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Optimization investment portfolio of ESG capital market in Indonesia: An investigation of Polynomial Goal Programming based on higher moments

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A B S T R A K

Perkembangan investor pasar modal di Indonesia mengalami pertumbuhan yang sangat pesat sehingga menyebabkan pergerakan pasar domestik yang semakin volatile. Dalam menghadapi permasalah tersebut, perusahaan atau Manajer Investasi dituntut untuk tetap dapat membentuk portofolio asset dengan expected return yang optimal dengan risiko yang terukur. Penelitian ini bermaksud untuk menganalisa kemungkinan kombinasi yang dapat terbentuk menggunakan ESG Capital Market Indonesia 2022 dan instrument safe-haven menggunakan teori Markowitz dan metode Polynomial Goal Programming (PGP). Penelitian ini menggunakan data sekunder dan objek penelitian yang digunakan adalah ESG Capital Market Indonesia 2022 dan emas pada periode Januari 2007 sampai Desember 2022. Berdasarkan penelitian sebelumnya, pembentukan kombinasi portofolio menggunakan instrumen safe-haven menggunakan teori Markowitz dan metode Polynomial Goal Programming (PGP) dapat memberikan kombinasi portofolio investasi yang lebih baik ketika menghadapi krisis. Selanjutnya, masing-masing kombinasi yang terbentuk diukur kinerjanya menggunakan Sharpe Ratio. Hasil peneltian mengindikasikan bahwa teori Markowitz dapat menghasilkan kinerja yang lebih baik dibandingkan metode PGP. Namun, memiliki nilai skewness dan kurtosis yang kurang optimum dibandingkan dengan metode PGP.

A B S T R A C T

The development of capital market investors in Indonesia has experienced rapid growth, leading to increasingly volatile movements in the domestic market. Companies or investment managers must form asset portfolios with optimal expected returns and measurable risks to address this issue. This study aims to analyze the potential combinations that can be formed using ESG

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Capital Market Indonesia 2022 and safe-haven instruments, utilizing the Markowitz theory and Polynomial Goal Programming (PGP) method. This research uses secondary data, and the research variables used are ESG Capital Market Indonesia 2022 and Gold from January 2007 to December 2022. Based on the previous research, the formation of portfolio combinations using safe-haven instruments, employing the Markowitz theory and Polynomial Goal Programming (PGP) method can provide better investment portfolio combinations during crises. Furthermore, the performance of each formed combination is measured using the Sharpe Ratio. The findings indicate that Markowitz's theory can generate better performance than the PGP method. However, it exhibits suboptimal skewness and kurtosis values compared to the PGP method.

INTRODUCTION

The development of capital market investors in Indonesia is experiencing rapid growth. In Indonesia, there was an increase in capital market investors from 2.28 million to 9.77 million investors or an increase of 30.55% from December 2021 of 7.48 million investors. A strategy or method is needed to form an optimum investment portfolio so that investing can provide an optimal return. Forming an optimal investment portfolio will be better if someone diversifies assets using uncorrelated instruments (Partovi & Caputo, 2004). The first modern investment portfolio formation theory (Markowitz Theory) was discovered in 1952. This model uses a mean approach, is weighted to measure investment performance, and uses the value of the portfolio variance to measure investment risk. Markowitz explained that the results of Markowitz's theory will be maximized if the return-on-investment instruments are normally distributed. However, Markowitz's theory is currently less relevant to use because the Markowitz theory approach only uses the mean and variance approach. So, it becomes less suitable for data that does not spread normally. Applied Markowitz's theory by incorporating elements of Kurtosis into the portfolio model indicates that the return value on the data distribution will be at the same frequency, thereby reducing the risk of portfolio selection (Harvey *et al*., 2010).

The objects used in this research are ESG-based investment instruments in Indonesia, namely ESG Capital Market Indonesia 2022, and safe-haven instruments, namely Gold. The use of ESG instruments in this study is based on the needs of investors starting to pay attention to ESG aspects and invest in ESG-based instruments or issuers. Azmi *et al.* (2019) explained that the Dow Jones Sustainability World index can provide better returns during the Global Financial Crisis. Investing in companies that implement the ESG (Environmental, Social, and Governance) framework is becoming a concern for global investors today and in the future (Taylor & Collins, 2022). Global investor interest in ESG products continues to increase, and with the current growth rate in the future, it is estimated that investment in ESG products can be higher than non-ESG products. Factors affecting global investor interest in ESG

products are caused by the Sustainable Finance Disclosure Regulation (SFDR) agreement, which requires investment managers to comply with SFDR rules in forming investment portfolios. It can be presented in Figure 1.

