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Investment Portfolio Optimization in Indonesia (Study On: Lq-45 Stock Index, Government Bond, United States Dollar, Gold and Bitcoin)

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ABSTRACT: In forming their portfolios, investors should analyze the risk and return of each investment instrument. This is aimed at preventing investors from speculating and gambling with their investments. Conducting an investment portfolio optimization study on LQ-45 stock index, government bond, USD, gold, and Bitcoin can provide valuable insights due to unique market characteristics in Indonesia. This research analyzes the formation of investment instruments over the last 60 months, specifically from January 2018 to December 2022. The research method used in this study is quantitative research aimed at selecting several investment instruments for a portfolio in Indonesia. The portfolio aims to minimize risk and maximize return using the Markowitz method, also known as the optimal portfolio. To fulfill the objectives of this research, data on the prices of each instrument are required. An optimal portfolio can be obtained by combining two instruments: 18% bitcoin and 82% gold. This optimal portfolio can achieve an expected return of 1.29% with a risk level of 5.15%. Considering a risk-free rate of 0.375%, this portfolio forms a slope of 0.1775, which is the largest slope formed between the combination of risk-free instruments and risky portfolios. Investors should allocate their funds more wisely, considering not only the highest return but also the associated risk. High returns often come with high risks, so investors need to assess the risk-return trade-off before making investment decisions.

KEYWORDS: Bitcoin, Government Bond, Gold, LQ-45, Portfolio Optimization, USD.

INTRODUCTION

The portfolio formed by an investor can provide high returns or, on the contrary, cause losses for the investor. In other words, risk is a deviation from the expected return. There is a positive relationship between return and risk in investing, known as high risk-high return, which means the greater the risk that must be borne, the greater the resulting return. Return is the result obtained from an investment, which can be in the form of realized return or expected return that has not yet occurred but is expected to happen in the future. Meanwhile, portfolio risk consists of systematic and unsystematic risk. Both of these risks are often referred to as total risk. Some factors that influence this uncertainty include securities prices and interest rates, which can change at any time. The benefits of diversification are well-known through the principle that says "Don't put all your eggs in one basket", because if that basket falls, then all the eggs in it will break. In the context of investment, this proverb can be interpreted as a recommendation not to invest all the funds owned in only one asset, because if that asset fails, then all the invested funds will disappear.

Investors expect to get maximum returns with minimum possible risk. However, the larger the profit obtained from an investment, the higher the associated risk. Therefore, investors need to consider the balance between risk and return in investing. Risk can be minimized by diversification or by combining several investment instruments into a portfolio. If one instrument experiences a loss while another instrument generates a profit, the profit from one instrument can offset the loss from the other investment instrument. Effective diversification of investment instruments yields efficient results in a portfolio, providing maximum expected returns with minimal variance for those expected returns. Such a portfolio is called a Markowitz Efficient Portfolio This study focuses on investment instruments in Indonesia, including the LQ-45 stock index, government bonds, United States dollar, gold, and Bitcoin can provide valuable insights due to unique market characteristics, diversification benefits, local investor perspectives, period-specific analysis, and the opportunity to contribute to existing knowledge.

The selected instruments represent different asset classes, each with its own characteristics and potential benefits. By including a mix of equities (LQ-45 stock index), fixed income (bonds), currencies (US dollar), commodities (gold), and cryptocurrencies (bitcoin), this can analyze how diversification across these assets may impact portfolio performance and risk management. The LQ45 stock index is a widely recognized benchmark index for the Indonesian stock market, providing insights into the performance of the country's largest and most liquid stocks. Government bonds, on the other hand, represent fixed-income securities issued by

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the Indonesian government, offering income and potentially lower risk compared to equities. The US dollar is a commonly used global reserve currency and serves as a benchmark for many international transactions. Gold is a well-known precious metal and often considered a store of value. Bitcoin, as a cryptocurrency, represents a digital and decentralized form of currency with its own unique characteristics. By including a diverse set of instruments, this can conduct a comprehensive analysis that covers a broader range of investment options. This can enhance the understanding of portfolio optimization, risk management, and the potential for achieving better risk-adjusted returns.

When forming a portfolio, investors seek to minimize risk and maximize returns. A portfolio that can achieve these goals is called an optimal portfolio. To form an optimal portfolio, several assumptions need to be made about investor behavior in making investment decisions. It is assumed that investors tend to avoid risk (risk averse). This type of investor would choose an investment with lower risk if presented with two investments with the same expected return but different levels of risk.

