Applicability of TOPSIS Model and Markowitz Model

Nur Aqilah Mohammed Fauzi¹, Munira Ismail², Saiful Hafizah Jaaman³ and Siti Noor Diana Mohd Kamaruddin¹

¹Pusat PERMATApintar Negara, Universiti Kebangsaan Malaysia, 43600 Bangi Selangor
²School of Mathematical Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi Selangor

E-mail: aqilah.fauzi@ukm.edu.my

Abstract. The proper tool to select a company with the best financial performance is one of paramount importance before generating an optimal portfolio. The right company selection can reduce the influence of firm-specific risk which in turn can maximize the expected return on portfolio and minimize the portfolio risk. There are many literature which focus on generating portfolios using optimal Markovitz Model but did not focus much on effective methods on how to select stocks before forming the portfolio. In this paper, a method is introduced a method to select stocks before the formation of portfolio based on company’s financial performance through multi-criteria decision making model using Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) model. The objective of this study is to evaluate, compare and rank the company's overall performance by sector using the TOPSIS model based on financial ratio data. Companies with the highest ranking by sector are then selected to form a portfolio. Next, the optimal portfolio is generated using the Markowitz model. When a company's financial performance results were evaluated using the TOPSIS model, five companies are selected according to sector to form a portfolio. The findings show that the combination of TOPSIS and Markowitz models can help investors to make portfolio investment decisions more efficiently as compared to randomly selected stocks.

1. Introduction
TOPSIS model is capable of ranking the companies’ performance by using financial ratio as the evaluation criteria. Financial ratios are important tool to predict the performance of a company as mentioned in [1], [2], and [3]. Previous studies as in [4], [5], [6], [7] and [8] applied TOPSIS model according to sectors and hence this paper. According to Litterman [9], the selection of assets across different industries is an important step to reach optimization. The right company selection consecutively would lessen the firm specific risk. Therefore, can maximize the expected return of the portfolio and minimize the risk of the portfolio when Markowitz model is applied to the selected shares. The Markowitz model is chosen to this research as it can improve the investment performance as in [10]. In order to show the effectiveness of the TOPSIS model, random portfolio is compared.

2. Data and methodology
The objective of this study is to show how significant the selection of shares by using TOPSIS model as compared to randomly selected shares. Next, two types of optimal portfolio of Markowitz are
generated using shares that are selected by using TOPSIS model (PT) and randomly selected (PR). The performance of the portfolios then is compared by using Sharpe ratio.

2.1. Data

This study focuses on 16 companies from four different sectors listed in the FTSE Bursa Malaysia KLCI as at July 16, 2018 which is shown in Table 1.

| Sector               | Company Name                        | Abbreviations | Code |
|----------------------|-------------------------------------|---------------|------|
| Consumer Staples     | IOI Corp Berhad                     | IOI           | 1961 |
|                      | Kuala Lumpur Kepong Berhad          | KLK           | 2445 |
|                      | Nestle (Malaysia) Berhad            | NESM          | 4707 |
|                      | PBB Group Berhad                    | PPB           | 4065 |
| Industrials          | HAP SENG Consolidated               | HAPSENG       | 3034 |
|                      | Sime Darby Berhad                   | SME           | 2445 |
|                      | Malaysia Airports Holdings Berhad   | MAHB          | 5202 |
|                      | MISC Berhad                         | MISC          | 3816 |
| Telecommunication    | Axiata Group Berhad                 | AXIATA        | 6888 |
| Services             | Digi.com Berhad                     | DIGI          | 6947 |
|                      | Maxis Berhad                        | MAXIS         | 6012 |
|                      | Telekom Malaysia Berhad             | TM            | 4863 |
| Health Care          | Hartalega Holdings Berhad           | HARTA         | 5168 |
|                      | IHH Healthcare Berhad               | IHH           | 5225 |
| Utilities            | Petronas Gas Berhad                 | PETGAS        | 6033 |
|                      | Tenaga Nasional Berhad              | TNB           | 5347 |

The study adopts seven types of financial ratios [7] in order to rank the companies according to their performances by using TOPSIS. The financial ratios data are taken from the company’s annual report from 2015 until 2017. The equation to calculate the financial ratios are shown in Table 2.

