

# Investment Risk Analysis Through Portfolio Diversification Using IT Based Company's Stocks and Cryptocurrency

Muhammad Iqbal Pandailing Widodo<sup>1\*</sup>, Dr. Ir. Abdul Mukti Soma<sup>2</sup>

<sup>1</sup> Master of Management Student, Faculty of Economics and Business Telkom University, Bandung, Indonesia

<sup>2</sup> Master of Management Lecturer, Faculty of Economics and Business Telkom University, Bandung, Indonesia

\*Corresponding Author:

Email: [iqbal.widodo@gmail.com](mailto:iqbal.widodo@gmail.com)

---

## Abstract.

*Investment is an activity carried out for the purpose of gaining profit in the future by entrusting their assets to several assets such as stocks, securities such as deposits and bonds, property, precious metals, jewelry, foreign currencies, cryptocurrencies, commodities, startup companies, and so on. Stock investment is one of the investment options that is considered profitable because its value will go hand in hand with the company's performance from the stock, and also the value of regular dividends which are an added value to the profits obtained. Cryptocurrency is also now starting to become a new alternative in investment solutions because of its decentralization concept which makes cryptocurrency have very high volatility where it has a fairly high risk but also has a high return value. Due to the advantages and disadvantages of Stocks and cryptocurrencies, an idea emerged to be able to diversify between stocks and cryptocurrencies in order to find the best and most optimal investment results by creating a portfolio that is a combination of stocks and cryptocurrencies. The results of this study are expected to be useful as a reference that can be used to set investment strategies for investors who are interested in investing in stocks and cryptocurrencies to get the most optimal results with the lowest risk.*

**Keywords:** Analysis, Investment Risk, Diversification, Markowitz Model, Stocks, Cryptocurrency, Investment, Google, Apple, Bitcoin and Ethereum.

---

## I. INTRODUCTION

Investment is an act of placing funds in the present with the expectation of getting a profit in the future [1]. Placing funds here can be intended to buy something that is believed to have added value in the future such as property, securities, gold, stocks, and cryptocurrencies. Stocks are an investment instrument that is quite popular with investors, considering that in addition to its value increasing along with the growth of the company, there are dividends that are also an advantage to be obtained by buying a stock. For investors who have a technological background or are interested in and monitor technological developments, stocks from information and technology (IT)-based companies are a safe choice. Technology is getting more advanced, digital device penetration is getting easier, and digital content is starting to become general content that is often enjoyed by the public, such as the world's technology giants, namely Google and Apple with their respective advantages. This is certainly a breath of fresh air that IT-based companies have the opportunity to develop in the future. In addition to IT company stocks, cryptocurrency is also an attractive investment instrument. Since the first time the world's first cryptocurrency called Bitcoin was released, the cryptocurrency instrument has become an investment instrument that has experienced a very tempting increase in value. Bitcoin was first coined by someone named Satoshi Nakamoto in 2008 through a paper [2]. Since then, many other coins have emerged that aim to develop better technology than Bitcoin, one of the largest cryptocurrencies is Ethereum.

Cryptocurrency has a very high return potential, but it is also accompanied by quite dangerous risks, due to the high volatility of its current price in the market. This makes Cryptocurrency still avoided by several investors to include cryptocurrency in their portfolio. Even so, it is possible that cryptocurrency will become a potential investment asset in the future. As can be seen today, Bitcoin and Ethereum, as the 2 largest cryptocurrencies in the world, are a very interesting phenomenon in the investment scene. Bitcoin and

Ethereum are cryptocurrencies that enter the top 5 coins with the highest market cap in the world [3]. The purpose of this study is expected to produce alternative strategies that can be used by investors in developing their portfolios more efficiently by dividing the risk of IT-based company stocks with cryptocurrency so that they can still get the most optimum risk and return values. By conducting portfolio analysis using the Risk Adjusted Return, Sharpe Ratio, and Treynor Ratio methods which are used to calculate the risks that arise and using Modern Portfolio Theory which is a further development of the Markowitz Model to find the diversification composition of each IT-based company stock and cryptocurrency that will be taken, it is expected to provide an investment asset distribution ratio that has the most optimum risk and return.

