Chapter 3

Application of Artificial Intelligence to Reduce Risk in Islamic Investment

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ABSTRACT

The main objective of investment activity is to gain higher return with minimum risk. Therefore, this project developed reduction risk method for Islamic investment using artificial intelligence. The method implemented in this project is using Modern Portfolio Theory with combination with genetic algorithm to search for higher return and minimum risk for portfolio selection. Data of this project are collected using Yahoo Finance database for KLCI stock prices of Shariah-compliant companies. The two assets are Top Glove Corporation Berhad and Axiata Group Berhad. The result of artificial intelligence method shows the minimum risk that can be achieved. The genetic algorithm method summarized that the minimum portfolio risk is 6.716 with expected return for portfolio is 0.392\%. The composition of portfolio is asset A 43.7\% and asset B 56.3 \%. This finding indicates optimization using artificial intelligence can produce more reliable and accurate result to forecasting investment risk and return for Islamic investment. The output of this project shows the hybrid method can propose better portfolio selection with minimum risk for desired return of investment.

Key Words: Islamic investment, Risk, Artificial Intelligence, Genetic Algorithm.

1. INTRODUCTION

Genetic Algorithm was developed in year 1975 and are a subset of stochastic optimization methods. This theory has been used widely in various research fields. Holland (1975) developed genetic algorithm theory that are computerized search methods based on the theories of genetics and natural selection. This theory is a random-based classical evolutionary algorithm. Genetic algorithm explores the solution space in an intelligent manner to evolve better solutions. The algorithm does not need any specific programming efforts but requires encoding the solution as strings of parameters. In genetic algorithm
method, some random solutions (individuals) are generated each containing several properties (chromosomes). Based on the laws of genetics, cross-over and mutations occur in chromosomes to produce a second generation of individuals with more diverse properties (Ghaheri, et al., 2015).


Besides applied genetic algorithm methods in the science field, Abu Bakar and Rosbi (2019) used genetic algorithm approach in the financial study. They combine the modern portfolio theory and genetic algorithm optimization approach and found that this hybrid method provides a better accuracy of prediction for return of investment and portfolio risk. However, study that apply genetic algorithm method in Islamic financial field are still lack of researchers. Thus, this study tries to fulfill the gap by evaluate the risk reduction in Islamic investment. Islamic investment was attracting more investors worldwide to participate. The basic understanding of Islamic investments is the system must follow shariah rules, which is the system must be free from elements of riba' (interest) gharar (uncertainty) and activities related to maysir (gambling), alcohol, tobacco, drugs or any form of activity that could pose potential harm to the society or nation (Abu Bakar and Rosbi, 2019).

2. LITERATURE REVIEW

Various methods are used in financial area in order to measure the performance of stock market. Study by Abu Bakar and Rosbi (2019) regarding the modern portfolio theory found that diversification method can maximize portfolio expected return for a given amount of risk. In others study Abu Bakar and Rosbi (2019) develop hybrid optimization method for reducing investment portfolio risk. The methods selected are combination of modern portfolio theory and genetic algorithm optimization approach and found that this study provides a better accuracy of prediction for return of investment and portfolio risk.

Besides modern portfolio theory, others methods are used in measuring the performance of finance. Study by Ismal (2010) regarding Value at Risk (VaR) approach in order to compute the volatility (risk) of returns and expected losses of Islamic bank financing in Indonesia. VaR is popular methods to measure the volatility of returns and expected losses of Islamic bank financing. He found that the volatility of returns and expected losses of bank financing finds that risk of investment and expected losses are well managed. Farooq and Pashayev (2020) used vector auto-regression (VAR) model to test the information transmission capacity of Shariah-compliant firms in India. The study show that the returns of non-Shariah-compliant firms lead the returns of Shariah-compliant firms. It is argued that non-Shariah-compliant firms possess certain financial characteristics (higher leverage, higher accounts receivable and higher cash holdings) that make their information environment better than information environment of Shariah-compliant firms.

Abu Bakar, et al., (2019) used various method in measuring the performance of Islamic stock market. They used market adjusted cumulative abnormal returns (MACAR)
for evaluate the performance of shariah compliant companies that issues initial public offerings. Therefore, this study was introduced difference methods apply in the previous study in financial area that are genetic algorithm method. This method has been widely used in science study. Abu Bakar, et al., (2019) investigate the long-term performance of Initial public offerings (IPO) for shariah compliant companies listed on Malaysia Stock Exchange using market buy-and-hold abnormal returns (MABHR) method. The main finding of this study shows MABHR is -43.161 percentages that indicates stock prices performed less than the market of Malaysia Stock Exchange.