| Financial Ratios          | Formula                                                                 |
|---------------------------|-------------------------------------------------------------------------|
| Current ratio (CR)        | \( \frac{\text{current asset}}{\text{current liabilities}} \)           |
| Return on equity (ROE)    | \( \frac{\text{Net profit}}{\text{Total shareholders' equity}} \times 100\%\) |
| Profit margin (PM)        | \( \frac{\text{Net profit}}{\text{Net sales}} \times 100\% \)            |
| Debt to equity ratio (DER) | \( \frac{\text{Total liabilities}}{\text{Total shareholders' equity}} \)  |
| Earning per share (EPS)   | \( \frac{\text{Net profit}}{\text{Number of shares}} \)                  |
| Dividend yield (DY)       | \( \frac{\text{Dividend per share}}{\text{Market price per share}} \times 100\%\) |
| Price earnings ratio (PER) | \( \frac{\text{Market price per share}}{\text{Earnings per share}} \)     |
2.2. **Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)**

The TOPSIS model was introduced by Hwang and Yoon [11]. TOPSIS is a multi-criteria decision making tool where the alternatives (the companies) can be ranked and then the best alternative can be obtained. The best alternative is an alternative that has the farthest distance from the negative ideal solution and has the closest distance to the positive ideal solution. The TOPSIS model contains seven steps and this study adapts the steps as in [12] as follows:

2.2.1. **Forming an initial decision matrix.** Initial decision matrix is formed by containing $m$ alternatives (type of company) and $n$ criteria (type of financial ratio). The score of each alternative according to each type of criteria is $a_{ij}$. The initial decision matrix is as follow:

$$A = \left( a_{ij} \right)_{m \times n} = \begin{bmatrix}
   a_{11} & \cdots & a_{1n} \\
   \vdots & \ddots & \vdots \\
   a_{m1} & \cdots & a_{mn}
\end{bmatrix}$$

(1)

2.2.2. **Standardization and normalization of decision matrix.** The initial decision matrix needs to be standardized in order to uniform the scores.

If $a_{ij}$ stands for benefit (for this study the benefit are current ratio, return on equity, profit margin, earning per share and dividend yield) then the standardization formula is as follow:

$$r_{ij} = \frac{a_{ij}}{\max \left( a_{ij} \right)}, i = 1,2,\ldots,m; j = 1,2,\ldots,n$$

(2)

If $a_{ij}$ stands for cost (for this study the cost are debt to equity ratio and price earnings ratio) then the standardization formula as follow:

$$r_{ij} = \frac{\min \left( a_{ij} \right)}{a_{ij}}, i = 1,2,\ldots,m; j = 1,2,\ldots,n$$

(3)

Subsequently, normalization is done to ensure that each score becomes dimensionless, hence each score can be compared. The formula for normalization is as follows:

$$r_{ij} = \frac{r_{ij}'}{\sum_{i=1}^{m} r_{ij}'}, i = 1,2,\ldots,m; j = 1,2,\ldots,n$$

(4)

2.2.3. **Weightage determination.** This study applies information entropy method for weightage determination as to prevent subjective judgement which is uncertain and random [13].

Let $e_j$ denotes entropy for score $j$ in normalized decision matrix. The formula to obtain $e_j$ is as follows:

$$e_j = -k \sum_{i=1}^{m} r_{ij} \ln r_{ij}, j = 1,2,\ldots,n$$

(5)

where $k = \frac{1}{\ln m}$, $0 \leq e_j \leq 1$. If $r_{ij} = 0, r_{ij} \ln r_{ij} = 0$

hence the weight for each score is according to the following formula:
\[ w_j = \frac{d_j}{\sum_{j=1}^{d} (1-e_j)} = \frac{1-e_j}{\sum_{j=1}^{d} (1-e_j)} \]  

(6)

2.2.4. *Weighted matrix.* Weighted matrix for each score is as follows:

\[
V = \begin{bmatrix}
  w_1 r_{11} & \cdots & w_n r_{nn} \\
  \vdots & \ddots & \vdots \\
  w_1 r_{nl} & \cdots & w_n r_{nn}
\end{bmatrix} = \begin{bmatrix}
  v_{11} & \cdots & v_{nn} \\
  \vdots & \ddots & \vdots \\
  v_{ml} & \cdots & v_{nn}
\end{bmatrix}
\]

