAt = 'lastof', drop.time = TRUE))

# Calculate monthly returns for JKSE
market_returns <- na.omit(ROC(monthly_market, type = "discrete"))

# Print monthly returns for JKSE
print(market_returns)

# Define the arithmetic mean function
arithmetic_means <- colMeans(market_returns)

# Print the arithmetic means
print(arithmetic_means)
```

```
# Define a function to calculate beta
calculate_beta <- function(asset_returns, market_returns) {
  covar <- cov(asset_returns, market_returns)
  var_market <- var(market_returns)
  beta <- covar / var_market
  return(beta)}

# Calculate betas for each asset
betas <- sapply(colnames(monthly_returns), function(asset) {
  calculate_beta(monthly_returns[, asset], market_returns[, 1])
})

# Print the betas
print(betas)

# Calculate portfolio beta
portfolio_beta <- sum(betas %*% optimal_weights)

# Print the portfolio beta
print(portfolio_beta)
```

After defining several data such as portfolio return, risk-free rate, and portfolio beta, the calculation for Treynor measure can be conducted. Below is the R code used to calculate the Treynor measure.

```
# Calculate Treynor Measure
treynor_ratio <- (portfolio_return - risk_free_rate) / beta_portfolio
cat("Treynor Ratio:", treynor_ratio, "\n")
```

**Table 10. Treynor Measure of Each Optimal Portfolio**

| | SRI-KEHATI | ESG Leaders | ESG Sector Leader IDX KEHATI | ESG Quality 45 IDX KEHATI |
|---|---|---|---|---|
| Portfolio Return | 1.56% | 3.19% | 1.96% | 2.39% |
| Portfolio Beta | 0.99 | 1.33 | 1.14 | 0.77 |
| Treynor Measure | 0.0105 | 0.0201 | 0.0126 | 0.0244 |

According to the calculation of the Treynor measure above, the optimal portfolio of ESG Quality 45 IDX KEHATI (0.0244) appeared to have the greatest ratio among other optimal portfolios, followed by the optimal portfolio of ESG Leaders (0.0201). The greater Treynor measure for the optimal portfolio shows that it is doing well with its risk. On the other hand, the low Treynor measure suggests lower performance relative to risk. As a result, the performance of the optimal portfolio of ESG Quality 45 IDX KEHATI exceeds the other optimal portfolios, making it the preferred investment option for the given period.

**Sharpe Ratio**

The Sharpe ratio needs several calculations, which are portfolio return, portfolio standard deviation, and risk-free rate. The risk-free rate that will be employed in this research is 0.52%. The optimal portfolio return and standard deviation have been calculated previously. To generate the Sharpe ratio, the R code used is as follows.

```
# Calculate Sharpe Ratio
sharpe_ratio <- (portfolio_return - risk_free_rate) / portfolio_sd
cat("Sharpe Ratio:", sharpe_ratio, "\n")
```

**Table 11. Sharpe Ratio of Each Optimal Portfolio**

| | SRI-KEHATI | ESG Leaders | ESG Sector Leader IDX KEHATI | ESG Quality 45 IDX KEHATI |
|---|---|---|---|---|
| Portfolio Return | 1.56% | 3.19% | 1.96% | 2.39% |
| Standard Deviation | 5.81% | 10.09% | 6.34% | 7.04% |
| Sharpe Ratio | 0.1794 | 0.2641 | 0.2277 | 0.2665 |

Based on the results, the optimal portfolio of ESG Quality 45 IDX KEHATI's Sharpe ratio (0.2665) is the highest among the others, followed by the optimal portfolio of ESG Leaders (0.2641). This shows that the performance of the optimal portfolio of ESG Quality 45 IDX KEHATI is superior to the performance of the other optimal portfolios when adjusting for total risk.

**Jensen's Alpha**

To compute Jensen's alpha of the optimal portfolios, some calculations must be done, including portfolio return, risk-free rate, average market return, and portfolio beta. The return and beta of the optimal portfolios as well as market return (JKSE) have already been determined. The risk-free rate utilized in this study is 0.52%. To calculate Jensen's alpha, the R code is described below.