LITERATURE REVIEW

A. Portfolio

Investing aims to generate profits with a certain level of risk. The purpose of creating an investment portfolio is to diversify risk so that the funds held have minimum risk. Investing in more than one investment instrument has lower risk compared to investing in only one instrument. The more investment instruments involved in the portfolio, the lower the risk. If there is a decrease in one investment instrument, then other instruments can offset or replace it. Therefore, investors must have diversity in their portfolio so that the funds held do not experience a decrease from their initial value (Markowitz, 1952) Markowitz assumed that investors would be able to create an efficient portfolio. He also stated that the portfolio should be diversified to achieve risk spreading. Such diversification will produce an efficient portfolio where it provides a higher level of return than other portfolios with the same risk and a lower risk than other portfolios with the same level of return.

B. Optimal Portfolio

The optimal portfolio is a portfolio that provides the highest expected return for a given level of risk or the lowest level of risk for a given level of expected return. In other words, it is the portfolio that offers the best risk-reward trade-off for an investor. The concept of the optimal portfolio was introduced by Harry Markowitz in his seminal paper "Portfolio Selection" in 1952. To find the optimal portfolio, an investor needs to consider the expected returns, standard deviations, and correlations of all the assets in the portfolio. The optimal portfolio can be identified by plotting the efficient frontier, which is a curve that represents the set of portfolios that offer the highest expected return for a given level of risk, or the lowest level of risk for a given level of expected return. The point on the efficient frontier that corresponds to the investor's risk tolerance and expected return is the optimal portfolio for that investor.

The optimal portfolio is crucial for investors who want to maximize their returns while minimizing their risk. By diversifying their portfolio and selecting assets with low correlations, investors can reduce their portfolio's risk and increase their expected returns. The optimal portfolio is also useful for portfolio managers who want to construct a portfolio that meets the investment objectives of their clients while minimizing risk.

C. Asset Allocation

Asset allocation is more focused on placing funds in various investment instruments rather than emphasizing stock choices in the portfolio. From the study results, differences in performance are more due to asset allocation rather than investment choices. According to Markowitz (1952), asset allocation is one of the factors that determine the level of return and risk of the portfolio. Perrit and Lavine (1990) state that besides diversification, this asset allocation is a very important factor in investment, for practical reasons such as targeting long-term investments, determining the risk that investors can tolerate over time, and eliminating investment decision changes based on changes in financial conditions.

D. Conceptual Framework

This study presents a conceptual framework encompassing the key elements of modern portfolio theory (MPT), including the optimal portfolio, Sharpe ratio, portfolio variance and covariance, risk preference, and efficient frontier. Developed by Harry Markowitz in the 1950s, MPT offers a robust framework for constructing portfolios that strive to optimize the delicate balance between risk and return.

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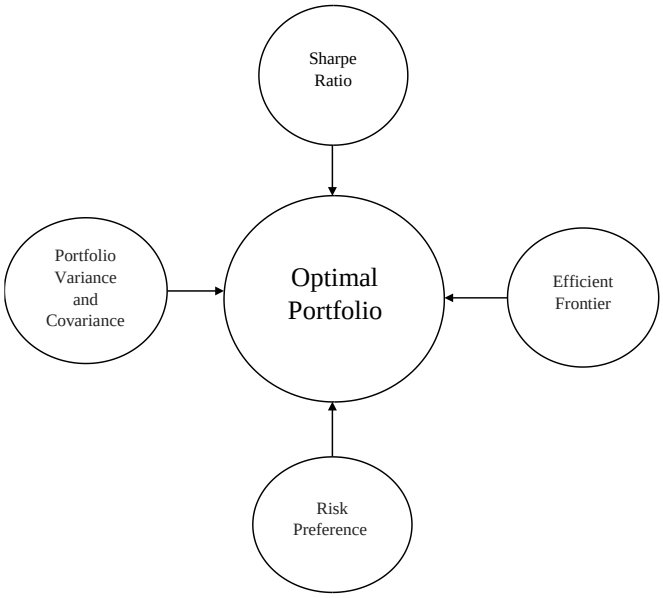

Figure 1. Conceptual Framework

RESEARCH METHODOLOGY

A. Data Collection Method

In this research, historical data was obtained by visiting websites that provide the required data. This research analyzes the formation of investment instruments over the last 60 months, specifically from January 2018 to December 2022. In selecting the instruments, several instruments were chosen to represent the entire range of instruments available in Indonesia.

B. Data Analysis Method

Due to the complexity of data processing, assistance from computer software, specifically Microsoft Excel, is required. Apart from being easy to operate, this software also offers the necessary functions and features for performing calculations. The functions in Microsoft Excel are highly useful for data processing, including stdevp (calculating standard deviation), average (calculating the mean), correl (calculating correlation), covar (calculating covariance), and varp (calculating variance).