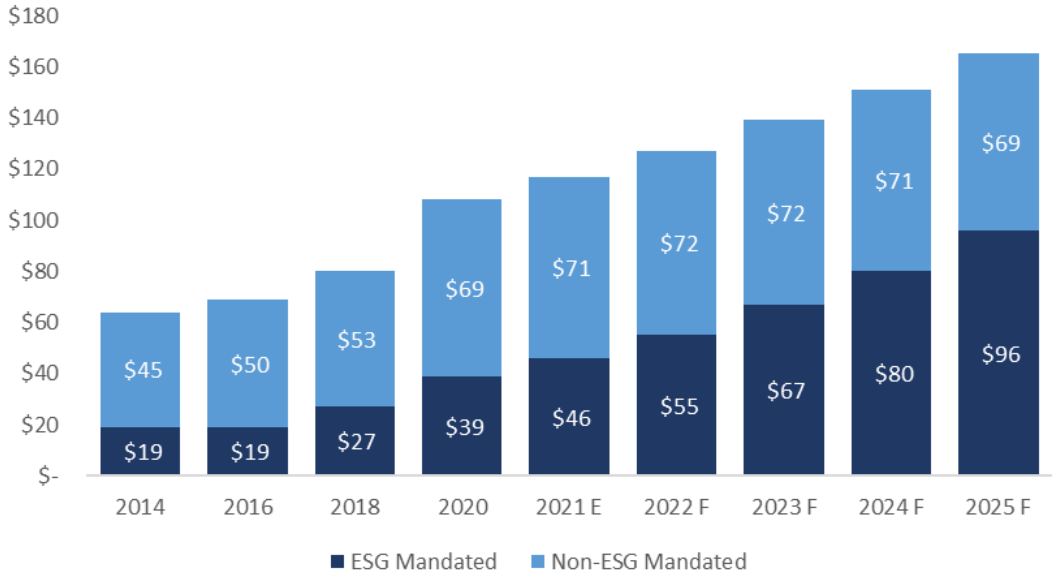

Figure 1
Global Assets Under Professional Management ($T)
Source: Taylor & Collins (2022)

In 2022, it is estimated that the Asset Under Management (AUM) of ESG products will be US $ 46 trillion, equivalent to 39% of the total Global Assets under professional management. In 2025, the AUM of ESG products is estimated to be US$ 96 trillion, equivalent to 58% of the total Global Assets under professional management. Leins (2020) explained that ESG has become a concept used by financial analysts in conducting calculations and analysis. Companies that have implemented ESG are considered to have carried out social responsibility so that the investments made not only provide returns from the financial side but also from the social side. The Financial Services Authority groups companies in Indonesia that have implemented ESG principles into the Indonesian ESG Capital Market. The safe-haven instrument in this study uses gold because gold is a commodity index often used, and gold has a relatively stable value when facing an economic crisis. When there was a decline in the stock index from December 2019 to March 2020 (COVID-19 period), the gold instrument became one of the attractive investment instruments for investors. External factors, such as the Global Financial Crisis, impact investment portfolio performance. The Global Financial Crisis of 2008 was caused by the real estate sector and the consumer sector becoming the most efficient and resilient sectors during that crisis. In contrast, during the COVID-19 period, the decline in the manufacturing sector led to a decrease in overall domestic consumption levels. The previous research has shown a limited study on using the Polynomial Goal Programming method in ESG instruments in Southeast Asia, especially in Indonesia. Previous research has

explained that an Efficient Frontier using investment instruments can be obtained by combining stock and digital asset instruments (Popescu, 2022). Furthermore, it has been described that the Mean-Variance Model method performs better when applied across all simulations (short-term and long-term tenors) (Job, 2022). A study that used Indonesian investment instruments explained that the Markowitz method could provide an optimal investment portfolio with lower risk when compared to a single index in measuring the Jakarta Islamic Index (JII) stocks (Chasanah *et al*., 2020). Based on those problems, this research will form an optimal investment portfolio that combines ESG-based instruments in Indonesia with the Gold index (XAU/US$) in 3 different periods [Global Financial Crisis (2007-2010), non-Global Financial Crisis (2011-2019), and COVID-19 Crisis (2020-2022)].