(7)

2.2.5. *Determination of positive ideal solution and negative ideal solution.*

\[
V^+ = \left\{ v_1^+, v_2^+, \ldots, v_n^+ \right\}
\]

\( = \left\{ \left( \max_{j \in J_1} v_j \mid j \in J_1 \right), \left( \min_{j \in J_2} v_j \mid j \in J_2 \right) \right\} | i = 1, 2, \ldots, m \) 

(8)

\[
V^- = \left\{ v_1^-, v_2^-, \ldots, v_n^- \right\}
\]

\( = \left\{ \left( \min_{j \in J_1} v_j \mid j \in J_1 \right), \left( \max_{j \in J_2} v_j \mid j \in J_2 \right) \right\} | i = 1, 2, \ldots, m \) 

(9)

*\( V^+ \)* denotes positive ideal solution, *\( V^- \)* denotes negative ideal solution, *\( J_1 \)* denotes corresponding benefit criterion and *\( J_2 \)* denotes corresponding cost criterion.

2.2.6. *Calculation of the relative distance.*

*\( L^+_i \)* denotes the distance between *\( v_j \)* and positive ideal solution as follows:

\[
L^+_i = \sqrt{\sum_{j=1}^{n} (v_j - v_j^+)^2}, i = 1, 2, \ldots, m
\]

(10)

*\( L^-_i \)* denotes the distance between *\( v_j \)* and negative ideal solution

\[
L^-_i = \sqrt{\sum_{j=1}^{n} (v_j - v_j^-)^2}, i = 1, 2, \ldots, m
\]

(11)

2.2.7. *Calculating TOPSIS evaluation value.* The higher TOPSIS value, the higher the rank. The formula is as follow.

\[
Y_i = \frac{L^-_i}{L^+_i + L^-_i}
\]

(12)

2.3. *Optimum portfolio based on Markowitz model*

2.3.1. *Allocation of risky asset.* The risky asset allocation based on min-variance model which is represented by equation 13, where *\( S_p \)* is Sharpe ratio, *\( E(r_p) \)* is expected return of risky portfolio, *\( r_f \)* is risk free rate, *\( \sigma_p \)* is standard deviation of risky portfolio and *\( \sigma_{ij} \)* is covariance of risky share *\( i \)* and *\( j \).*

The daily adjusted closing price of the selected companies is obtained from Yahoo Finance from 2nd January 2015 until 29th December 2017.
Maximize \( S_p = \frac{E(r_p) - r_f}{\sigma_p} \)

Subjects to
\[
\sigma_p = \sum_{i=1}^{N} w_i^2 \sigma_i^2 + 2 \sum_{i=1}^{N} \sum_{j=1}^{N} w_i w_j \sigma_{ij},
\]  

\[
E(r_p) = \sum_{i=1}^{N} w_i E(r_i)
\]

\[
\sum_{i=1}^{N} w_i = 1,
\]

\[
w_i \geq 0, i = 1, \ldots, N.
\]  

(13)

2.3.2. Percentage of risk free asset and risky asset. A complete optimum portfolio is generated by obtaining the percentage of risky asset, \( y \) by using the equation 14, where \( A \) is the risk aversion.

\[
y = \frac{E(r_p) - r_f}{A\sigma_p^2}
\]  

(14)

2.3.3. Expected return and standard deviation of complete portfolio. To compare the portfolio, the expected return and standard deviation of complete portfolio are calculated by using equation 15.

\[
E(r_c) = r_f + y(E(r_p) - r_f)
\]

\[
\sigma_c = y\sigma_p
\]  

(15)

3. Results and Discussion

This section will discuss the result of companies selection by using TOPSIS model and randomly selected companies. Hence the two types of optimal portfolio (PT and PR) are generated according to Markowitz model.

3.1. The companies selection by using TOPSIS model

According to the listed companies and financial ratios in Table 1 and Table 2, the initial decision matrix is shown in Table 3. The TOPSIS model is run separately according to the sector. The result of TOPSIS value \( Y_i \) of the first rank company according to sector is NESM: 0.916, SIME:0.834, DIGI:0.987, HARTA:0.729, TNB:0.509.