In addition to these functions, the additional features in Microsoft Excel, especially the Solver feature, are crucial for data processing. This feature allows for finding solution values in linear programming equations by setting value criteria and applying various constraints or objective function limitations. In addition to its usefulness, one of the advantages of Microsoft Excel is its ease of application in the portfolio calculation procedure using the Markowitz Method employed in this study. It is user-friendly and widely popular software in the community.

C. Calculating Investment Instrument Returns and Market Value

The historical data obtained consists of monthly instrument prices or given return values. For data that is still in the form of instrument prices, the initial step of calculation is to compute the monthly returns.

D. Calculating Average Returns of Instruments and Market Value

The next step is to calculate the average return and standard deviation. From the historical return data, the monthly average return and standard deviation are calculated. With a total of 60 records, the average return for each instrument and market value is calculated to obtain the monthly average return.

E. Calculating Standard Deviation of Instruments and Market Value

To simplify the calculation, the stdevp(argument) function is used, where the argument contains the return data of the instruments during the research period in Microsoft Excel software.

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F. Calculating Correlation of Investment Instruments

The next step is to calculate the correlation coefficient between instruments. The correlation coefficient is used to analyze whether a variable has a significant relationship with another variable. It helps determine the strength of the relationship, as well as how one variable influences the other. In this case, the variables are investment instruments.

The correlation coefficient indicates the magnitude of the relationship between the movements of two variables relative to their respective deviations. In statistics, the correlation coefficient ranges between two extreme values: perfect positive correlation (+1), indicating a strong positive relationship, perfect negative correlation (-1), indicating a strong inverse relationship, and a correlation coefficient of zero (0), indicating no correlation.

G. Calculating Covariance of Investments Instruments

The next step is to calculate the covariance between instruments. Covariance is the average of the products of deviations between one instrument and another.

H. Calculating Portfolio Variance

The next step is to calculate the portfolio variance. In calculating the portfolio variance, the portfolio standard deviation is calculated first. The portfolio standard deviation is the square root of the portfolio variance. The portfolio variance is obtained by multiplying the covariances between instruments with the weights of each instrument in the portfolio.

I. Calculating Portfolio Return and Standard Deviation

The next step is to calculate the portfolio return. To calculate the portfolio return, we first calculate the average return per instrument per month over the research period. Then, the portfolio return can be calculated by accumulating the average returns per instrument in the research. The next step is to calculate the standard deviation of the portfolio. The next step is to find the portfolio return and portfolio standard deviation using the Solver feature in Microsoft Excel. To facilitate the calculation process, the solver feature in Microsoft Excel is used. In this feature, several variables need to be filled in order to obtain the instrument weights that minimize the variance. From filling in all the variables mentioned above, the spreadsheet calculation process is performed by clicking the solve button. The portfolio standard deviation and portfolio return resulting from the solver calculation process represent a combination of all instruments that minimize the variance, which is also known as the Global Minimum Variance (GMV) point.

J. Constructing the Minimum Variance Frontier Curve

The next step is to find the points that represent combinations of portfolio return and portfolio standard deviation, forming the minimum variance frontier curve using the solver feature in Microsoft Excel. Before finding these values, it is necessary to identify the instrument with the highest return and the instrument with the lowest return as individual instruments. If needed, the data should be plotted on a graph for easier search. Then, determine the number of points to be generated between the highest return and the lowest return, which will result in a return increment (delta return).

To obtain these points, the solver feature is used with the objective function and constraints as described in section 3.10. The difference is that in the subject to constraints column, a constraint for the portfolio return is added. The lowest individual return is added to the delta return, resulting in a different standard deviation. Similarly, the other points are processed by adjusting the subject to constraints column with multiples of the delta return until reaching the highest individual return. From the generated points, a line can be drawn through all of them, forming a curve that opens to the right. This curve will also pass through the GMV point directly since this point represents the minimum point of the efficient frontier.

K. Selecting the Efficient Frontier Curve

The next step is to determine the efficient frontier, which is a part of the minimum variance frontier curve. By forming the points described in section 3.10, the minimum variance frontier curve can be created. From the data processing in section 3.9, the GMV point located on the minimum variance frontier curve is obtained. The curve below the GMV point on the minimum variance frontier is considered the non-efficient frontier. This is because, with the same standard deviation, portfolios on the minimum variance frontier curve above the GMV point can achieve higher returns.

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L. Finding the Optimal Portfolio

The next step is to find the optimal point in the risky asset portfolio. In order to obtain the optimal portfolio point, the risk-free rate needs to be determined. Once known, an equation to calculate the reward-to-variability ratio is created in specific cells, referencing other cells that contain portfolio returns, the risk-free rate, and portfolio standard deviation.