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Research related to investment portfolio optimization strategies has been carried out by previous researchers both from the domestic and non-domestic sides. From some of these studies, each country has investment instruments that have different characteristics from one another. For example, Lv *et al.* (2023) explained that Hong Kong does not require asset diversification to obtain optimal returns. This contradicts other researchers who demonstrate the need for asset diversification. Another research by Trichilli *et al.* (2020) explained that asset diversification is needed for bullish and bubble-state conditions in conventional financial markets. Wahyuni (2014) said that gold is considered because the stock movement does not have a mutual relationship with gold investment. Gold investment is the best choice compared to stock investment during the pandemic. During COVID-19, investors made investments by considering the Gold index as an alternative when facing a crisis. Then, it remained one of the safe-haven instruments during the COVID-19 crisis. When there was a decline in stock indices from December 2019 to March 2020, Gold became an attractive investment option for investors (Akhtaruzzaman *et al*., 2021). Each country has different characteristics of investment instruments. So, this research is important to determine how Indonesia's strategy of forming an optimal investment portfolio is applied. Therefore, our hypothesis shows that an optimal investment portfolio is obtained through portfolio diversification. The observation period factors during the Global Financial Crisis and Non-Global Financial Crisis periods need to be considered due to the impact of external factors. Then, Gold (as a safe-haven instrument) is necessary to generate a more optimal investment portfolio.

Portfolio Optimization Method

The Markowitz Theory also introduced the Mean-Variance Model (MVM) approach in its research, known as the first modern portfolio optimization method (Steinbach, 2001). This model utilizes a mean approach and assigns weights to measure investment performance using the portfolio's variance value to assess

investment risk. Markowitz explains that the results of the MVM model will be more optimal when the returns of investment instruments are normally distributed. The results of empirical studies, considering higher moments such as skewness and kurtosis, indicate more efficient and robust investment portfolio outcomes in facing market uncertainty. Chen & Zhou (2018) highlighted that this can assist investors and investment managers.

Previous research by Konno *et al*. (1993) found that the Mean-Variance Model (MVM) on non-normally distributed data can exhibit indications of skewness and kurtosis. On the other hand, Harvey *et al.* (2010) attempted to apply the MVM by incorporating kurtosis elements into the portfolio, indicating that the return values in the data distribution occur at the same frequency, thus reducing the risk of portfolio selection. Therefore, the distribution of returns in investment instruments with skewness and kurtosis values can yield different results when the returns of investment instruments are not normally distributed. The MVM cannot capture the risk values in the non-normally distributed returns of investment instruments.

In the formation of investment portfolios, there is a method that combines the Mean-Variance Model (MVM) with Skewness-Kurtosis, known as Polynomial Goal Programming (PGP), to calculate Mean-Variance-Skewness-Kurtosis (MVSK) simultaneously.

As explained by Job (2022), it was found that the Mean-Variance optimization model with combination yields better results compared to conventional methods in almost all simulations (both short and long tenors). Other research on portfolio formation by hedge fund companies suggests that portfolio formation without considering skewness and kurtosis can lead to biased results in portfolio formation (Proelss & Schweizer, 2014). Additionally, PGP can assist in solving problems related to the formation of investment portfolios, including in Indonesia.

The researcher will compare the portfolio optimization method using the polynomial goal programming method and Markowitz's theory. According to Chasanah (2017), the Markowitz method can form an investment portfolio with lower risk than a single-index method. Another researcher also found that the Mean-Variance approach method is considered less effective due to the characteristics of real data containing skewness and kurtosis, and the data does not always meet normality assumptions (Khan *et al*., 2020). However, the Mean-Variance optimization model yielded better results than conventional methods in almost all simulations (short-term and long-term tenors) (Job, 2022). Regarding the previous research and current data, the researcher wants to compare the Polynomial Goal Programming method and the Markowitz theory when implemented in investment instruments in Indonesia.

RESEARCH METHODS

This study uses secondary data from third parties, such as Bank Indonesia, Bloomberg, and/or Refiniv. Some investment instruments that are the object of this research include the closing prices of all ESG Capital Market Indonesia 2022 and Gold issuers from January 2007 to December 2022. Researchers will calculate the weight value of the portfolio formed using Markowitz's theory, which measures the weight of the investment portfolio based on the value of the mean and variance of the total return portfolio. The performance of Markowitz's Theory is measured based on the expected return value formed. Furthermore, the same thing is done using the Mean-Variance-Skewness-Kurtosis Theory. The method used to measure the four indicators simultaneously using the Polynomial Goal Programming (PGP) approach.

