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Original Article

Portfolio Optimization of Technology Companies in Malaysia: An Application of Fuzzy TOPSIS-Mean-Absolute Deviation Approach

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Abstract

Selecting and weighting the companies are the main processes in portfolio optimization. It is important to select and determine the companies' weights in constructing the optimal portfolio. In this paper, we propose a two-phase Mean-Absolute Deviation (MAD) model in portfolio optimization of technology companies in Malaysia. In the first phase, the companies' financial performance is determined and ranked with Fuzzy Technique for Order of Preference by Similarity to the Ideal Solution (TOPSIS). Selection of good financial performance companies can minimize the influence of firm-specific risk in minimizing the risk of the portfolio at the expected return. In the second phase, the optimal portfolio is generated by weighing the selected companies with MAD model. The results indicate that the investors can minimize the portfolio risk to achieve the expected return with the two-phase MAD model. The significance of this paper is to contribute to the development of portfolio optimization by integrating the Fuzzy TOPSIS and MAD approaches. In conclusion, the investors can generate the expected return at minimum risk with the two-phase MAD model. The significance of this paper is to contribute to the development of portfolio optimization in academic by integrating the Fuzzy TOPSIS and MAD model. Besides that, it is a pioneer study in Malaysia. For the future research, it is recommended to study the two-phase MAD model in other countries.

1. Introduction

The investors wish to generate the expected return at the minimum portfolio risk in their investment. In portfolio optimization, the mean-absolute deviation (MAD) model minimizes the portfolio risk (Jaaman et al., 2013; Konno & Yamazaki, 1991). The investors will be able to minimize the portfolio risk in generating the expected return using the MAD model. The past studies focus on constructing the optimal portfolio with MAD model without considering the companies' financial performance (Jaaman et al., 2013). In fact, selection of the good financial performance companies is important because it can reduce the firm-specific risk in minimizing the portfolio risk. Therefore, we study the selection of the best financial performance companies with Fuzzy Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) before developing the optimal portfolio using Mean-Absolute Deviation (MAD) model.

Fuzzy TOPSIS can solve multi-criteria decision making (MCDM) problem by determining the alternative that gives the shortest distance to the fuzzy positive ideal solution (FPIS) and the farthest distance from the fuzzy negative ideal solution (FNIS) in uncertain environment (Nădăban et al., 2016; Opricovic & Tzeng, 2004). MCDM problem considers multiple decision criteria and alternative in determining the optimal solution (L W Hoe et al., 2018). Fuzzy TOPSIS has been applied in various MCDM problems such as the selection of plant location (Awasthi et al., 2011; Safari et al., 2012), supplier selection (Chen et al., 2006), ranking renewable energy supply systems (Şengül et al., 2015), project selection (Walczak & Rutkowska, 2017) and risk evaluation (Liu & Wei, 2018).

The objective of this study is to propose a two-phase MAD model for portfolio optimization of technology companies in Malaysia. In the first phase, the top financial performance companies are selected using Fuzzy TOPSIS before constructing the optimal portfolio with MAD model in the second phase. Technology sector is very important in the information and communication technology based on applications and innovations that enhance organizational performance and economic growth of a country.

2. Materials and Methods

2.1. Proposed Two-Phase Mean-Absolute Deviation Model

Selecting and weighting the companies are the main processes in portfolio optimization. Therefore, it is important to select and determine the companies' weights in constructing the optimal portfolio. Selection of the right companies can minimize the influence of firm-specific risk in minimizing the portfolio risk at the expected return. Hence, we focus on the selection of the best financial performance companies with Fuzzy TOPSIS in this study before constructing the optimal portfolio using MAD model. We propose a two-phase MAD model for portfolio optimization as follows:

Phase 1: Selection

In the first phase, we determine and rank the companies' financial performance with Fuzzy TOPSIS. The financial ratios such as current ratio, debt to asset ratio, debt to equity ratio, earnings per share, return on asset and return on equity are considered in this research since these financial ratios are the important indicators in assessing the financial performance of the companies (Akkoc & Vatansever, 2013; Gündoğdu, 2015). Next, the top performance companies are selected as the inputs for portfolio optimization in the second phase.