## II. METHODS

The analytical techniques selected to conduct this investigation are using *Modern Portfolio Theory (MPT)* as the Diversification strategy. Next, to see the result of the return from the Diversification, this research will use *Risk Adjusted Ratio, Sharpe Ratio, and Treynor Ratio. Modern Portfolio Strategy (MPT)* is a theory developed from the diversification theory proposed by Harry Markowitz which was developed to divide the portfolio in order to minimize risk but maximize the return value. Simply put, *MPT* is a method of selecting investments with the aim of maximizing returns with an acceptable level of risk [4]. In *MPT*, the risk and return in a portfolio are not separated one by one, but rather the continuity is sought between one portfolio and another. The value of a portfolio in *MPT* is a combination of several investment instruments selected by carrying out a weighting process on each investment instrument, where the weight is used to ensure the most optimal risk and return from the combination of several investment instruments. In simple terms, *MPT* uses the following calculation formula to calculate the amount of investment made

$$\text{Total Sum of Investment} = \sum_{i=1}^n w_i x_0$$

- $n$  = amount of assets owned
- $w_i$  = weight of an assets in the order of  $i$
- $x_0$  = the initial amount of money to be invested by the investor

Where the weight of each asset will be different, divided equally with the total weight reaching 100%, no less and no more. To be able to find the effective *MPT* weight ( $w$ ), first you need to find the ratio value ( $R$ ) of the return based on the purchase price and the selling price.

$$R = \frac{x_1}{x_0}$$

Where  $x_0$  is the purchase value of an asset, and  $x_1$  is the sale value of an asset. After the ratio value ( $R$ ) is found, the next step is to find the rate of return value ( $r$ ) where

$$r = \frac{x_1 - x_0}{x_0} = R - 1$$

The formula of ratio ( $R$ ) and rate of return ( $r$ ) is used to see the pattern of return data of an investment. In this study, a search was conducted for the rate of return ( $r$ ) for the number of periods needed ( $r_0, r_1, r_2, r_3, r_4, \dots, r_n$ ). After the collection of "rate of return" ( $r_n$ ) is found, group the investment assets into several groups with the same matrix size.

$$z = \begin{pmatrix} r_0 \\ r_1 \\ \dots \\ r_n \end{pmatrix}$$

The next step after doing the matrix, can be searched for Sample Covariance from the formula. Covariance is used to determine the relationship between two random variables obtained from two different investment assets in a portfolio, and if the data used is Sample data. Then the Covariance formula used is Sample Covariance, the value of the Sample Covariance will be positive if the value of the investment asset tends to increase or decrease at the same time.

$$Cov.S(z_0, z_1) = \frac{\sum(z_{0i} - \bar{z}_0)(z_{1i} - \bar{z}_1)}{n - 1}$$

- $z_0$  = investment asset matrix 1
- $z_1$  = investment asset matrix 2
- $z_{0i}$  = value of variables in  $z_0$
- $z_{1i}$  = value of variables in  $z_1$
- $\bar{z}_0$  = average of  $z_0$
- $\bar{z}_1$  = average of  $z_1$

The calculation continues until the covariance of all investment assets is found. All covariance assets are then collected into a matrix of size  $n \times n$  with the following placement.

$$Mat(Cov.s) = \begin{bmatrix} Cov.S(z_0, z_0) & Cov.S(z_0, z_1) & Cov.S(z_0, z_n) \\ Cov.S(z_1, z_0) & Cov.S(z_1, z_1) & Cov.S(z_1, z_n) \\ Cov.S(z_n, z_0) & Cov.S(z_n, z_1) & Cov.S(z_n, z_n) \end{bmatrix}$$

After the Sample Covariance value is found, the next step is to search for the Variance value to see the distribution of data against the average of the data. The greater the value of a Variance, the greater the distribution of data against the average. In research using Sample data, the Variance formula is used for the sample.

$$Variance.S(z) = \frac{\sum_{i=1}^n (z_i - \bar{z})^2}{n - 1}$$

- $z$  = investment asset matrix
- $z_i$  = value in the  $i$ -th order investment asset matrix
- $\bar{z}$  = average of all values in  $z$
- $n$  = numbers of data in  $z$

After the Sample Covariance and Sample Variance values are found, the next step is to find the Beta values, or Beta values. Beta values are the results of measuring the volatility of an investment asset against the stock market as a whole. (Liberto, Catalano, & Eichler, 2024). The formula for Beta can use the following calculation

$$Beta(z) = \frac{Cov.S(z, z_m)}{Variance.S(z_m)}$$

As the benchmark in the form of stocks and cryptocurrencies investment, the stock index that can be used is the S&P 500 because its value movements tend to move in the same direction. The output of the Beta value will be  $>1.0$  if the profit rate of stocks or cryptocurrencies is greater than the profit rate of the S&P 500 market, so that the systematic risk of stocks or cryptocurrencies is greater than the systematic risk of the market. Conversely, if the Beta value is  $<1.0$ , the profit rate of stocks or cryptocurrencies is smaller than the market profit rate, so that the systematic risk of stocks is smaller than the market.