PGP is an approach developed as one of the best methods in capital budgeting and financial planning with several criteria (Spronk, 1981). The application of PGP by considering Mean-Variance-Skewness-Kurtosis can provide complete information on data conditions that have returns that are not normally distributed.

$$Mean = R(x) = X^T \bar{R} = \sum_{i=1}^{n} x_i R_i \quad \text{..... 1}$$

$$Variance = V(x) = X^T VX = \sum_{i=1}^{n} x_i^2 \sigma_i^2 + \sum_{i=1}^{n} \sum_{j=1}^{n} x_i x_j \sigma_{ij} (i \neq j) \quad \text{..... 2}$$

$$Skewness = S(x) = E(X^T (R - \bar{R}))^3 \quad \text{..... 3}$$

$$Kurtosis = S(x) = E(X^T (R - \bar{R}))^4 \quad \text{..... 4}$$

With the information that R is the distribution of return data and R is the average or mean of the return. XT is the transpose vector of weights used in portfolio formation. XT=(x1,x2,x3,…,xn) with n the number of investment objects or issuers observed and xi is the percentage weight invested in the investment object or issuer to be invested. From the four equations, the value with maximum return, minimum Variance return, maximum Skewness return, and minimum Kurtosis return is selected or can be written in the model (P1).

$$(\text{P1}) \begin{cases} \text{Maximize } R(X) = X^T \overline{R} \\ \text{Minimize } V(X) = X^T VX \\ \text{Maximize } S(X) = E(X^T (R - \overline{R}))^3 \\ \text{Minimize } K(X) = E(X^T (R - \overline{R}))^4 \\ \text{subject to } X^T I = 1 \\ \qquad\qquad X \geq 0 \end{cases} \quad \text{..... 5}$$

The PGP method makes the multi-objective equation in P(1) above into a single objective equation. Therefore, the model in equation (5) is modified into equation (6).

$$
(P6)\begin{cases}
\text{Minimize} & Z=\left|\frac{d_1}{R^*}\right|^{\lambda_1}+\left|\frac{d_2}{V^*}\right|^{\lambda_2}+\left|\frac{d_3}{S^*}\right|^{\lambda_3}+\left|\frac{d_4}{K^*}\right|^{\lambda_4} \\
\text{subject to} & X^T\overline{R}+d_1=R^* \\
& X^TVX-d_2=V^* \\
& E(X^T(R-\overline{R}))^3+d_3=S^* \\
& E(X^T(R-\overline{R}))^4-d_4=K^* \\
& X^TI=1 \\
& X\geq 0 \\
& d_i\geq 0, i=1,\cdots,4
\end{cases} \quad \text{..... 6}
$$

The researcher formed a portfolio using eight different risk preferences based on the mean (1), variance (2), skewness (3), kurtosis (4). The Markowitz (Mean and Variance) method (1,1,0,0) is used to compare to other investment portfolios. Several portfolio simulations are used using several different risk preferences, including (3,1,1,0), (3,1,3,1), (3,1,2,3), (1,2,3,2), (2,3,3,1), (1,3,0,1), (1,3,1,3) which formulated within the Polynomial Goal Programming Framework in Table 1.

Table 1
Polynomial Goal Programming Framework (PGP)

	Polynomial Goal Programming							Markowitz Theory
	High Risk			Moderate Risk		Low Risk		
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
1	3	3	3	1	2	1	1	1
2	1	1	1	2	3	3	3	1
3	1	3	2	3	3	0	1	0
4	0	1	3	2	1	1	3	0

Source: Lai *et al.* (2006)

Investors who want to get maximum return with higher risk are described in preferences (3,1,1,0), (3,1,3,1), (3,1,2,3). Meanwhile, investors who have a low-risk appetite are described in preferences (1,3,1,3), (1,3,0,1). As for more flexible investors, it is described in preferences (1,2,3,2) and (2,3,3,1). Investors' risk preferences affect the four moments associated with the portfolio. Differences in investor risk preferences can impact investment strategies and the resulting investment performance, thus requiring various simulations, as shown in Table 1 (Khan et al., 2020). Furthermore, researchers will compare two combination results between ESG Capital Market Indonesia and Gold in the three periods: Combination I (ESG Capital Market Indonesia + Gold) and Combination II (ESG Capital Market Indonesia). Calculations using the above method are then carried out in three periods (the Global Financial Crisis, the non-Global Financial Crisis, and the COVID-19 Crisis).

The results of the optimal portfolio formation will be compared with one

another to obtain the results of portfolio formation using Markowitz Theory and Polynomial Goal Programming when applied to investment instruments in Indonesia. One of the methods used in this study to measure the performance of investment portfolios is the Sharpe Ratio. This method was first developed by William F. Sharpe in 1966 and is used to measure portfolio performance at different risk levels (Pratama *et al*., 2019). The Sharpe Ratio calculation formula is to subtract the value of the expected return on investment from the risk-free rate. It was divided by the standard deviation value. Mathematically explained by the following equation.

$$SR = \frac{Return - Risk\ Free\ Rate}{\sigma} \quad \text{..... 7}$$

RESULT AND DISCUSSION

Descriptive Statistics

The data used for observation in this study is how much the return value generated on each investment instrument was observed from January 2007 to December 2022. Furthermore, the data is calculated as the value of the JB test statistic to determine whether there is an indication that the data usually spreads.