M. Finding the Complete Optimal Portfolio

The next step is to construct a portfolio that involves investment in a risk-free instrument. By combining the risk-free instrument with the optimal portfolio of risky instruments, a complete optimal portfolio can be formed.

RESULT AND DISCUSSION

A. Data Processing with Markowitz Method

With the available historical data for several sample instruments including Bitcoin, gold, government bond, LQ45, and the US dollar from the period of 2018 to 2022, data processing is conducted. The goal is to form an optimal portfolio with measured portfolio performance.

B. Instrument Return Analysis

Investment Return Analysis begins with calculating the return of each instrument. According to Kritzman (1990, p.7) in his book titled "Asset Allocation for Institutional Portfolios," return is the income generated from an asset, adjusted for changes in prices that occur over a specific period, divided by the price of the asset at the beginning of the period. According to Levy (1999, p.198) in his book titled "Introduction to Investments," expected return represents the average of the potential rates. Expected return is also known as the mean return, simplified as the mean. Expected return has two components, namely the probability and the rate of return of an asset. The fluctuation in prices of each instrument makes it difficult for the author to estimate the probability distribution of each instrument. Therefore, to calculate the expected return per month, the researcher assumes that the probability distribution remains constant. This means that the denominator is the sum of monthly sample returns (closing price per month) for each instrument during the research period. In this study, there are sixty months from January 2018 to December 2022.

C. Average Return and Risk

The initial step in data processing, according to Bodie, Kane, and Marcus (2011, p.156), is to calculate the average return. From the historical returns of all instruments obtained, the average return can be calculated for each instrument over the entire research period. This is done by dividing the total return of each instrument during the research period by the number of months in the research period. The "average" function in Microsoft Excel can be used with the arguments of each return for the entire research period to obtain the expected return per instrument.

The next step in data processing, according to Bodie, Kane, and Marcus (2011, p.156), is to calculate the risk (standard deviation) for each instrument over the entire research period. Risk is the square root of variance, so calculating risk is aligned with calculating variance. The "stdev" function in Microsoft Excel can be used with the arguments of each return for the entire research period to obtain the risk per instrument.

Table 1. Standard Deviation and Monthly Returns of Individual Instruments

No.	Instrument	Standar Deviation (σ)	Expected Return (E(r))
1	Bitcoin (BTC)	21.67%	3.26%
2	Gold	4.15%	0.86%
3	Goverment Bond	5.59%	0.26%
4	LQ45	5.27%	-0.14%
5	US Dolar	2.77%	0.29%

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From Table 1. above, it can be seen that Bitcoin has the highest risk, with a standard deviation of 21.67% and an expected return of 3.26%. On the other hand, the US Dollar has the lowest risk, with a standard deviation of 2.77% and an expected return of 0.29%, confirming the concept of high risk high return.

D. Correlation Coefficients

The next step is to calculate the correlation coefficients for all the instruments. The correlation coefficient, or simply correlation, is a statistical measure used to assess the relationship between individual instrument returns or the tendency of two instruments to move together. The correlation coefficient of returns between two instruments is calculated using the statistical function "correl" in Microsoft Excel, with the arguments being the returns of the two instruments.

Table 2. Correlation Coefficients among Instruments

Correlation	BTC	Emas	Goverment Bond	LQ45	US Dolar
BTC	1	0.00888	-0.03914	0.26831	-0.12025
Gold	0.0088 8	1	-0.05084	-0.25173	0.41984
Goverment Bond	-0.03914	-0.05084	1	-0.38037	0.55016
LQ45	0.2683 1	-0.25173	-0.38037	1	-0.64063
US Dolar	-0.12025	0.41984	0.55016	-0.64063	1

From Table 2. above, it can be observed that the correlations among instruments range between $-0.64063 < \rho < 0.55016$. No instrument exhibits positive correlation with all other instruments. For example, Bitcoin shows positive correlation with Gold and LQ45, but negative correlation with Government Bond and US Dollar, with coefficients of -0.03914 and -0.12025, respectively. On the other hand, no instrument exhibits negative correlation with all other instruments. Government Bond, for instance, shows negative correlation with Bitcoin, Gold, and LQ45, but positive correlation with US Dollar, with a coefficient of 0.55016.

E. Covariance

The next step is to calculate the covariance of all instruments. Covariance is a measure of how two different sets of data vary together. Covariance determines the extent to which two variables are related or how they vary together. Covariance is the average of the deviations from each data point to their respective means. By knowing the covariances and correlations among instruments, investors can determine the composition of available assets to achieve an optimal portfolio with minimal risk and maximum return. The covariance between two instruments is calculated using the covar statistical function in Microsoft Excel, with the arguments being the returns of the two instruments.