Next, the value of the Capital Asset Pricing Model (CAPM) can be found. CAPM is a formula used to calculate and determine the expected return of an asset or investment [5]. CAPM was first developed by William F. Sharpe in the 1960s, then expanded by John Lintner and Jan Mossin. CAPM is used to help investors understand various events in the market that are difficult to understand. The following formula can be used to calculate the CAPM calculation formula

$$CAPM(z) = Rfr + [Beta(z) * (Rm - Rfr)]$$

- $Rfr$  = Risk Free Rate
- $Rm$  = Market Return

*Risk Free Rate* is the return offered by an investment instrument that has no risk. From an investor's perspective, the *Risk Free Rate* is the minimum return expected by investors for each investment instrument

when they make an investment. An example of this *Risk Free Rate* Investment is the *10 Years Treasury Table* which shows the yield of United States government bonds with a tenor of 10 years [5].

To prepare for further calculations, data on the CAPM can be collected into a matrix with dimensions  $n \times I$  with the following example

$$Mat(CAPM) = [CAPM(z0) \quad CAPM(z1) \quad CAPM(zn)]$$

After CAPM is found, the next step is to find the value of the initial weight ( $a$ ) for each asset in the portfolio to be used. The output of the weight is in the form of a matrix with dimensions  $n \times I$  as follows

$$w_0 = \frac{a_0}{a_0 + a_1 + \dots + a_n} \times 100\%$$

To test the formula that has been found in the MPT, an analysis related to the portfolio that has been created can be used. Analysis of a portfolio can be done using the Risk Adjusted Ratio (RAR), Sharpe Ratio, and Treynor ratio. To be able to find the RAR, Sharpe Ratio, and Treynor ratio, it is necessary to find the Annualized Return and Annualized Risk of each Investment Instrument in the Portfolio. First, the Annual Return is searched for first, starting by finding the value of the Geometric Mean Variable for each investment instrument in the portfolio.

Geometric Mean Variable is a formula where all numbers as many as  $n$  numbers are multiplied, then rooted at the power of  $n$ . Unlike the average in general, the Geometric mean is used as a calculator for portfolio performance. The calculation focuses entirely on the return figure itself and presents an accurate comparison when comparing two or more investment options over more than one time period (Hayes, Khartit, & Perez, 2024)[6]. The formula for the Geometric Mean Variable is

$$GMV(x) = \sqrt[n]{r_1 * r_2 * r_3 * \dots * r_n}$$

- $x$ = investment instrument
- $r_1, r_2, r_3$  = return data each month of  $x$
- $n$ = numbers of data in  $x$

Geometric Mean Variable Used to search for Annualized Return. Annualized Return is a formula used to see the financial return conditions of an investment for 1 year [7]. By taking historical data from the Geometric Mean Variable, the next step is to search for Annual Return to see the potential of an asset investment using the formula

$$Ann. Ret(x) = ((1 + GMV(x))^{\frac{1}{n}}) - 1$$

Next, it is necessary to find the Annualized Risk variable of an investment instrument. Annual Risk or Annual Volatility is a method used to see the volatility or uncertainty of an investment instrument during a 1-year period (Miglietti, 2019). To find the Annual Risk, the following formula is used

$$Ann. Ris(x) = STD.Dev(x) * \sqrt{12}$$

After Annual Return and Annual Risk are found, the next step is to calculate Investment Performance to see the performance of an investment. Investment performance is the return on an investment portfolio [8]. An investment portfolio can contain one asset or several assets. Investment performance is measured over a certain period of time and in a certain currency. Investment Performance is often used to test whether an investment produces a profitable return or not. There are several methods that can be used to test the performance of an investment such as the Risk Adjusted Ratio, Treynor Ratio, and Sharpe Ratio. Risk Adjusted Ratio (RAR) is a calculation used to measure the return obtained from an investment in an asset or portfolio, relative to the amount of risk from the investment in a certain period [9]. Sharpe Ratio is a calculation to analyze excess returns for each Annualized risk taken. While the Treynor ratio is to analyze

excess returns against the Beta of an investment. To find the RAR value, the Sharpe Ratio and Treynor Ratio can use the following formula.

