Development of Stock Portfolio Optimization Application Program Using Fuzzy Linear Programming

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Abstract

Investing in the stock area is one of the popular category of investment nowadays. To get the maximum profit in stock trading, user usually creates a portfolio. In this paper the author presents the Fuzzy Linear Programming approach to optimize the stock proportion in the Markowitz’s portfolio selection model. Computer based program with PHP programming language are made to facilitate and improve the accuracy in the calculation of the optimal allocation of the stock portfolio selection. The computer program are able to passively analyze 45 best stocks contained in the Indonesia Stock Exchange.

Keywords: Portfolio Theory, Stock, Fuzzy Linear Programming, Program Development, Optimization
INTRODUCTION

Investment interest is increasingly rising. It is caused by the awareness in the investment community are increasingly arising in the ordinary, as well as computer technology and the internet is growing, so the impact to more easily and quickly in investing in the technology media.

Stocks are excellent investments in recent years. In addition because it offers a relatively large gains, equity investments also offer a ‘comfort’ in the form of risk level is not too high, when compared with the Forex investments and so on.

Investment in outline is the delay current consumption for use in the efficient production over a given period. Investment in the world economy and the stock that we know more specifically means investing activities are either directly or indirectly, to obtain the maximum profit with the least possible risk. To minimize the risks arising from the activities of the investment, the portfolio of investments that are made.

In the world of stock investing, investment portfolio called stock portfolio is a means to minimize losses and maximize profits. Steps to be taken is to choose to buy a different stock with a maximum weight into account to produce the optimal combination.

Activity determines the weight of share allocation has basically been done long ago before investing in stocks has grown as it is now. Is a Harry Markowitz in 1952 who has made a quantitative calculation that produces an allocation model to calculate the weight of the stock purchase, which last to this day known as the Markowitz model.

The process of formation of allocation weights in stocks will often find many constraints compared to the number of shares purchased. The number of shares traded on the Indonesia Stock Exchange until August 2012 reached 451 shares and will continue to grow from year to year as the height of the IPO (Initial Public Offer) and an increase in economic prosperity. Although in the end the research is limited to 45 stocks in the stock, but investors still need to know the weight of each stock to determine the formation of many possible solutions of the future stock portfolio.

Weight calculation manually stock allocation with the number of combinations of stocks and the data in it produces a distinctive difficulties and requires a very high level of accuracy. Therefore, the use of intelligence computer software is now absolutely necessary to facilitate and accelerate the process of allocation of decision-making [1].

Software that is currently widely used to determine the allocation weights are incorporated into the portfolio shares are still using the old formula and the formula in practice. Along with the development of mathematics and some research about the stocks according to the rules of mathematical optimization, and therefore the innovations in the field of optimization software portfolio stock selection absolutely must be done to increase the accuracy and reliability.

On the issue of the establishment of a stock portfolio, the data used to compare the nature of the data is fuzzy (fuzzy) because the dynamics of change in a relatively high share data, so it needs an appropriate method for the determination of the weight
Development of stock portfolio optimization application program

allocation is often beyond the usual methods used at the time such as genetic algorithms and quadratic Programming [10]. Therefore chosen method of Fuzzy Linear Programming is an optimization method of Linear Programming development but with a fuzzy constraint or constraint.

In this paper designed a program for the establishment of an optimal portfolio of stocks using Fuzzy Linear Programming method that explanation will be given in more detail in the next section.

Problems Formulation
The problem faced is:
- The absence of a computer program that can be used to determine the optimal portfolio based on fuzzy linear programming method.
- Can the program be used for optimization of Indonesia Stock Exchange LQ45 particular?
- Can be used for Fuzzy Linear Programming optimization stock portfolio?

Given the breadth of the topic of discussion, the authors limit the issues discussed as follows:
1. Program applications will be made use the PHP programming language.
2. Analysis on the Indonesia Stock Exchange was limited to stocks that are included in the ranks of LQ45.
3. Calculation of the optimal portfolio does not pay attention to external factors that affect stock pergerkan like the economic crisis, natural disasters and other factors.