Table 3. Instruments Covariances

Covariance	BTC	XAU_IDR	Goverme nt Bond	LQ45	USD_IDR
BTC	4.616 %	0.008%	-0.047%	0.301%	-0.071%
XAU_IDR	0.008 %	0.169%	-0.012%	-0.054%	0.047%
Goverment Bond	-0.047%	-0.012%	0.307%	-0.110%	0.084%
LQ45	0.301 %	-0.054%	-0.110%	0.273%	-0.092%
USD_IDR	-0.071%	0.047%	0.084%	-0.092%	0.075%

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F. Variance

The portfolio variance is calculated using equation 3.9 in chapter 3. Due to the number of instruments used in this study being six, the equation becomes quite long and complex. The variance of each instrument is calculated using the multiplication function in Microsoft Excel. The portfolio variance is calculated in the spreadsheet with a matrix arrangement designed to facilitate the calculation of the long and complex equation.

Table 4. Instrument Variances

Variance	BTC	XAU_IDR	Goverment Bond	LQ45	USD_IDR
[Individual] Weight (Wi)	0%	6%	2%	31%	61%
[Portofolio] Total Weight (Wp)	100%				
[Individual] Variance	0.000%	0.001%	0.000%	0.007%	0.013%
[Individual] Expected Return	3.26%	0.86%	0.26%	-0.14%	0.29%
[Individual] Expected Return * (Wi)	0.000	0.001	0.000	0.000	0.002
[Portofolio] Variance	0.022%				
[Portofolio] Standard Deviation	1.50%				
[Portofolio] Expected Return	0.19%				
Risk Free Rate	0.375%	4.5% annually			
CAL slope	-12.18%				

G. Optimal Portfolio

To obtain an optimal portfolio, several steps need to be taken, namely forming the minimum variance frontier curve, calculating the GMV (Global Minimum Variance) Portfolio point, selecting the efficient frontier curve, determining the optimal portfolio point, and forming several Capital Allocation Lines. The process of determining the optimal portfolio point will be detailed below.

H. Forming the Minimum Variance Frontier Curve

The minimum variance frontier curve is initially formed by the instruments that provide the highest return and the instruments with the lowest return. Once obtained, 20 other frontier points are formed that minimize variance. As a result, a curve is obtained that opens in the opposite direction to the Y-axis, which represents expected return.

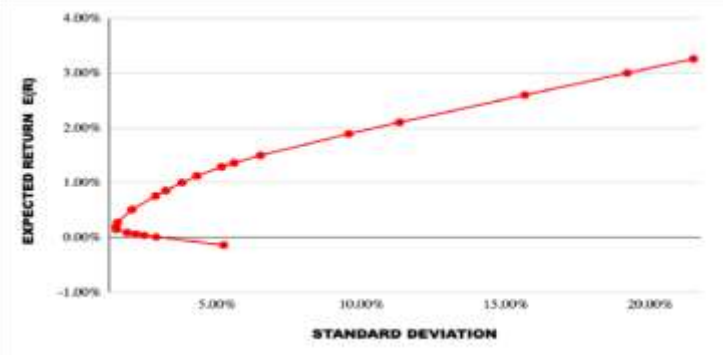

Figure 2. Minimum Variance Frontier Curve

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I. Global Minimum Variance Portfolio

The principle behind the frontier set of risky portfolios is to capture all levels of risk. However, investors are primarily interested in portfolios that provide the highest return. The entire range of portfolio compositions between risk levels and return levels is depicted in the arrangement of points on the efficient frontier of risky assets. From this arrangement, the Global Minimum Variance (GMV) Portfolio is determined, which minimizes variance while maximizing return.

Table 5. Global Minimum Variance

Individual	W1	BTC	0%
	W2	XAU_IDR	6%
	W3	Goverment Bond	2%
	W4	LQ45	31%
	W5	USD_IDR	61%
	Total		100%
Portofolio		Varian	0.022%
		Std Dev	1.50%
		Exp Return	0.19%
		Risk Free Rate	0.375%
		Slope	-12.18%