Table 2
Descriptive Analysis of ESG Capital Market in Indonesia

	Mean	Sample Variance	Kurtosis	Skewness	JB test statistic	*P-value*
BBCA	0.001	0.001	5.296	0.294	4893.405	0.000
BBNI	0.001	0.001	8.907	0.552	13884.078	0.000
BBRI	0.001	0.001	5.215	0.569	4910.609	0.000
BMRI	0.001	0.001	5.649	0.531	5694.483	0.000
SMGR	0.001	0.001	8.845	0.161	13504.882	0.000
UNVR	0.001	0.001	6.355	0.743	7342.875	0.000
AKRA	0.001	0.001	4.097	0.437	3024.755	0.000
BSDE	0.001	0.001	18.695	0.992	60922.462	0.000

Source: Processed data results

The results of the JB test statistic at the 95% confidence level assuming that the initial hypothesis of the data is normally distributed and the alternative hypothesis of the data is not normally distributed, it can be concluded that the return data in the period January 2007 - December 2022 is not normally distributed because all p-values are less than 0.05. So, the original hypothesis is rejected, and the alternative hypothesis is accepted. From this data, it is obtained that each investment instrument observed does not fulfill the assumption of data normality and the existence of elements of skewness and kurtosis. Therefore, the Polynomial Goal Programming (PGP) method must be considered in forming an optimal investment portfolio by considering skewness and kurtosis. Furthermore, we will compare the two combined results between ESG Capital Market Indonesia and Gold in 3 different periods (Global Financial Crisis, Non-Global Financial Crisis, and COVID-19 Crisis).

Observations in the 2008 Global Financial Crisis period (2007-2010)

Equations (1), (2), (3), and (4) are calculated to obtain individual optimum values. Furthermore, the results of the individual optimum values are calculated using equation (6) to get the overall value. The calculation results for the 2008 Global Financial Crisis period (2007-2010) are shown in Table 3.

Table 3
Descriptive Analysis of the Global Financial Crisis Period

	Polynomial Goal Programming							**Markowitz Theory**
	High Risk			**Moderate Risk**		**Low Risk**		
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
1	3	3	3	1	2	1	1	1
2	1	1	1	2	3	3	3	1
3	1	3	2	3	3	0	1	0
4	0	1	3	2	1	1	3	0
BBCA	14%	58%	38%	51%	62%	62%	42%	**32%**
BBNI	0%	18%	33%	27%	23%	23%	42%	**0%**
BBRI	0%	0%	0%	0%	0%	0%	0%	**0%**
SMGR	7%	0%	0%	0%	0%	0%	0%	**13%**
UNVR	79%	23%	29%	22%	16%	16%	16%	**27%**
AKRA	0%	0%	0%	0%	0%	0%	0%	**22%**
Mean	0.128%	0.134%	0.130%	0.132%	0.135%	0.135%	0.131%	**0.152%**
Variance	0.033%	0.027%	0.027%	0.028%	0.029%	0.029%	0.031%	**0.022%**
Skewness	0.247	0.185	0.279	0.244	0.217	0.217	0.370	**-0.537**
Kurtosis	3.706	3.330	4.177	3.722	3.330	3.330	4.568	**5.765**

Source: Processed data results

Table 3 explains that Markowitz's theory is the optimal portfolio method with an expected return value of 0.152% per day with a portfolio composition of 32% BBCA, 27% UNVR, 22% AKRA, and 13% SMGR from the entire portfolio. However, the skewness value is -0.537, which explains the potential for losses when investing and the kurtosis of 5.765, which is relatively large compared to other portfolio combinations, which explains the value of investment returns that are relatively less homogeneous. When considering the Polynomial Goal Programming method, the best combination obtained is BBCA 62%, BBNI 23%, UNVR 16%, with an expected return of 0.135%, a skewness value of 0.217, and a kurtosis value of 3.330, which indicates that the likelihood of data generating positive returns is higher. The investment portfolio method using Polynomial Goal Programming is relatively lower in risk during this period. Furthermore, the researcher compared the performance of Combination I (ESG Capital Market Indonesia + Gold) and Combination II (ESG Capital Market Indonesia) during the 2008 Global Financial Crisis period (2007-2010), which is explained in Figure 2.