$$Risk\ Adjusted\ Ratio\ (x) = \frac{Ann.\ Ret(x)}{Ann.\ Ris(x)}$$

$$Sharpe\ Ratio\ (x) = \frac{Ann.\ Ret(x) - Risk\ Free}{Ann.\ Ris(x)}$$

$$Treynor\ Ratio\ (x) = \frac{Ann.\ Ret(x) - Risk\ Free}{Beta\ (x)}$$

The higher the *RAR*, *Sharpe Ratio*, and *Treynor Ratio* values obtained, the better the performance of an investment or portfolio. The IT based company stocks used in this research is Alphabet Inc class A (GOOGL), and Apple (AAPL), the cryptocurrency used in this research is Bitcoin (BTCUSD) and Ethereum (ETHUSD), and the benchmark for the diversification process used in this research will use S&P 500 (.INX). All the data was gathered from 1 January 2020 until 12 December 2024. Both data is secondary data gathered from Google Finance, where the data related to securities used comes from trusted data that has been selected by Google, and its truth is guaranteed by Google [10]. Because of that statement, the validity and reliability of the data can be recognized as authentic and guaranteed by Google.

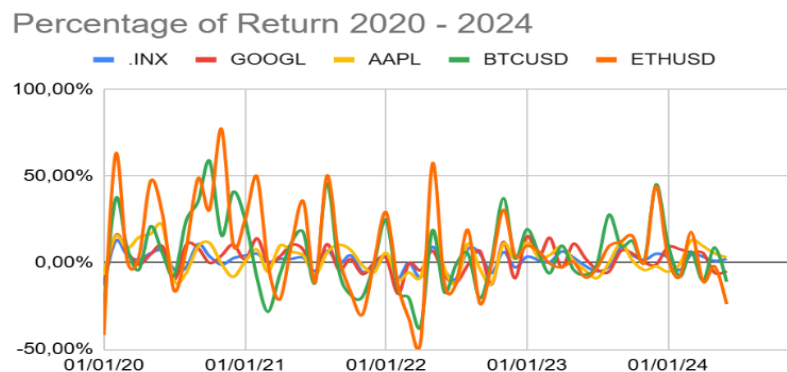
### III. RESULT AND DISCUSSION

To be able to calculate investment profitability, it is necessary to understand the variables needed and also the method of calculating investment profitability that will be used. To be able to find these values, the *Geometric Return Variable* is first needed from GOOGL, AAPL, BTCUSD, and ETHUSD. Here is the example of the sample from the entire *Geometric Return Variable*

Date	Return					Geometric return variable (return +1)				
	.INX	GOOGL	AAPL	BTCUSD	ETHUSD	.INX	GOOGL	AAPL	BTCUSD	ETHUSD
28/02/2020	-8,41%	-6,53%	-11,68%	-7,35%	23,00%	91,59%	93,47%	88,32%	92,65%	123,00%
31/03/2020	-12,51%	-13,23%	-6,98%	-27,26%	-41,66%	87,49%	86,77%	93,02%	72,74%	58,34%
30/04/2020	12,68%	15,89%	15,54%	37,08%	62,85%	112,68%	115,89%	115,54%	137,08%	162,85%
29/05/2020	4,53%	6,46%	8,22%	9,01%	2,12%	104,53%	106,46%	108,22%	109,01%	102,12%

**Fig 1.** Sample of return data used in this research, Including GOOGL, AAPL, BTCUSD, ETHUSD and .INX

As a broader picture, the movement patterns of GOOGL, AAPL, BTCUSD, ETHUSD, and .INX can be seen in the following graph. It can be seen that GOOGL, AAPL, BTCUSD, and ETHUSD have movements that show a pattern similar to .INX in accordance with the previously found phenomenon [11] in accordance with predictions from previous research [12]. Of the five variables shown in the return percentage, it can be found that BTCUSD and ETHUSD have higher data fluctuations compared to GOOGL and AAPL.



**Fig 2.** Graph of return data from 2020-2024 for each GOOGL, AAPL, BTCUSD, ETHUSD and .INX

To find the weight ( $w$ ) that will be used for the diversification process, several calculations need to be done first. The diversification process will use the flow that has been explained previously in sequence until the weight of the MPT is found. Sequentially search for the values of *Covariance*, *Variance*, *Beta*, *CAPM*, and *MPT Weight*.