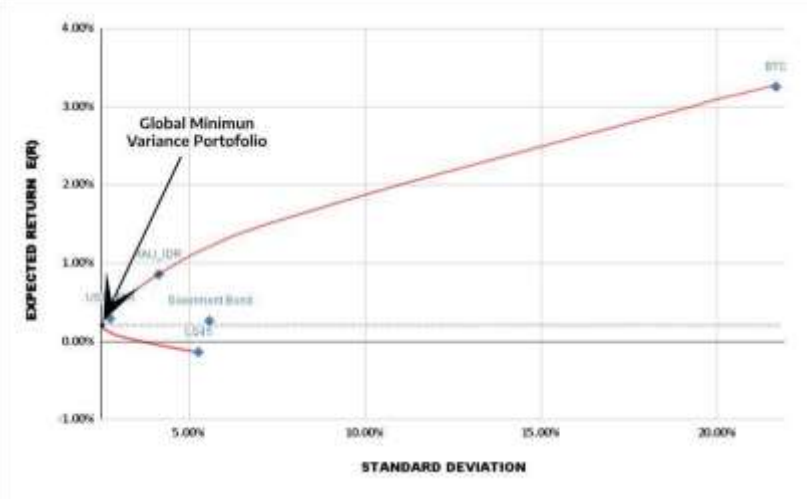

Figure 3. Global Minimum Variance Portfolio

The GMV point represents the formation of the lowest-risk and efficient portfolio, obtained by minimizing the variance in the portfolio. Since minimizing variance in the portfolio corresponds to the points on the minimum frontier curve, the GMV point is guaranteed to lie on this minimum frontier curve. The GMV point is located on the curve with the smallest variance or standard deviation, so it lies at the end of the curvature of the minimum frontier curve. As this point is at the far end of the curve, it is ensured to be unique. If a line is drawn from the GMV point parallel to the X-axis (standard deviation), it forms the GMV line that serves to separate the efficient curve and the inefficient curve. The efficient curve is the minimum frontier curve located above the GMV line, while the inefficient curve consists of the minimum frontier below the GMV line.

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J. Efficient Frontier Curve of Risky Assets

The Efficient Frontier Curve of Risky Assets is a segment of the minimum variance frontier curve that provides efficient performance, aiming to achieve higher portfolio returns with the same level of risk. This curve is formed by a collection of portfolios that are located above the GMV portfolio line.

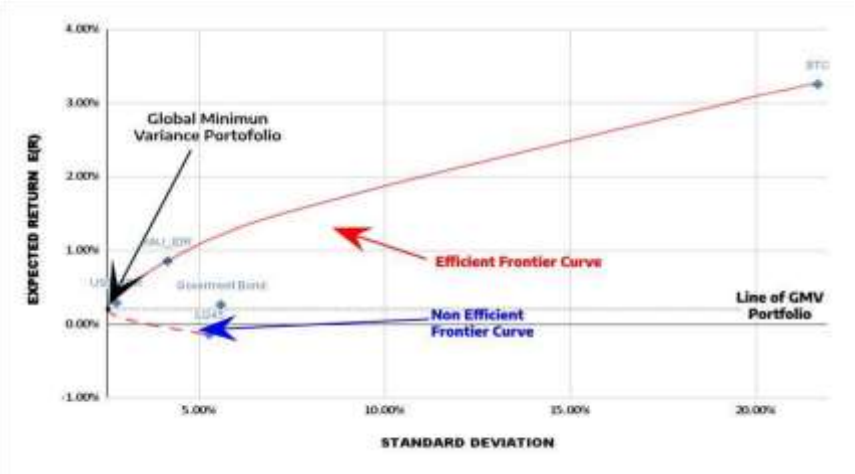

Figure 4. Efficient Frontier Curve

The connected curve above the GMV Portofolio line represents the efficient frontier of risky assets, while the disjointed curve below the GMV Portofolio line represents the inefficient frontier. This curve is a plot of the dominant efficient portfolios as they have higher returns compared to portfolios with the same standard deviation located below the GMV Portofolio.

Assuming that investors are rational and risk-averse, they will choose portfolios with higher returns when faced with two portfolios that have the same level of risk. Therefore, portfolios located below the GMV portfolio do not need to be depicted in the graph above. In the efficient frontier curve, the portfolio with the lowest level of risk is the GMV portfolio with a standard deviation of 1.50% and a return of 0.29%. The curve will then bend parabolically, and the maximum return is achieved at a position of 3.26% with a standard deviation of 21.67%, where the entire portfolio is invested in bitcoin.