3. METHODOLOGY

The main objective of this paper is to utilize artificial intelligence in reducing risk for Islamic investment. Therefore, this study selected two shariah compliant stock prices to develop investment portfolio. Then, this study evaluated the normality of data distribution of return rate for asset A and B. Next, the modern portfolio theory is implemented to calculate objective function of investment risk. Then, artificial intelligence method namely genetic algorithm is applied to achieve global minimum risk for investment portfolio.

3.1. Data selection and normality checking

The daily stock prices are collected from Yahoo Finance database. The two company is selected in developing portfolio with lower correlation value between to achieve minimum portfolio risk. In probability theory, a normal distribution is a type of continuous probability distribution for a real-valued random variable. The normality data distribution is described as probability density function in Equation (1).

\[ f(x) = \frac{1}{\sigma \sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \] ................................. (1)

The variables in Equation (1) are described as follow:
- \( x \) : Random variable,
- \( \mu \) : Mean of variable \( x \),
- \( \sigma \) : Standard deviation of data distribution.

Normality characteristics is important due to the central limit theorem. It states that, under some conditions, the average of many samples observations of a random variable with finite mean and variance is itself a random variable whose distribution converges to a normal distribution as the number of samples increases.

Next, the statistical test for normality is performed using Shapiro-Wilk normality test. The Shapiro-Wilk normality test is parametric test to detect all departures from normality. The test rejects the hypothesis of normality when the p-value is less than or equal to 0.05. Failing the normality test allows to state with 95% confidence the data does not fit the normal distribution. Passing the normality test only allows to state no significant departure from normality was found.
Consider the null hypothesis indicates that a sample \( x_1, x_2, \ldots, x_n \) from a normally distributed population. The Shapiro Wilk normality test statistics can be expressed as Equation (2).

\[
W = \frac{\left( \sum_{i=1}^{n} a_i x_{(i)} \right)^2}{\sum_{i=1}^{n} (x_i - \bar{x})^2} \tag{2}
\]

\( x_{(i)} \): Order statistics for variable \( x \), where \( x_{(i)} \) is the smallest order statistics,

\( \bar{x} = \frac{x_1 + x_2 + \ldots + x_n}{n} \): Sample mean for variable \( x \) with \( n \) sample size,

\( a_i \): Tabulated coefficient that derived by Equation (3).

\[
(a_1, a_2, \ldots, a_n) = \frac{m^T V^{-1}}{C} = \frac{m^T V^{-1}}{\|V^{-1}\|} = \frac{m^T V^{-1}}{(m^T V^{-1}V^{-1}m)^{1/2}} \tag{3}
\]

\( m = (m_1, m_2, \ldots, m_n)^T \): vector made of expected values of the order statistics of independent and identically distributed random variables sampled from the standard normal distribution,

\( V \): Covariance matrix of order statistics.

### 3.2. Modern Portfolio Theory

In developing modern portfolio theory, the investment return is calculated using Equation (4).

\[
E(R_p) = \sum_{i=1}^{n} w_i E(R_i) \tag{4}
\]

In Equation (4), the variables are described as below:

\( E(R_p) \): Expectation of portfolio return,

\( w_i \): The proportion of investment in asset \( i \),

\( E(R_i) \): The expectation of return for asset \( i \).

Next, this study calculated risk for portfolio investment of two assets as shown in Equation (5).

\[
\sigma_p^2 = \sum_{i} w_i^2 \sigma_i^2 + \sum_{i<j} w_i w_j \sigma_i \sigma_j \rho_{ij} \\
\sigma_p = \sqrt{\sum_{i} w_i^2 \sigma_i^2 + \sum_{i<j} w_i w_j \sigma_i \sigma_j \rho_{ij}} \tag{5}
\]

In Equation (6), the variables are described as follows:

\( \sigma_p \): Standard deviation of investment portfolio,

\( \rho_{ij} \): Correlation coefficient between the returns on asset \( i \) and \( j \).
In this study, the correlation coefficient is calculated using Pearson correlation statistical method.

\[ \rho_{X,Y} = \frac{\text{cov}(X,Y)}{\sigma_X \sigma_Y} \]  

\[ \text{cov}(X,Y) : \text{Covariance between } X \text{ and } Y, \]
\[ \sigma_X : \text{Standard deviation of } X, \text{ and} \]
\[ \sigma_Y : \text{Standard deviation of } Y. \]

3.3. Genetic Algorithm

Genetic algorithm is a heuristic search and optimisation technique inspired by natural evolution. Genetic algorithm generates a population of points at each iteration. The best point in the population approaches an optimal solution. Genetic algorithm selects the next population by computation which uses random number generators. Figure 1 shows the procedure of genetic algorithm. At each step, the genetic algorithm uses the current population to create the children that make up the next generation. The algorithm selects a group of individuals in the current population, called parents, who contribute their genes to their children. The algorithm usually selects individuals that have better fitness values as parent.