Phase 2: Weightage

In the second phase, we generate the optimal portfolio by weighting the selected companies using MAD model. We analyze the listed Malaysia's technology companies with the proposed two-phase MAD model, namely Fuzzy TOPSIS-MAD model based on the financial reports from 2015 to 2017. The conceptual framework is presented in Table 1 to measure the companies' financial performance at the first phase of the proposed model using Fuzzy TOPSIS.

Table 1. Conceptual framework

Objective(s)	Evaluation of the financial performance of technology companies
Decision criteria	Current ratio (CR)
	Debt to assets ratio (DAR)
	Debt to equity ratio (DER)
	Earnings per share (EPS)
	Return on asset (ROA)
	Return on equity (ROE)
Decision Alternatives	ECS
	EFORCE
	ELSOFT
	GRANFLO
	GTRONIC
	INARI
	JCY
	KESM
	MPI
	THETA
	UNISEM
	VITROX
	WILLOW

The financial ratios that needed to be minimized are DAR and DER. In contrast, CR, EPS, ROE and ROA are required to be maximized. In this study, equal weight is assigned to each financial ratio since these financial ratios are equally important in measuring the companies' financial performance (Akkoc & Vatansever, 2013; Bulgurcu, 2012). The top six performance companies are selected as the inputs in generating the optimal portfolio based on the past studies in portfolio optimization (Beasley et al., 2003; Canakgoz & Beasley, 2009). In the second phase, the optimal portfolio is constructed with the MAD model. The optimal solution is obtained by using the LINGO software (Hoe et al., 2017; Lam et al., 2017). The portfolio mean return, portfolio risk and portfolio performance of the MAD optimal portfolio are generated in this study.

2.2. Fuzzy TOPSIS

Fuzzy TOPSIS model is employed to determine the ranking of the companies and measure the compromise solution that is the closest to the FPIS and farthest from the FNIS in uncertain environment (Nădăban et al., 2016; Opricovic & Tzeng, 2004). Step 1: Develop a fuzzy decision matrix and select the appropriate linguistic variables for the decision alternatives according to the criteria.

$$D = \begin{bmatrix} \tilde{x}_{11} & \cdots & \tilde{x}_{1j} & \cdots & \tilde{x}_{1n} \\ \vdots & & \vdots & & \vdots \\ \tilde{x}_{i1} & \cdots & \tilde{x}_{ij} & \cdots & \tilde{x}_{in} \\ \vdots & & \vdots & & \vdots \\ \tilde{x}_{m1} & \cdots & \tilde{x}_{mj} & \cdots & \tilde{x}_{mn} \end{bmatrix} \tag{1}$$

$$\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij}), \quad i = 1,...,m, j = 1,...,n$$

a_{ij} is the lowest ratio from the period of study for alternative i with respect to criterion j. b_{ij} is the average ratio from the period of study for alternative i with respect to criterion j. c_{ij} is the highest ratio from the period of study for alternative i with respect to criterion j.

Step 2: The fuzzy-decision matrix R is normalized as follows.

$$\tilde{R} = [\tilde{r}_{ij}]_{m\times n}, \quad i = 1,2,...,m, \quad j = 1,2,...,n \tag{2}$$

$$\tilde{r}_{ij} = \left(\frac{l_{ij}}{u_j^+}, \frac{m_{ij}}{u_j^+}, \frac{u_{ij}}{u_j^+} \right), \tag{3a}$$

$$u_j^+ = \max_i \{u_{ij} \mid i = 1,2,...,m\} \tag{3b}$$

The weighted fuzzy normalized decision matrix is shown as following matrix:

$$\tilde{V} = [\tilde{v}_{ij}]_{n\times n}, \ i = 1,2,...,m \quad j = 1,2,...,n \tag{4a}$$

$$\tilde{v}_{ij} = \tilde{r}_{ij} \times \tilde{w}_j \tag{4b}$$

Step 3: Determine the Fuzzy Positive-Ideal Solution (FPIS) and Fuzzy Negative-Ideal Solution (FNIS) as follows.