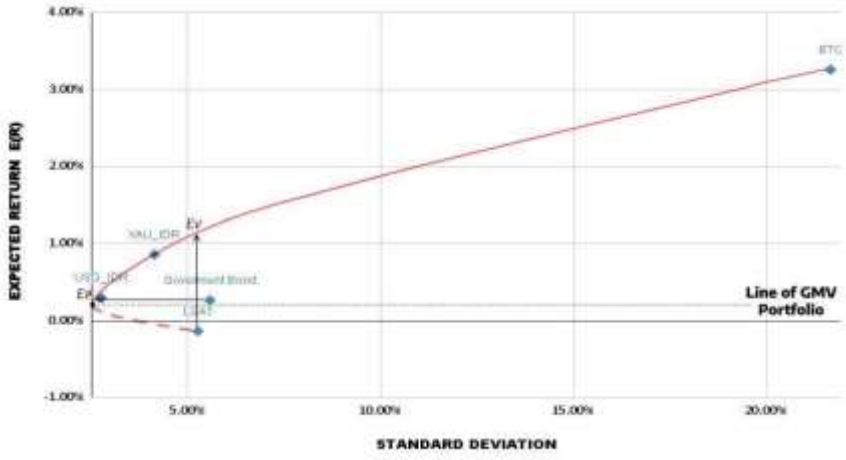

Figure 5. Efficient Frontier Curve 2

As seen in Figure 4.5, the curve formed below the GMV portfolio line represents the inefficient frontier. This is evident in the case of the LQ45 instrument, which bears a risk of 5.27%. By diversifying and forming a portfolio, the expected return can be increased. By observing the intersection point of LQ45 with the efficient frontier curve (Ev), the expected return can be increased from -0.45% to 1.29% without increasing the risk. Similarly, as shown in Figure 4.5, in the case of Government Bond, which obtains

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a return of 0.26%, diversifying and forming a portfolio can reduce the risk. By observing the intersection point of Government Bond with the efficient frontier curve (Ep), the risk can be reduced from 5.59% to 1.54% without increasing the risk. This demonstrates that diversification in the form of a portfolio can reduce the level of risk in investments. In other words, investing in a single instrument alone is inefficient compared to investing in a portfolio.

K. Optimal Portfolio

From various combinations and allocations of instruments resulting in a portfolio, with the help of the solver function in Microsoft Excel, data on portfolio returns and standard deviations are obtained. These data are plotted on a graph to form the efficient frontier curve.

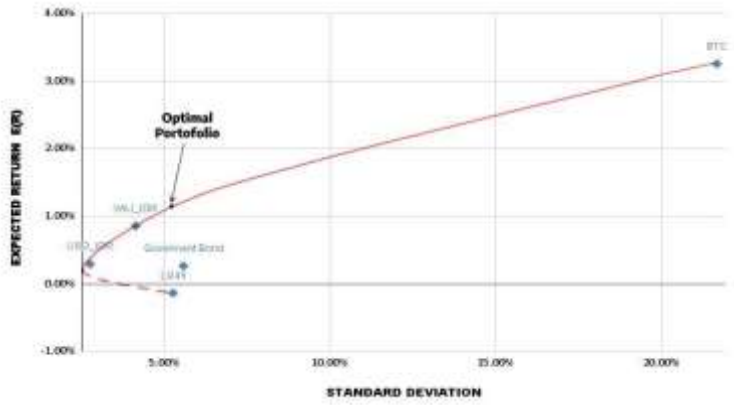

Figure 6. Optimal Portfolio

The Optimal Portfolio can be determined from one of the points on the efficient frontier curve. To determine which point is the optimal portfolio, another factor needs to be considered, which is the return rate of the risk-free asset. The return rate of the riskfree asset at the end of the research period or at the time of portfolio formation is 4.5% per year or 0.375% per month. As mentioned earlier, the best portfolio is the one that provides the best trade-off between the risk taken and the return obtained. The slope of the Capital Allocation Line (CAL) is a ratio that calculates the relationship between excess return and risk. It is referred to as the rewardto-variability ratio.

Table 6. Optimal Portfolio

Individual	W1	BTC	18%
	W2	XAU_IDR	82%
	W3	Governmen t Bond	0%
	W4	LQ45	0%
	W5	USD_IDR	0%
	Total		100%
Portofolio		Varian	0.27%
		Std Dev	5.15%
		Exp Return	1.29%
		Risk Free Rate	0.375%
		Slope	17.75%

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From Table 6. it can be seen that the portfolio consists of only two instruments, namely bitcoin and gold. Gold has the largest weight with a composition of 82% and the weight of bitcoin is only 18%. From the types of assets obtained, the optimal portfolio is formed from a combination of the gold instrument, which has a correlation of 0.0088 or approximately 0.9%. This is in line with Markowitz's theory that in order to reduce risk, investors need to form a portfolio with the lowest possible correlation. This is to ensure that losses incurred from one or more instruments in the portfolio can be offset by other instruments with lower correlation.