Objectives and Benefits
The objectives are as follows:
1. Search for the optimal combination of shares of a stock portfolio using Fuzzy Linear Programming.
2. Introducing Fuzzy Linear Programming method to determine the optimal proportions in a portfolio of stocks.
3. Creating a PHP-based application program for determining the optimal proportion of the portfolio of stocks with Fuzzy Linear Programming.

Benefits to be achieved are as follows:
1. For Readers: provide written information or references in the field of Fuzzy Linear Programming, computer programming and also on a stock portfolio optimization.
2. For other researchers: adding insight and knowledge about methods of Fuzzy Linear Programming and also in the world of investment, particularly investment in the stock sector.
3. For Authors: add to knowledge about how to determine the optimal stock portfolio as well as how to create a PHP-based application program.
4. For Investors: can utilize the application program designed to determine the optimal stock portfolio weights.
METHODS

Methods to be used include the following stages:
1. To study literature.
Authors conducted a study of literature and writing materials for the library through the
internet and other sources. Authors understand the sources are then incorporated into the
papers.
2. Method of Analysis
Methods of analysis in this study is divided into several steps:
   i. Study the investment instruments and stock
   ii. Studying theory and Markowitz model stock portfolio.
   iii. Studying optimization and linear
        programming.
   iv. Studying Fuzzy Linear Programming.
   v. Learn the PHP programming language and MySQL database.
   vi. Study and analyze the formation of a stock portfolio using Fuzzy Linear
        Programming, and its implementation into a computer program.
3. The design method
Stages of design in this paper is divided into several stages, namely:
   a. The design of algorithms and the structure of the program for every step in
      making the selection of a stock portfolio application program using Fuzzy
      Linear Programming.
   b. System design algorithms using Fuzzy Linear Programming via flowchart.
   c. Design program with applications using UML diagrams that illustrate some,
      usecase diagram, activity diagram, and the menu hierarchy.
   d. Database design selection stock portfolio optimization program.
   e. Designing the display screen.

RESULT and DISCUSSIONS

Optimal Portfolio Selection of the Regular Case
Suppose an investor choose \( x_i \) proportion invested in asset \( i \), where \( 1 \leq i \leq n \) for
\( n \) number of asset (stock). The obstacles include \( \sum_{i=1}^{n} x_i = 1 \) and \( x_i \geq 0, i = 1, 2, ..., n \). Return
\( R_i \) for \( i \) asset is a random variable, with expected return \( \eta_i = E(R_i) \). Let
\( R = (R_1, R_2, ..., R_n)^T, x = (x_1, x_2, ..., x_n)^T \) and \( r = (r_1, r_2, ..., r_n)^T \). In this case, transaction cost for
\( i \) asset is \( c_i \) which are described as [9][11]:

\[
c_i = k_i |x_i - x_i^0|, \quad i = 1, 2, ..., n
\]

Where \( x = (x_1^0, x_2^0, ..., x_n^0)^T \) is asset given value and \( k_i \geq 0 \) is the transaction cost
for the unit asset \( i \).

So the total transaction cost can be described as:
Total return can be described as:

\[ R(x) = E \left( \sum_{t=1}^{n} R_t x_t - \sum_{t=1}^{n} k_t |x_t - x_t^0| \right) = \sum_{t=1}^{n} \eta_t - \sum_{t=1}^{n} k_t |x_t - x_t^0| \]

So total risk can be described as:

\[ V(x) = \sum_{i=1}^{n} E \left( R_i - E(R_i) \right) x_i = \sum_{i=1}^{n} d_i \]

Where \( d_i = E \left( R_i - E(R_i) \right) x_i \)

Basically, the portfolio preferences of investors want high returns and low risk. This can be formulated mathematically as a programming model with two objective functions [4].

\[ \max R(x) = \sum_{i=1}^{n} \eta_i x_i - \sum_{i=1}^{n} k_i |x_i - x_i^0| \]

\[ \min V(x) = \sum_{i=1}^{n} d_i x_i \]