![Figure 1: Procedure of genetic algorithm for Islamic investment](image-url)
4. RESULT AND DISCUSSION

The objective of this study is to develop optimization method using modern portfolio theory with combination of genetic algorithm.

4.1. Data selection for stock price

In this study, two stock prices were selected namely Top Glove Corporation Berhad and Sime Darby Berhad. Both of stock price were collected from data base of Yahoo Finance. Daily stock prices were collected and the value of stock price for first trading day selected as monthly share price. Then, return for each of monthly data were calculated. The observation periods involving 22 months from June 2018 until March 2020.

The first company is Top Glove Corporation Berhad that a leading manufacturer of disposable rubber gloves. Top Glove Corporation Berhad provide a comprehensive range of high quality gloves at an efficient low cost. Meanwhile, second company is Axiata Group Berhad with core businesses operate in telecommunications sector with extensive operations in Asia. Axiata Group Bhd. is an investment holding company, which engages in the provision of mobile communication and network transmission related services.

Figure 2 shows the movement of stock price for Top Glove Corporation Berhad. Figure 3 shows the movement of Sime Darby Berhad.

![Figure 2: Stock price movement for Top Glove Corporation Berhad](image1)

![Figure 3: Stock price movement for Axiata Group Berhad](image2)
4.2. Return calculation for stock price

Return calculation was calculated using Equation (7) as follows:

\[ R_i = \frac{P_i - P_{i-1}}{P_{i-1}} \times 100\% \]  \hspace{1cm} (7)

In Equation (1), the variables are described as below:
- \( R_i \): Return for stock price at monthly observation period \( i \),
- \( P_i \): Stock price at monthly observation period \( i \), and
- \( P_{i-1} \): Stock price at monthly observation period \( i-1 \).

Figure 4 shows the dynamic movement of return for stock price of Top Glove Corporation Berhad. Figure 5 shows histogram of return for stock price of Top Glove Corporation Berhad. Data distribution are follow normal distribution.

![Figure 4: Dynamic movement of return for stock price of Top Glove Corporation Berhad](image)

![Figure 5: Histogram of return for stock price of Top Glove Corporation Berhad](image)
Next, this study evaluated data distribution using statistical test namely Shapiro-Wilk normality test as shown in Table 1. The significant value is 0.605 that is larger than chosen alpha. Therefore, data distribution for Top Glove return of stock price follows normal distributions.

<table>
<thead>
<tr>
<th>Kolmogorov-Smirnov</th>
<th>Shapiro-Wilk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistic</td>
<td>df</td>
</tr>
<tr>
<td>Top Glove return</td>
<td>0.132</td>
</tr>
</tbody>
</table>

* This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Figure 6 shows dynamic movement of return for stock price of Axiata Group Berhad. Figure 7 shows histogram of data distribution for return of Axiata Group Berhad stock price. Table 2 shows the statistical test of normality distribution for return of Axiata Group Berhad. The significant value is 0.091 that is larger than 0.05. Therefore, data distribution follows normal distribution.
4.3. Modern portfolio theory

Modern portfolio theory is mathematical framework for assembling a portfolio of assets such that the expected return is maximized for a given level of risk. In the same time, minimizing investment risk for required level of return. The function of modern portfolio theory is to reduce unsystematic risk for an investment. The modern portfolio theory develops efficient frontier for optimal weighted of investment portfolio. Modern portfolio theory is based on a few assumptions as follow:

(a) Investors are rational and behave in a manner as to maximise their utility with a given level of income or money.
(b) Investors have free access to fair and correct information on the returns and risk.
(c) The markets are efficient and absorb the information quickly and perfectly.
(d) Investors are risk averse and try to minimise the risk and maximise return.
(e) Investor make decision to choose portfolio with higher return for a given level of risks.

In the case of 2-asset combination for modern portfolio theory, the expected return for investment portfolio is calculated using Equation (8).

\[ E(R_p) = w_A E(R_A) + w_B E(R_B) \]  

In Equation (8), the variables are described as follows:

\( E(R_p) \) : Estimation of return for portfolio,

\( E(R_A) \) : Estimation of return for asset A,
$w_A$: Proportion of asset A,
$E(R_B)$: Estimation of return for asset B,
$w_B$: Proportion of asset B.