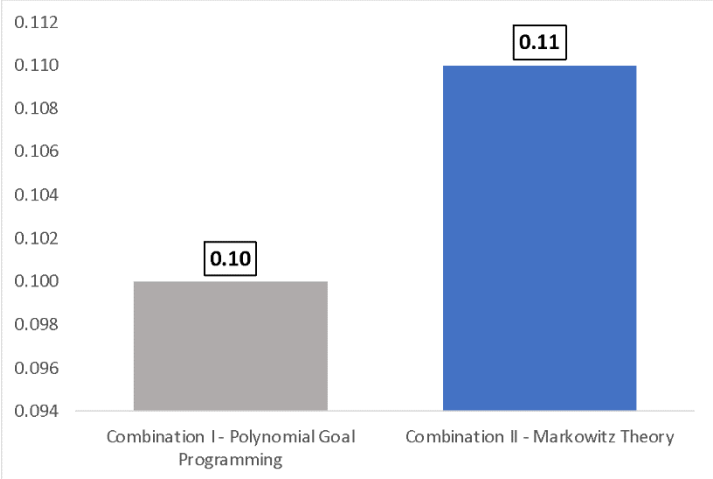

Figure 2
Sharpe Ratio of Global Financial Crisis

Figure 2 explains that the Sharpe Ratio value in Combination II has a value of 0.11 and is greater than Combination I, which explains the 2008 Global Financial Crisis period (2007-2010). Combination II has a better investment portfolio performance. Furthermore, the same analysis was conducted in the non-Global Financial Crisis period (2011-2019).

Observations in the non-Global Financial Crisis period (2011-2019)

With the same steps, equations (1), (2), (3), and (4) are calculated to obtain individual optimum values. Furthermore, the results of the individual optimum values are calculated using equation (6). The calculation results for the non-Global Financial Crisis period (2011-2019) can be seen in Table 4.

Table 4
Descriptive Analysis of the non-Global Financial Crisis Period

	Polynomial Goal Programming							Markowitz Theory
	High Risk			Moderate Risk		Low Risk		
	A	B	C	D	E	F	G	H
1	3	3	3	1	2	1	1	1
2	1	1	1	2	3	3	3	1
3	1	3	2	3	3	0	1	0
4	0	1	3	2	1	1	3	0
BBCA	0%	0%	**0%**	0%	0%	0%	0%	16%
BBNI	0%	0%	**0%**	0%	0%	0%	0%	0%
BBRI	0%	0%	**0%**	0%	0%	0%	0%	0%
SMGR	30%	30%	**38%**	37%	37%	15%	0%	0%
UNVR	13%	13%	**3%**	4%	3%	0%	22%	15%
AKRA	0%	0%	**0%**	0%	0%	26%	0%	2%
BSDE	0%	0%	**0%**	0%	0%	4%	25%	6%
GOLD	57%	57%	**59%**	59%	59%	54%	52%	61%
Mean	0.121%	0.121%	**0.132%**	0.131%	0.131%	0.111%	0.087%	0.087%
Variance	0.012%	0.012%	**0.015%**	0.014%	0.014%	0.013%	0.009%	0.009%
Skewness	- 0.03	- 0.03	**0.08**	0.07	0.07	- 0.14	- 0.30	- 0.38
Kurtosis	1.93	1.93	**1.81**	1.82	1.81	1.47	3.41	3.85

Source: Processed data results

Table 4 explains that using the Polynomial Goal Programming (PGP) method with high-risk preferences is the most optimal investment portfolio with an expected return value of 0.132%. The diversified portfolio composition is 59% Gold, 38% SMGR, and 3% UNVR. When examining the Markowitz Theory approach, the optimal mix consists of BBCA at 16%, UNVR at 15%, AKRA at 2%, BSDE at 6%, and Gold at 61% yielding an expected return of 0.087%. Additionally, the skewness is measured at -0.38, and the kurtosis at 3.85, suggesting a higher likelihood of negative return generation from the data. Using Markowitz's Theory to construct the investment portfolio is associated with relatively higher risk during this period. The portfolio formed has negative skewness and maximum kurtosis. Furthermore, researchers compared the performance of Combination I (ESG Capital Market Indonesia + Gold) and Combination II (ESG Capital Market Indonesia) in the non-Global Financial Crisis period (2011-2019), which is described in Figure 3.