Obstacle. \( \sum_{i=1}^{n} x_i = 1, \quad x_i \geq 0, \quad i = 1, \ldots, n \)

**Portfolio Selection in Fuzzy Case**

In the investment process, the knowledge and experience of experts are critical in the decision of an investor. Based on the complexity and not terprediksinya financial markets, it is difficult to give a precise value for the prediction of risk and return, but it can be solved by forming a fuzzy objective function. According to [3] return can be formed into fuzzy values to make it in the form of a trapezium fuzzy numbers \( \tilde{r} = (\tilde{r}_1, \tilde{r}_2, \tilde{r}_3, \tilde{r}_4) \) where \( r_1 < r_2 \leq r_3 < r_4 \). Linear membership function of fuzzy numbers \( \tilde{r} \) can be noted as:

\[
\mu(x) = \begin{cases} 
 x - r_1, & r_1 \leq x \leq r_2 \\
 r_2 - r_1, & r_2 \leq x \leq r_3 \\
 1, & r_3 \leq x \leq r_4 \\
 r_4 - r_3, & r_4 \leq x \\
 0, & \text{otherwise}
\end{cases}
\]

Trapezoidal fuzzy number will be a triangular fuzzy number in the event \( r_2 = r_3 \). Besides, being a consideration in determining the optimal proportion of shares in the
portfolio is the Value at Risk or VaR, where value is the value given risk tolerance that can be borne by the investor. VaR values formulated fuzzy and annotated by trapezoidal fuzzy number $\mathbf{f} = (b_1, b_2, b_3, b_4)$. To determine the appropriate proportion of optimal stock levels for maximum return on a floor [5][6] also concluded fuzzy linear programming for optimal stock portfolio selection has been put forward according to the model below:

$$\max \frac{\sum_{j=1}^{n} \eta_j x_j + \sum_{j=1}^{n} \eta_j x_j}{3} + \frac{\sum_{j=1}^{n} \eta_j x_j + \sum_{j=1}^{n} \eta_j x_j}{6} - \sum_{j=1}^{n} c_j x_j$$

Obstacles

$$\begin{align*}
(1-\beta) \left( \sum_{j=1}^{n} \eta_j x_j - b_4 \right) + \beta \left( \sum_{j=1}^{n} \eta_j x_j - b_2 \right) & \geq 0 \\
\sum_{j=1}^{n} x_j & = 1 \\
l_j & \leq x_j \leq u_j, \ j = 1, \ldots, n
\end{align*}$$

Description:

$\eta_j = \text{Expected return of } j - \text{stock}$

$x_j = \text{Stock proportion of } j - \text{stock}$

$c_j = \text{Transaction costs of } j - \text{stock}$

$b = \text{Fuzzy Value at Risk value}$

$l_j = \text{Minimum threshold proportion of } j - \text{stock}$

$u_j = \text{Maximum threshold proportion of } j - \text{stock}$

$\beta = \text{Stock’s beta value}$

Application Design

Figure 1. Use Case Admin

On the Use-Case diagrams this admin session (Figure 1). Admin can perform three main activities, namely to login into the system, input stock data and to input the news into web sites.
On the Use-Case diagrams user session (Figure 2) [7]. Users can do a few things such as membership registration on the web site, manage an optimal portfolio, read the news about the world of finance, business and matters relating to the shares, and log in as the user [2].

Discussions

Taken a case, an investor wants to invest his money in the form of stock investment. At first the investors form a portfolio that contains 5 shares of LQ45, stock shares is:

- PT. ANTM, Tbk.
- PT. ASII, Tbk.
- PT. EXCL, Tbk.
- PT. MNCN, Tbk.
- PT. UNVR, Tbk.