$$A^+ = (\tilde{v}_1^*, ..., \tilde{v}_j^*, ..., \tilde{v}_n^*)$$

$$\tilde{v}_i^* = \begin{cases} \max v_{ij}, \ j \in N & i=1,...,m, \text{ for benefit criteria} \\ \min v_{ij}, \ j \in N & i=1,...,m, \text{ for cost criteria} \end{cases}$$

$$A^- = (\tilde{v}_1^-, ..., \tilde{v}_j^-, ..., \tilde{v}_n^-)$$

$$\tilde{v}_i^- = \begin{cases} \min v_{ij}, \ j \in N & i=1,...,m, \text{ for benefit criteria} \\ \max v_{ij}, \ j \in N & i=1,...,m, \text{ for cost criteria} \end{cases}$$

Step 4: Calculate the Distance of each Alternative from FPIS and FNIS.

The distances ($\tilde{d}_i^+$ and $\tilde{d}_i^-$) of each alternative from A^+ and A^- is determined as follows.

$$\tilde{d}_i^+ = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^*), \quad i = 1,2,...,m \tag{5}$$

$$\tilde{d}_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^-), \quad i = 1,2,...,m \tag{6}$$

The distance between two triangular fuzzy numbers $\tilde{a} = (a_1, a_2, a_3)$ and $\tilde{b} = (b_1, b_2, b_3)$ is shown as follows:

$$d(\tilde{a}, \tilde{b}) = \sqrt{\frac{1}{3}\left[(a_1 - b_1)^2 + (a_2 - b_2)^2 + (a_3 - b_3)^2 \right]} \tag{7}$$

Step 5: Computing the Closeness Coefficients of each Alternative as follows.

$$CC_i = \frac{d_i^-}{d_i^+ + d_i^-}, \quad i = 1,2,...,m \tag{8}$$

The highest CC_i value of alternative implies the best alternative.

2.3. Mean-Absolute Deviation (MAD) model

In MAD model, the absolute deviation is used as measurement of risk. Konno & Yamazaki (1991) and Lam et al. (2017) are formulated MAD model as follows:

Minimize:

$$w(x) = E\left[\left| \sum_{j=1}^{n} R_j x_j - E[\sum_{j=1}^{n} R_j x_j] \right| \right. \tag{9}$$

subject to

$$\sum_{j=1}^{n} E[R_j] x_j \geq \rho M_{0,} \tag{10}$$

$$\sum_{j=1}^{n} x_j = M_{0,} \tag{11}$$

$$0 \leq x_j \leq u_{j,} j = 1,...,n.$$

where $M_{0,}$ is the total value of fund, u_j is the maximum amount invested in asset j , ρ is a parameter representing the minimum return set by the investor, R_j is the return of asset j , x_j is the weight of asset j .

3. Results

This study presents the result of FPIS and FNIS for each financial ratio in Table 2 below:

Table 2. FPIS and FNIS for each financial ratio

Financial Ratio	FPIS A⁺	FNIS A⁻
CR	(0.0811, 0.1297, 0.1667)	(0.0005, 0.0007, 0.0009)
DAR	(0.0006, 0.0007, 0.0008)	(0.1017, 0.1027, 0.1667)
DER	(0.0004, 0.0005, 0.0006)	(0.0864, 0.0888, 0.1667)
EPS	(0.0980, 0.1083, 0.1667)	(0.0016, 0.0045, 0.0080)
ROA	(0.0900, 0.1216, 0.1667)	(0.0032, 0.0126, 0.0204)
ROE	(0.0776, 0.1218, 0.1667)	(0.0038, 0.0118, 0.0182)