L. Capital Allocation Line and Efficient Frontier Curve

In determining the previous portfolio, all the instruments used were risky assets. If we include an element or opportunity to invest in a risk-free asset, such as the interest rate of Bank Indonesia Certificates, a new portfolio will be obtained. The risk-free asset will be linked to a risky portfolio and form a straight line called the Capital Allocation Line (CAL). By finding the point where CAL intersects the Efficient Frontier curve, an optimal alternative portfolio can be obtained, known as the tangency portfolio, which represents the maximum slope (CAL slope) between the return of risky assets and the risk-free asset on the Efficient Frontier curve.

The risk-free point (r_f) represents an instrument with a combination of standard deviation and expected return that is free from risk (standard deviation = 0), obtained from the Bank Indonesia interest rate instrument (Sertifikat Bank Indonesia - SBI). In this study, the average interest rate over the research period was taken, which is 4.5% per year or 0.375% per month. Thus, for the riskfree asset, the point (r_f) is obtained at the coordinates (0, 0.0375%). Therefore, CAL(A) can be formed by connecting the point (r_f) and the maximum expected return, which is the return of the bitcoin instrument. Bitcoin has the highest expected return among individual assets, which is 3.26% with a risk level of 21.67%. For the second asset allocation line, CAL(G) can be formed by connecting the point (r_f) and the global minimum variance portfolio (GMV portfolio) point. The GMV portfolio has an expected return of 0.19% with a risk level of 1.5%. As for CAL(P), it is formed from the point (r_f) to the tangency point between CAL and the efficient frontier curve. This point represents the optimal portfolio that provides the highest performance, with an expected return of 1.29% and a risk level of 5.15%, as shown in Figure 7. below:

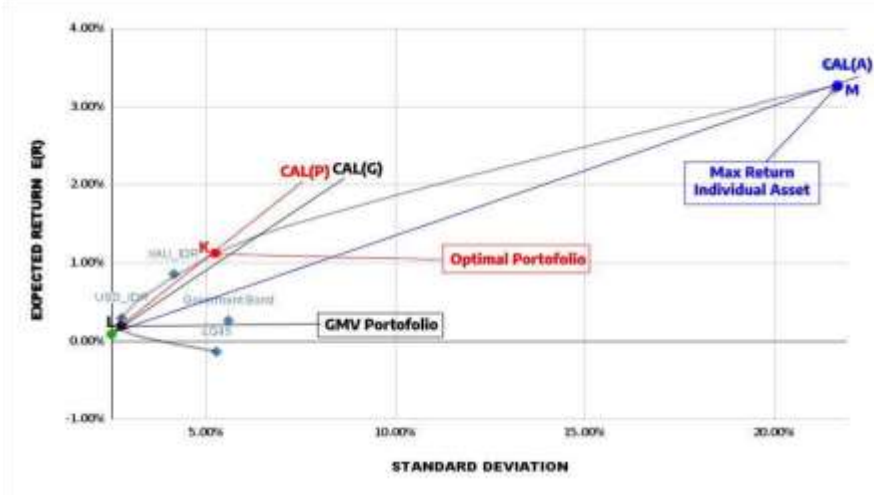

Figure 7. Capital Allocation Line

If a line is drawn from the risk-free asset rate point (r_f) parallel to the Y-axis (standard deviation), it will intersect with the CAL lines. Among the capital allocation lines (CALs), CAL(P) forms the largest tangent angle with the risk-free asset line. This is considered the optimal portfolio according to Sharpe (1995) as it provides the highest value among the angles formed by the other CALs.

CONCLUSION AND RECOMMENDATION

The investment portfolio instruments have varying levels of return and risk. Bitcoin has the highest return among the instruments, with a difference of 3.26% compared to the others. However, it is also associated with a high level of risk, reaching 21.67%. Other instruments such as gold, government bonds, LQ45, and US dollars have much lower levels of return compared to bitcoin.

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Diversification in investment can help investors increase their investment returns while maintaining the same level of risk as individual assets. Additionally, the risk level of an asset can be reduced in a portfolio investment with the same return level as individual assets. Based on the calculation of returns from the five instruments and the average standard deviation, an optimal portfolio can be obtained by combining two instruments: 18% bitcoin and 82% gold. This optimal portfolio can achieve an expected return of 1.29% with a risk level of 5.15%. Considering a risk-free rate of 0.375%, this portfolio forms a slope of 0.1775, which is the largest slope formed between the combination of risk-free instruments and risky portfolios. Investors should allocate their funds more wisely, considering not only the highest return but also the associated risk. High returns often come with high risks, so investors need to assess the risk-return trade-off before making investment decisions. It is recommended for future research to use data from a period that is not a transitional phase. The data used in this study covers the years 2018 to 2022, which includes the period affected by the COVID-19 pandemic starting from early 2020. This global pandemic has significantly influenced all global economic movements, and it may be beneficial to analyze data from a more stable period for a more accurate assessment of investment performance.

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