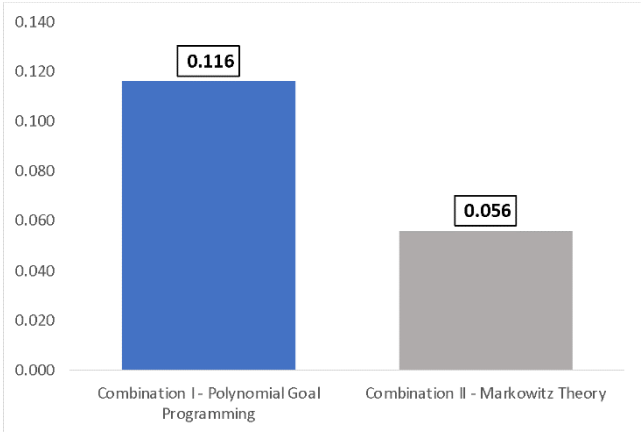

Figure 3
Sharpe Ratio of non-Global Financial Crisis

Figure 3 describes the Sharpe Ratio value in Combination I has a value of 0.116 and is greater than Combination II, which explains the non-Global Financial Crisis period (2011-2019). The combination I has better investment portfolio performance. Furthermore, the same analysis was carried out during the COVID-19 Crisis period (2020-2022).

Observations in the COVID-19 Crisis period (2020-2022)

With the same steps, equations (1), (2), (3), and (4) are calculated to obtain the individual optimum value. Furthermore, the individual optimum value results are calculated using equation (6). The calculation results for the COVID-19 Crisis period (2020-2022) can be seen in Table 5.

Table 5
Descriptive Analysis of the COVID-19 Crisis Period

	Polynomial Goal Programming							Markowitz Theory
	High Risk			Moderate Risk		Low Risk		
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
1	3	3	3	1	2	1	1	1
2	1	1	1	2	3	3	3	1
3	1	3	2	3	3	0	1	0
4	0	1	3	2	1	1	3	0
BBCA	0%	0%	0%	0%	0%	0%	0%	**16%**
BBNI	0%	0%	0%	0%	0%	0%	0%	**0%**
BBRI	0%	0%	0%	0%	0%	0%	0%	**0%**
SMGR	30%	30%	38%	37%	37%	15%	0%	**0%**
UNVR	13%	13%	3%	4%	3%	0%	22%	**15%**
AKRA	0%	0%	0%	0%	0%	26%	0%	**2%**
BSDE	0%	0%	0%	0%	0%	4%	25%	**6%**
GOLD	57%	57%	59%	59%	59%	54%	52%	**61%**
Mean	0.082%	0.095%	0.091%	0.095%	0.095%	0.101%	0.099%	**0.102%**
Variance	0.010%	0.011%	0.010%	0.011%	0.012%	0.010%	0.011%	**0.009%**
Skewness	1.26	0.25	0.33	0.40	0.38	-0.13	0.38	**0.13**
Kurtosis	14.14	2.78	3.47	3.11	2.96	2.49	3.28	**3.82**

Source: Processed data results

Table 5 explains that Markowitz's theory can produce an optimal investment portfolio in the COVID-19 Crisis period (2020-2022). The investment portfolio is composed of 61% Gold, 16% BBCA, 15% UNVR, 6% BSDE, and 2% AKRA of the overall portfolio. However, the skewness value is 0.13, the two lowest of the eight combinations formed, showing a positive but relatively small investment return. The kurtosis value is 3.82, the two largest of the eight combinations formed. The large kurtosis value explains that the data tends to be inhomogeneous. When we contemplate the Polynomial Goal Programming method, we arrive at an optimal blend comprising 22% UNVR, 25% BSDE, and 52% Gold. This mix yields an anticipated return of 0.099%, with a skewness measure of 0.38 and a kurtosis measure of 3.28. These statistics suggest an increased likelihood of the data yielding positive returns. Furthermore, using Polynomial Goal Programming to construct the investment portfolio exhibits comparatively lower risk during this time frame. Moreover, researchers compared the performance of Combination I (ESG Capital Market Indonesia + Gold) and Combination II (ESG Capital Market Indonesia) in the COVID-19 Crisis period (2020-2022), which is explained in Figure 4.

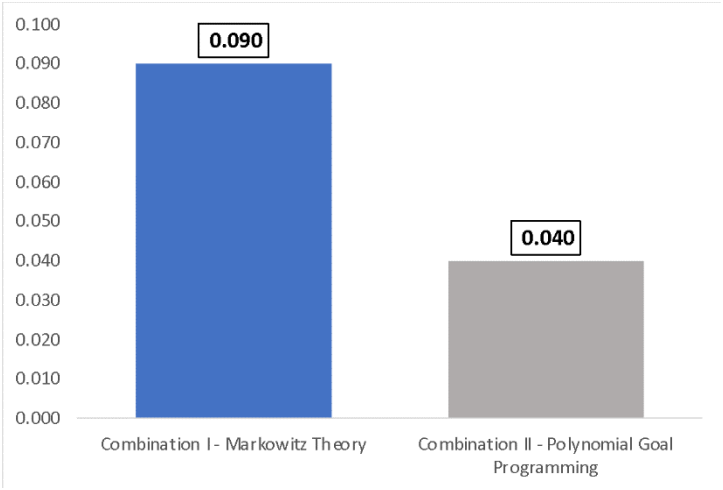

Figure 4
Sharpe Ratio of the COVID-19 Crisis

Figure 4 highlights the portfolio formed using combination I (ESG Capital Market Indonesia + Gold) has a Sharpe ratio value of 0.09, higher than Combination II (ESG Capital Market Indonesia) in the COVID-19 Crisis period (2020-2022). This explains that Combination I have better investment performance than Combination II.

