Implementation of the Markowitz method in the Robo-Advisor application for best investment selection

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Abstract. Investment is the best way to ensure financial security in the future. The number of investment choices available often makes potential investors confused in determining the right investment choice. The purpose of this study is to implement the Markowitz Method in the Robo-Advisor application to the selection of appropriate mutual fund investment products. This research is experimental in finding the best mutual fund portfolio. The Mutual Fund products used are Danareksa Flexible Orchid (DAF), Bahana Trailblazer Fund (BTF), CIMB Principal Total Return Equity (CIMBPTRE), and Danareksa Mawar Consumer 10 (DMK). The data used amounted to 60 data from 2014 to 2018. Based on the results of calculations, the first portfolio has a higher return rate of 0.55%, while the second portfolio has a return rate of 0.54%.

1. Introduction
Investment can be interpreted as our efforts to set aside part of our income or assets to spend or save, in the hope of earning benefits in the future. Many ways and forms of investment that we can do, of course, not easy for us to invest. We need to be careful in investing; we must be smart to assess the condition of investment products that we will use up to their derivative products. Mutual fund investment products are currently in high demand by the people of Indonesia, especially young people. Mutual fund investment has better benefits compared to other investment products. However, that does not mean that mutual fund investment products have no risk. There are investment risks that can occur at any time experienced by mutual fund customers [1-3].

One of these risks can be reduced through the use of Robo-Advisor. Robo-Advisor is used to be portfolio management in investing. Robo-Advisor produces Mutual Fund investment product portfolio recommendations based on the risk profile [4,5]. The Markowitz method in the Robo-Advisor application is used for necessary statistical measurements in developing a portfolio plan. This method formulates the existence of elements of return and risk in an investment, where the risk element can be minimized through diversification and combining various investment instruments into a portfolio [6-9]. Robo-Advisor must be able to provide a certain level of an investment portfolio, which can be obtained from matching the results of the sharp ratio. Research on Robo-Advisors was conducted by Bhatia and Arti Chandani [10], Carlos, Lourenço, and Dellaert [11], Amaral [12,13], and Hermansson [14]. However, this research does not explain the portfolio of investment products from the specific mutual funds in Indonesia.
2. Methodology, results and discussion

2.1. Markowitz method

One feature of the Markowitz method in investment selection is the time spent in only one investment period, and investor preferences are solely based on the expected return and risk of the portfolio [7, 15]. The stages of implementing the Markowitz method in Robo-Advisor application are as follows:

2.1.1. Robo-Advisor application architecture. System architecture implementation of the system architecture of the Markowitz method in the selection of the Robo-Advisor application the best investment in mutual funds agreed in figure 1:

- Prospective investors will choose investments according to the criteria owned by investors.
- Laravel in System Robo-Advisor will access the database and will be sent to python in the form of JSON.
- Python will process the JSON data that Laravel has given to be used as a portfolio to be sent back by Laravel together, standard deviations, Sharpe ratios, and backtest from the portfolio.
- Laravel will display data in the form of a pie chart from data that has been sent from python in the form of JSON.

2.1.2. Norwitz optimal portfolio. After selecting the type of investment (moderate, moderate and conservative), potential investors will get information about the optimal portfolio of choices for investment that matches the criteria.

Figure 1. Robo-Advisor application architecture.

Figure 2. Selection of the best investment.
The choice of investment type is shown in figure 2. The page featuring optimal portfolios displays the two best investment portfolio, models. Users can back test these two portfolio models.

### 2.1.3 Backtest portfolio

Basket of portfolios chosen by investors is shown in Figure 3. The output generated from the backtest process is in the form of a graph. The graph shows the best investment portfolio performance in a certain period. The test is carried out using existing historical data to predict future price increases.

![Graph showing backtest portfolio performance](image)

**Figure 3.** Backtest portfolios.

### 2.2 Testing

Before starting to calculate portfolios, investing in mutual funds first becomes four mutual funds, namely the Money Market, Fixed Income, Mixed, and Stock. Each type of investor will get a portfolio model of two types of mutual funds. After calculating, then the daily return and volatility are calculated, and then an optimal mutual fund portfolio is created using the Markowitz method. Table 1 is the daily return of the Dana Reksa Flexible Orchid (DAF), Bahana Trailblazer (BTF) Fund, CIMBPTRE Principal Total Return Equity (CIMBPTRE), and Dana Reksa Mawar Consumer 10 (DMK). The amount of test data used was 60 data, from 2014 to 2018.

| Date       | DAF | BTF  | CIMBPTRE | DMK  |
|------------|-----|------|----------|------|
| 1/30/2014  | 0.02099 | 0.03325 | 0.03720 | 0.06212 |
| 2/27/2014  | 0.02579 | 0.06430 | 0.06511 | 0.03639 |
| 3/31/2014  | 0.05500 | 0.07421 | 0.07900 | 0.05535 |
| ...        | ...  | ...  | ...      | ...  |
| 12/28/2018 | 0.01337 | 0.01525 | 0.0139  | 0.02194 |

![Table 1. Daily return](image)

After the daily return is obtained, so that potential investors get an assessment of future investments, then the expected value is calculated for each mutual fund investment product. Table 2 explains the expected return on investment products of DAF mutual funds, BTF CIMBPTRE, and DMK per month.
To find out the team in planning, then after that, it is expected to be obtained again, then the standard deviation is calculated. Table 3 is the standard deviation (11), from DAF, BTF, CIMBPTRE, and DMK mutual fund products per month.

Table 3. Standard deviation.

| Mutual Funds Product Name | Expected Return | Standard Deviation |
|---------------------------|----------------|-------------------|
| DAF                       | 0.00474        | 0.024359          |
| BTF                       | 0.00481        | 0.037273          |
| CIMBPTRE                  | 0.006          | 0.037122          |
| DMK                       | 0.00662        | 0.03523           |

After obtaining the expected return and standard deviation for each mutual fund product, the next step is to enter a predetermined investment weight, which is 25%: 25%: 25%: 25%: 20%: 20%: 30%: 30%. The system will automatically weigh investment. Next, determine the expected portfolio return. Table 4 is the optimal portfolio calculation results consisting of DAF, BTF, CIMBPTRE, and DMK mutual fund products per month.

Table 4. The level of mutual funds portfolio benefits.

| Portfolio | ( ) | ( ) | ( ) | ( ) | ( ) |
|-----------|-----|-----|-----|-----|-----|
| 1         | 25% | 25% | 25% | 25% | 0.00474 | 0.00481 | 0.006 | 0.00662 | 0.0055 |
| 2         | 20% | 20% | 30% | 30% | 0.00474 | 0.00481 | 0.006 | 0.00662 | 0.0054 |

After doing one portfolio calculation, the system will repeat it to calculate the optimal portfolio up to the specified limit. Then the portfolio calculation is done within the practical limit. After that, the system will provide the best portfolio based on Sharpe ratios and the highest expected returns from the practical limits that have been made for customers. Based on the calculation of daily return and standard deviation, the search for expected return for the best portfolio, it is found that portfolio 1 has a higher rate of return (0.55%) than portfolio 2 (0.54%).

3. Conclusions

Implementation of the Markowitz Method in the Robo-Advisor application of the best investment selection for Mutual Fund residents can display the best portfolio of mutual fund products. The results of the expected return calculation and the standard deviation of each portfolio made are then sent to investors to allocate the asset class according to the portfolio chosen. The development of the Robo-Advisor application can then implement or compare several methods or algorithms. Investment products used can combine mutual funds, bonds, and stocks with more varied data.
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