Weights (w)		
Ticker	Weight	Adj. Weight
GOOGL	64,694	35,31%
AAPL	98,029	53,50%
BTCUSD	16,705	9,12%
ETHUSD	3,812	2,08%

**Fig 3.** Weight result who will be used for the MPT Diversification

After the weights are found, the MPT portfolio will be compiled by dividing the investment assets according to the percentage of weights that have been obtained. Next, the portfolio calculation is carried out by assuming that the investment assets are purchased with the same amount of money (assuming \$1000 for each), with a scheme of \$1000 GOOGL only, \$1000 AAPL only, \$1000 BTCUSD only, \$1000 ETHUSD only, and \$1000 with MPT diversification. After that, a process is carried out to find the value of the Risk Adjusted Ratio, Sharpe Ratio, and Treynor Ratio. This study focuses on finding the most optimum risk value obtained by using diversification, so that the greater the value obtained, both the Risk Adjusted Ratio, Sharpe Ratio, and Treynor Ratio, the more optimum the investment risk will be.

	GOOGL	AAPL	BTCUSD	ETHUSD	MPT Div.
<b>RAR</b>	<b>0,8216</b>	<b>0,9145</b>	<b>0,8671</b>	<b>0,9487</b>	<b>1,0645</b>
<b>Sharpe Rasio</b>	<b>0,7244</b>	<b>0,8223</b>	<b>0,8287</b>	<b>0,9185</b>	<b>0,9754</b>
<b>Treynor Rasio</b>	<b>0,1923</b>	<b>0,1945</b>	<b>0,2722</b>	<b>0,2784</b>	<b>0,2107</b>

**Fig 4.** Result of RAR, Sharpe Ratio, and Treynor Ratio calculation

It can be seen that MPT is superior compared to investments that focus on only one investment instrument, based on RAR and Sharpe Ratio. However, the value of Treynor Ratio, MPT is still not more optimal when compared to cryptocurrency, both BTCUSD and ETHUSD.

#### IV. CONCLUSION

Based on the analysis of Investment Performance using RAR, Sharpe Ratio, and Treynor Ratio against the results of diversification using MPT, it can be seen from the results of RAR and Sharpe Ratio, that the results of diversification using MPT weighting can provide a higher value compared to investing in only one IT-based company stock instrument represented by GOOGL and AAPL or cryptocurrency represented by BTCUSD and ETHUSD only. However, the Treynor Ratio shows that BTCUSD and ETHUSD are higher than MPT, so based on these data it can be concluded that if you look at the Treynor Ratio, MPT is more optimal than investing in units of IT-based company stock instruments represented by GOOGL and AAPL, but not more optimal than investing in units of cryptocurrency instruments represented by BTCUSD and ETHUSD.

Thus, the hypothesis H3 "Investment through Diversification using MPT can provide optimum investment profitability in the portfolio created, and has the most optimal risk and return compared to a portfolio of IT-based company stocks or a portfolio of cryptocurrencies" is supported by the calculation results using RAR and Sharpe Ratio, but is not supported by the calculation results of the Treynor Ratio. For further research, the researcher suggests extending the research period. The researcher also suggests doing other diversification such as gold, bonds, mutual funds, and other investment instruments that have the potential to have different data properties that can give different result while fused with cryptocurrency. The researcher also suggests using forecasts to see the potential for future return growth.

## V. ACKNOWLEDGMENTS

The author would like to thank the Master of Management of Telkom University for their support in this project, and to the honorable Mr. Dr. Ir. Abdul Mukti Soma, for his direction and guidance during the research process.