3.2. The randomly selected companies

Five companies from 16 companies listed in Table 1 are selected randomly. The companies are IOI, NESM, SIME, AXIATA and IHH.

3.3. Optimal portfolio

The two types of portfolios are generated using Markowitz model as in equation 13, 14 and 15. Table 4 shows the portfolio constructed from stocks that are selected by TOPSIS model has higher value of percentage of risky asset, expected return, standard deviation of complete portfolio and Sharpe ratio than the random portfolio. The higher the Sharpe ratio means the better the portfolio diversification. PT has three risky stocks [NESM:13%, HARTA: 4%, TNB:1%] while PR has two risky stocks [NESM:10%, IHH:2%]. PT is more diversified than PR. Sharpe ratio 12.49% means that the investor of PT will enjoy a 12.49% expected excess return for every 1% of risk free asset.
Table 3. Initial decision matrix of companies according to sectors

| Sector      | Companies | CR  | ROE  | PM   | DER  | EPS  | DY   | PER |
|-------------|-----------|-----|------|------|------|------|------|-----|
| Consumer    | IOI       | 1.988 | 6.462 | 3.801 | 1.314 | 0.075 | 2.074 | 189.326 |
|             | KLK       | 1.980 | 10.739 | 7.251 | 0.632 | 1.085 | 2.149 | 22.873 |
|             | NESM      | 0.660 | 94.241 | 12.356 | 2.787 | 2.663 | 3.220 | 31.798 |
|             | PPB       | 2.817 | 5.362 | 27.265 | 0.058 | 0.929 | 1.512 | 17.620 |
| Industrials | HAPSENG   | 1.368 | 19.508 | 22.068 | 1.012 | 0.430 | 4.082 | 19.263 |
|             | SIME      | 3.563 | 89.824 | 6.052 | 0.824 | 0.383 | 6.740 | 11.413 |
|             | MAHB      | 1.383 | 1.309 | 2.629 | 1.477 | 0.036 | 1.548 | 70.413 |
|             | MISC      | 1.466 | 6.533 | 24.039 | 1.156 | 0.525 | 3.796 | 15.457 |
| Telecommunication | AXIATA | 0.651 | 5.452 | 7.023 | 1.315 | 0.151 | 2.830 | 52.964 |
| Services    | DIGI      | 0.652 | 310.254 | 24.317 | 9.270 | 0.207 | 4.191 | 24.722 |
|             | MAXIS     | 0.546 | 38.383 | 22.962 | 2.810 | 0.262 | 3.740 | 24.224 |
|             | TM        | 1.127 | 8.200 | 5.393 | 2.139 | 0.213 | 3.458 | 30.215 |
| Health      | HARTA     | 2.598 | 16.832 | 17.032 | 0.269 | 0.155 | 4.663 | 15.303 |
|             | IHH       | 1.571 | 3.363 | 8.652 | 0.508 | 0.100 | 0.474 | 66.114 |
| Utiliti     | PETGAS    | 3.179 | 15.214 | 40.137 | 0.328 | 0.930 | 3.049 | 22.045 |
|             | TNB       | 1.540 | 12.897 | 15.006 | 1.478 | 1.203 | 3.012 | 11.103 |

Table 4. Percentage of risky asset, expected return, standard deviation of complete portfolio and Sharpe ratio of resulting portfolio

| Portfolio                  | y         | $E(r_C)$ | $\sigma_C$ | $S_P$ |
|----------------------------|-----------|----------|------------|-------|
| PT- portfolio constructed from stocks that are selected by TOPSIS model | 18.25% | 0.023% | 0.11% | 12.49% |
| PR- portfolio constructed from stocks that are randomly selected | 11.58% | 0.013% | 0.07% | 7.22% |

4. Conclusion
It is evident by using Sharpe ratio that portfolio that made up from stocks that are selected by TOPSIS model performs better than the random portfolio. Therefore, by ranking and selecting the companies based on the financial performance would help the investor on the decision making process and hence maximize the return and minimize the risk of the portfolio.

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