```
# Calculate Jensen's Alpha
jensen_alpha <- portfolio_return - (risk_free_rate + (market_return - risk_free_rate) *
beta_portfolio)
cat("Jensen's Alpha:", jensen_alpha, "\n")
```

**Table 12. Jensen's Alpha of Each Optimal Portfolio**

| | SRI-KEHATI | ESG Leaders | ESG Sector Leader IDX KEHATI | ESG Quality 45 IDX KEHATI |
|---|---|---|---|---|
| Portfolio Return | 1.56% | 3.18% | 1.96% | 2.39% |
| Portfolio Beta | 0.99 | 1.33 | 1.14 | 0.77 |
| Jensen's Alpha | 0.0131 | 0.0302 | 0.0175 | 0.0208 |

Based on the Jensen's alpha measure, all optimal portfolios reached positive Jensen's alpha which shows that they outperform the expected return based on its beta. However, the optimal portfolio of the ESG Leaders has the greatest alpha (0.0302) among the others, followed by the optimal portfolio of the ESG Quality 45 IDX KEHATI (0.0208). A greater alpha of the optimal portfolio of the ESG Leaders indicates stronger portfolio performance. Investors frequently desire high alpha levels to guarantee that they earn more returns for the same degree of risk.

## CONCLUSION

Despite growing awareness of ESG issues, many investors still face hurdles such as a lack of expertise and confusing information, in implementing ESG investment. The Markowitz approach can help investors optimize their ESG stocks portfolios. This method employs historical data on asset returns, variances, and covariances to identify the optimal frontier that maximizes the risk/return ratio. The Markowitz strategy, which emphasizes diversity, helps to lower unsystematic risk.

Using the Markowitz model, the optimal portfolios from four Indonesian green indices: SRI-KEHATI, ESG Leaders, ESG Sector Leaders IDX KEHATI, and ESG Quality 45 IDX KEHATI Indexes are successfully generated, offering better balance in risk/return ratio. Using monthly data from June 30$^{th}$, 2019, until June 30$^{th}$, 2024, the optimal portfolio of SRI-KEHATI consisting of six stocks, which are ANTM, AUTO, BMRI, BSNG, SIDO, and SSMS, could generate a return of 1.56% with a standard deviation of 5.81%. During the same period, the optimal portfolio of ESG Leaders consisting of six stocks, which are AUTO, MPMX, BFIN, AKRA, TBIG, and TPIA, could obtain a return of 3.19% with a standard deviation of 10.09%. For the optimal portfolio of ESG Sector Leaders IDX KEHATI consisting of five stocks, which are AKRA, DSNG, HEAL, MPMX, and SIDO, could generate a return of 1.96% with a standard deviation of 6.34%. While the optimal portfolio of ESG Quality 45 IDX KEHATI consisting of six stocks, which are AKRA, DSNG, HEAL, MPMX, SILO, and TBIG, could obtain a return of 2.39% with a standard deviation of 7.04%. Ultimately, investors can pick any option of the proposed portfolios in four Indonesian green indexes based on their financial objectives and risk tolerance.

To ensure that investments are well managed, this study involves a performance comparison of those optimal portfolios using indicators such as the Treynor measure, Sharpe ratio, and Jensen's alpha, which offer more comprehensive insights. Calculating these indicators also helps investors to know better which optimal portfolio offers the best performance relative to the risks.

The optimal portfolios suggested by the four green indexes have a positive Treynor measure, which suggests that they perform well in terms of risk. The optimal portfolio of ESG Quality 45 IDX KEHATI is the one that successfully achieved the highest value of Treynor Measure. This also reached the highest value in the Sharpe ratio. This indicates that the optimal portfolio of ESG Quality 45 IDX KEHATI

outperforms the other optimal portfolios when total risk is taken into consideration. Based on Jensen's alpha measure, all optimal portfolios have a positive Jensen's alpha implies the optimal portfolios beat the predicted return based on the beta. However, the optimal portfolio of ESG Leaders has the highest alpha among the other optimal portfolios. A greater alpha of the optimal portfolio of ESG Leaders indicates stronger portfolio performance. The outperformance of the optimal portfolios suggested by ESG Leaders and ESG Quality 45 IDX KEHATI shows that these optimal portfolios become preferred investment options for the specified period.

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