## REFERENCES

- [1] Halim, A. *Analisis Investasi dan Aplikasinya: dalam Aset Keuangan dan Aset Riil Edisi 3*. Jakarta: Penerbit Salemba Empat, 2024.
- [2] Indodax. *Apa itu Bitcoin*. Indodax Academy: <https://indodax.com/academy/apa-itu-bitcoin/>, 2024
- [3] Coin Market Cap, *Coin Market Cap*: <https://coinmarketcap.com/>, 2024
- [4] Investopedia Team. *Modern Portfolio Theory: What MPT Is and How Investors Use It*. Investopedia: <https://www.investopedia.com/terms/m/modernportfoliotheory.asp#:~:text=A%20key%20component%20of%20the,their%20individual%20tolerance%20to%20risk> , 2023
- [5] OCBC. *CAPM Adalah: Cara Menghitung, Kelebihan dan Kekurangannya*. OCBC: <https://www.ocbc.id/id/article/2023/06/20/capm-adalah#:~:text=Kelebihan%20Model%20CAPM&text=CAPM%20adalah%20metode%20perhitungan%20yang,menentukan%20tingkat%20pengembalian%20yang%20dibutuhkan>, 2023
- [6] Hayes, A., Khartit, K., & Perez, Y. *What is Geometric Mean? How to Calculate and Example*. Investopedia: <https://www.investopedia.com/terms/g/geometricmean.asp>, 2024
- [7] Murphy, C. B., Wohlner, R., & Rosenston, M. *Annualize: Definition, Formulas, and Examples*. Investopedia: <https://www.investopedia.com/terms/a/annualize.asp>, 2024
- [8] Performance Measurement Solutions. *What is Investment Performance*. Performance Measurement Solution: <https://www.performancemeasurementsolutions.com/what-is-investment-performance>, 2024
- [9] Chen, J., Renfro, B., & Reeves, M. *Understanding Risk-Adjusted Return and Measurement Method*. Investopedia: <https://www.investopedia.com/terms/r/riskadjustedreturn.asp#:~:text=A%20risk%20Dadjusted%20return%20measures,yielding%20a%20slightly%20different%20result>. 2023
- [10] Google Finance. *Google Finance Disclaimer*. Google Finance: [https://www.google.com/intl/id\\_ID/googlefinance/disclaimer/](https://www.google.com/intl/id_ID/googlefinance/disclaimer/), 2024
- [11] Trading View. *BTC/S&P 500 Correlation: What Stock Market Can Tell Us About Bitcoin Price*. Trading View U. Today: [https://www.tradingview.com/news/u\\_today:2a7d5345a094b:0-btc-s-p-500-correlation-what-stock-market-can-tell-us-about-bitcoin-price/](https://www.tradingview.com/news/u_today:2a7d5345a094b:0-btc-s-p-500-correlation-what-stock-market-can-tell-us-about-bitcoin-price/), 2024
- [12] Yalamati, S. *Forecast Cryptocurrency Market Investments Based on Stock Market Performance*. *International Journal of Innovations in Applied Sciences & Engineering (IJASE) 2023, Vol. No. 9, Jan-Dec*, 19-27.
- [13] Phelia, *Kajian Evaluasi TPA dan Analisis Biaya Manfaat Sistem Pengelolaan Sampah di TPA (Studi Kasus TPA Bakung Kota Bandar Lampung)*, Tesis, 2019, pp. 1-167.
- [14] Visvanathan, K. Joseph, R. Nagendran, K. Thanasekaran, W. Hogland, *Dumpsite Rehabilitation Manual (first edition)*, Anna University, India, 2008.
- [15] E. Damanhuri, T. P. Damanhuri, *Pengelolaan Sampah Terpadu (second edition)*, ITB Press, Bandung, 2019.
- [16] Badan Standardisasi Nasional. *SNI 19-2454-2002., Tata Cara Teknik Operasional Pengelolaan Sampah Perkotaan*. Jakarta (ID).
- [17] Intergovernmental Panel on Climate Change (2006), *IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 1*, IPCC, Japan.
- [18] S. Sinaga, M. M. Sari, A. A. Hutasuhut, S. T. Zahara, A. Amanda, A. Fitri, M. A. Caesario, Comparison of capital budgeting methods: NPV, IRR, Payback Period, *World Journal of Advanced Research and Reviews*, 19:2, 2023, pp. 1078-1081.
- [19] D. Ruminta, Analisis Perbandingan Perhitungan Kelayakan Finansial Konvensional dan Syariah, *Jurnal Ecodemica*, 4, 2020, pp. 92-102.
- [20] M. Chaerul, S. A. Rahayu, Cost Benefit Analysis dalam Pengembangan Fasilitas Pengolahan Sampah: Studi Kasus Kota Pekanbaru, *Journal of Natural Resources and Environmental Management*, 9:3,2019, pp.710-722.
- [21] R. A. Ula, I. Haryanto, A. Prasetya, Analisis Keekonomian Skenario Pengelolaan Sampah di TPA Gunung Panggung Tuban Jawa Timur, *Jurnal Rekayasa Proses*, 17, 2023, pp. 1-11.