By calculating the stock price data monthly and annual dividend of the year 2011 - 2013, the results obtained in the form of return expectations and transaction costs in detail depicted in Table 1 below:
Table 1. Return and Risk Stocks Data Table

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Expected Return</th>
<th>Transaction Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT. ANTM, Tbk.</td>
<td>0.0394199</td>
<td>0</td>
</tr>
<tr>
<td>PT. ASII, Tbk.</td>
<td>0.0624412</td>
<td>0.001</td>
</tr>
<tr>
<td>PT. EXCL, Tbk.</td>
<td>0.0224061</td>
<td>0.001</td>
</tr>
<tr>
<td>PT. MNCN, Tbk.</td>
<td>0.0560869</td>
<td>0.002</td>
</tr>
<tr>
<td>PT. UNVR, Tbk.</td>
<td>0.0252979</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Having obtained the data return expectations and risk of each stock to be included in the portfolio. Subsequent data required is tolerance level VaR, $\beta$ and the maximum allowable proportion of each stock. Data from VaR, $\beta$ and the maximum proportion $u_j$ are as follows:

- Fuzzy VaR Level ($\delta$) = (0.04; 0.046; 0.048; 0.05)
- $\beta = 0.05$
- Maximum proportion for each stock $u_j : 0.39$

Then the next step is to substitute these variables into a linear programming model below:

$$\max \sum_{j=1}^{n} 3 \eta_j x_j + \sum_{j=1}^{6} 6 \eta_j x_j + \sum_{j=1}^{n} \eta_j x_j - \sum_{j=1}^{n} c_j x_j$$

Obstacles:

$$\begin{cases} (1-\beta) \left( \sum_{j=1}^{n} \eta_j x_j - b_4 \right) + \beta \left( \sum_{j=1}^{n} \eta_j x_j - b_3 \right) \geq 0 \\ \sum_{j=1}^{n} x_j = 1 \\ l_j \leq x_j \leq u_j, \quad j = 1, ..., n \end{cases}$$

So we get the following linear programming model [8]:

**Objectives**:

$$\text{Max } z = 0.055x_1 + 0.0833x_2 + 0.051x_3 + 0.09x_4 + 0.066x_5$$
Obstacles:

\[
0.2625x_1 + 0.05725x_2 + 0.02325x_3 + 0.06325x_4 + 0.04025x_5 \geq 0.0499
\]

\[
x_1 + x_2 + x_3 + x_4 + x_5 = 1
\]

\[
0 \leq x_j \leq 0.39, \quad j = 1, \ldots, 5
\]

Once the model is obtained, the next step was to work on Linear Programming models using 2-Phase Simplex method. So that the optimal proportion of the stock portfolio results obtained following this:

\[
x_1 \text{(ANTM)} = 0
\]

\[
x_2 \text{(ASII)} = 0.39
\]

\[
x_3 \text{(EXCL)} = 0
\]

\[
x_4 \text{(MNCN)} = 0.39
\]

\[
x_5 \text{(UNVR)} = 0.22
\]

\[
Z \text{ (Portfolio return)} = 0.082107
\]

After performing numerical calculations manually and through the implementation of the program through an application made, the result of both methods:

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Expected Return</th>
<th>Optimal Proportion (Manual)</th>
<th>Optimal Proportion (Program)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT. ANTM, Tbk.</td>
<td>0.0394199 22</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>PT. ASII, Tbk.</td>
<td>0.0624412 7</td>
<td>0.39</td>
<td>0.39</td>
</tr>
<tr>
<td>PT. EXCL, Tbk.</td>
<td>0.0224061 95</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>PT. MNCN, Tbk.</td>
<td>0.0560869 12</td>
<td>0.39</td>
<td>0.39</td>
</tr>
<tr>
<td>PT. UNVR, Tbk.</td>
<td>0.0252979 58</td>
<td>0.22</td>
<td>0.22</td>
</tr>
</tbody>
</table>

The same end result of both experiments either manually or using the program signifies the application program can be relied upon to calculate stock portfolio selection optimization.
CONCLUSIONS

Based on the results of the analysis of application programming optimization stock portfolio selection using fuzzy linear programming, the following conclusion can be drawn: Stock selection in the stock portfolio can be optimized using Fuzzy Linear Programming, application program for the optimization of stock portfolio selection can be made in both the technical and design concepts and Program can be used to form the stock portfolio of stocks listed on the Indonesia Stock Exchange LQ45 through a defined strategy.

REFERENCES


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