The proportion of investment proportion is described as follow.

$$w_A + w_B = 1 \quad \text{........................................... (9)}$$

Next, the investment risk for portfolio is calculated using variance in Equation (10).

$$\sigma_p^2 = w_A^2 \sigma_A^2 + w_B^2 \sigma_B^2 + 2w_Aw_B\sigma_A\sigma_B\rho_{AB}$$

$$\sigma_p = \sqrt{w_A^2 \sigma_A^2 + w_B^2 \sigma_B^2 + 2w_Aw_B\sigma_A\sigma_B\rho_{AB}} \quad \text{........................................... (10)}$$

The variables in Equation (10) are described as follows:

$\sigma_p$: Risk of portfolio is measured using standard deviation.
$\sigma_A$: Standard deviation of return for asset A,
$\sigma_B$: Standard deviation of return for asset B,
$\rho_{AB}$: Correlation between asset A and asset B.

The Pearson correlation between asset A and asset B is calculate using Equation (11).

$$\rho_{AB} = \frac{\text{cov}(X,Y)}{\sigma_X \sigma_Y} \quad \text{........................................... (11)}$$

The equation (5) can be re-write into Equation (12).

$$\rho_{AB} = \frac{E[(X-\mu_X)(Y-\mu_Y)]}{\sigma_X \sigma_Y} \quad \text{........................................... (12)}$$

The variables in Equation (12) are described as follows:

$E$: Expectation,
$\mu_X$: Mean of variable $X$,
$\mu_Y$: Mean of variable $Y$.

In this study, the parameters for modern portfolio theory are described as follows:

Return for asset A, Top Glove Corporation Berhad: $R_A = 0.792\%$

Standard deviation for asset A, $\sigma_A = 11.076$

Return for asset B, Axiata Group Berhad: $R_B = 0.081\%$

Standard deviation for asset B, $\sigma_B = 9.620$

The Pearson correlation between asset A and B: $\rho_{AB} = -0.144$

Then, this study adjusted the weightage for asset A and asset B to calculate portfolio return and risk as shown in Table 3. Figure 8 shows the minimum risk is at point Y with portfolio return is 0.401 \% with risk 6.725 where asset a is 45\% and asset b is 55\%.
### Table 3: Portfolio risk and return analysis

<table>
<thead>
<tr>
<th>Weightage for asset A</th>
<th>Weightage for asset B</th>
<th>Portfolio risk</th>
<th>Portfolio return</th>
</tr>
</thead>
<tbody>
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<td>1.00</td>
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<tr>
<td>0.95</td>
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</table>

![Figure 8: Modern portfolio theory analysis](image-url)

#### 4.4. Optimization using Genetic Algorithm

In this section, this study validated the finding of modern portfolio theory with implementing optimization method namely artificial intelligence genetic algorithm. Genetic algorithm is a method for solving both constrained and unconstrained optimization problems based on a natural selection process that mimics biological evolution. The algorithm repeatedly
modifies a population of individual solutions. At each step, the genetic algorithm randomly selects individuals from the current population and uses them as parents to produce the children for the next generation. Over successive generations, the population evolves toward an optimal solution. In genetic algorithm optimization, there is mutation process, crossover process in developing better solution space for a problem.

Figure 9 shows the best fitness candidates with comparison to mean fitness. In the same time, Figure 8 shows the average distance between individuals. The result indicates the best fitness value for investment risk is 6.716. The expected value for asset A proportion is 43.7% and asset B proportion is 56.3 %. The portfolio return is 0.392%.

![Figure 9: Genetic algorithm analysis](image)

5. CONCLUSION

The purpose of this study is to minimize risk in Islamic investment using combination of two methods namely modern portfolio theory (MPT) and genetic algorithm (GA) in artificial intelligence method. The main findings of this study are:

a. This study selected two stock prices for developing Islamic investment portfolio. The asset A is Top Glove Corporation Berhad with average monthly return is 0.79% and standard deviation is 11.08. The asset B is Axiata Group Berhad with average monthly return is 0.081% and standard deviation 9.62.
b. Both of the return rate for stock prices follow normal distribution. Then, Pearson statistical is carried out and the correlation value is -0.1443 between return of asset A and asset B.

c. Modern portfolio theory indicated the minimum investment risk is 6.725 with 0.4 % return for Islamic investment of two assets. The combination of portfolio is 45% in asset A and 55% in asset B.

d. Then, this study validated the finding in modern portfolio theory using artificial intelligence method namely genetic algorithm. The genetic algorithm method summarized that the minimum portfolio risk is 6.716 with expected return for portfolio is 0.392%. The composition of portfolio is asset A 43.7% and asset B 56.3 %. This finding indicates optimization using artificial intelligence can produce more reliable and accurate result to forecasting investment risk and return for Islamic investment.

Further study can be extent to developing portfolio with more type of assets. In the same time, the performance of investment portfolio also can be analysed using regression analysis to evaluate determinants that contributes to better profit in Islamic investment.

REFERENCES