CONCLUSIONS, LIMITATIONS, AND SUGGESTIONS

There are still other combinations in which Markowitz theory and the Polynomial Goal Programming (PGP) method can be used. As an illustration, consider the COVID-19 Crisis (2020–2022), the non–Global Financial Crisis (2011–2019), and the Global Financial Crisis (2007–2010). It can also provide an optimum investment portfolio. The optimum portfolio was obtained using Markowitz theory in the 2008 Global Financial Crisis period (2007-2010) and the COVID-19 Crisis period (2020-2022) of the two combinations formed. While in the non-Global Financial Crisis period (2011-2019) of the two combinations formed, the optimum portfolio was obtained using the PGP method. Second, considering a safe haven (Gold) provides a higher Sharpe ratio value in terms of the Sharpe ratio value generated by the combination. In the 2008 Global Financial Crisis period (2007-2010), Combination II (ESG Capital Market Indonesia) produced the highest Sharpe ratio, while in the non-Global Financial Crisis period (2011-2019) and the COVID-19 Crisis period (2020-2022) combination I (ESG Capital Market Indonesia + Gold) produced the highest Sharpe ratio.

There are two managerial implications (companies and investment managers). In forming an asset portfolio, it is expected to achieve two things: cost reduction and yield enhancement. One method that can be used to help form an asset portfolio is the Polynomial Goal Programming (PGP) method. PGP is a method of compiling a portfolio that meets several objectives, such as maximizing returns, minimizing risk,

and minimizing costs. There are several benefits in using PGP for companies. First, PGP can help management measure how much risk a company can accept. This is possible because, in calculating portfolio formation, there is a calculation of the risk preference element so that the PGP method is more flexible and can adjust the needs of company management. Second, company management can calculate the expected return measurably. So, it can help management achieve the initial goal of forming an asset portfolio. Third, company management can reduce costs and avoid potential risks that may occur in the future.

With the right strategy, company management can get the most efficient cost and optimal return. Management can find potential risks because the PGP method shows how much the value of skewness and kurtosis is formed. However, company management must consider several things when forming a portfolio using the PGP method. First, the PGP method requires cost and time in forming the PGP calculation algorithm, especially in forming large portfolios. As for interpreting the results of the PGP method, human judgment from management is needed whether it follows risk preferences and the expected return generated in the future. The research limitation in this study is that the data used only considers historical data and does not consider the company's internal or external factors that can influence the future price movements of investment instruments. In general, the PGP method can be a tool for company managers who intend to improve the performance of the company's asset portfolio.

There are differences in the results of investment portfolio formation using Markowitz's Theory and the PGP method. However, from 2 combinations formed in the 2008 Global Financial Crisis period (2007-2010) and the COVID-19 Crisis period (2020-2022), the optimum portfolio was obtained using Markowitz theory. Still, it produced a kurtosis value of 5.765 and 3.82, explaining that investment returns tended to be inhomogeneous. While in the non-Global Financial Crisis period (2011-2019) of the two combinations formed, the optimum portfolio was obtained using the PGP method.

ESG-based investment instruments described by ESG Capital Market Indonesia 2022 combined with safe-haven (Gold) provide higher Sharpe Ratio (SR) results compared to ESG-based investment instruments without considering safe-haven (Gold). This happened in 2 periods out of 3 different observation periods studied by researchers. The PGP method and Markowitz Theory can be regarded as forming an optimal investment portfolio but require adjustment from company management to ensure that the portfolio formed follows the company's risk appetite.

When constructing an optimal investment portfolio, it is advisable to consider other domestic investment instruments not discussed in this study, such as mutual funds and government or corporate bonds. For safe-haven instruments, you may also consider other safe-haven options like US Treasury securities, US$ currency, and JPY currency.

The Markowitz theory and the PGP method are still relevant when forming an optimal portfolio. However, exploring other optimal portfolio methods based on Big Data and/or Machine Learning may be worthwhile. Nevertheless, it's important to note that these methods should serve as tools and not replace human judgment as the primary guiding factor in portfolio construction.

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