Table 2 shows the FPIS for CR, DAR, DER, EPS, ROA and ROE are (0.0811, 0.1297, 0.1667), (0.0006, 0.0007, 0.0008), (0.0004, 0.0005, 0.0006), (0.0980, 0.1083, 0.1667), (0.0900, 0.1216, 0.1667) and (0.0776, 0.1218, 0.1667) respectively. The FNIS for CR, DAR, DER, EPS, ROA and ROE are (0.0005, 0.0007, 0.0009), (0.1017, 0.1027, 0.1667), (0.0864, 0.0888, 0.1667), (0.0016, 0.0045, 0.0080), (0.0032, 0.0126, 0.0204) and (0.0038, 0.0118, 0.0182) respectively. Table 3 shows the separation distance of each company from the FPIS and FNIS respectively.

Table 3. Separation distance of each company from the FPIS and FNIS

Companies	$\tilde{d}_i^+$	$\tilde{d}_i^-$
ECS	0.4120	0.3189
EFORCE	0.5648	0.1751
ELSOFT	0.3193	0.4124
GRANFLO	0.4996	0.2358
GTRONIC	0.2528	0.4875
INARI	0.3685	0.3662
JCY	0.4341	0.2973
KESM	0.4215	0.3384
MPI	0.1889	0.5541
THETA	0.7084	0.0581
UNISEM	0.5745	0.1637
VITROX	0.4300	0.3294
WILLOW	0.3954	0.3386

Table 3 captures the MPI (0.1889) gives the shortest distance to the FPIS followed by GTRONIC (0.2528) and ELSOFT (0.3193). In addition, MPI (0.5541) has the largest distance from the FNIS followed by GTRONIC (0.4875) and ELSOFT (0.4124). Therefore, MPI, GTRONIC and ELSOFT are identified as the top three technology companies. Table 4 presents the overall performance of technology companies based on the closeness coefficient in this study.

Table 4. Overall performance of technology companies

Companies	Closeness coefficient	Ranking
ECS	0.4363	7
EFORCE	0.2366	11
ELSOFT	0.5636	3
GRANFLO	0.3207	10
GTRONIC	0.6585	2
INARI	0.4984	4
JCY	0.4065	9
KESM	0.4453	6
MPI	0.7458	1
THETA	0.0758	13
UNISEM	0.2217	12
VITROX	0.4338	8
WILLOW	0.4613	5

Table 4 displays MPI achieves the first ranking because of the highest closeness coefficient (0.7458) followed by GTRONIC (0.6585), ELSOFT (0.5636), INARI (0.4984), WILLOW (0.4613) and KESM (0.4453). This implies that MPI, GRONIC, ELSOFT, INARI, WILLOW and KESM are identified as the top six performance companies. Therefore, these companies have been selected by the proposed model at the first phase using fuzzy-TOPSIS approach. At the second phase of the proposed model, the optimal portfolio composition of MAD model is presented in Table 5.

Table 5. Optimal portfolio composition of MAD model

Companies	Compositions (%)
ELSOFT	10.00
GTRONIC	10.00
INARI	31.27
KESM	13.41
MPI	10.00
WILLOW	25.32

Table 5 indicates that the portfolio of MAD model comprises ELSOFT (10.00%), GTRONIC (10.00%), INARI (31.27%), KESM (13.41%), MPI (10.00%) and WILLOW (25.32%). The weight of each company in the portfolio is determined based on the optimal solution of MAD model. Table 6 shows the summary statistics of the optimal portfolio of MAD model.

Table 6. Summary statistics of the optimal portfolio of MAD model

Portfolio of MAD	Statistics
Mean return	0.0354
Risk	0.0466
Performance	0.7607

Table 6 captures the MAD optimal portfolio gives the portfolio mean return at 0.0354 with the portfolio risk at 0.0466. It implies that the investors will be able to generate the expected return at the minimum portfolio risk. The performance of the MAD optimal portfolio is 0.7607.

4. Conclusions

The investors aim to determine the trade-off between the minimization of risk and maximization of return in portfolio optimization. In this study, two-phase MAD model is proposed by selecting the top financial performance companies with Fuzzy TOPSIS before constructing the optimal portfolio using MAD model. In conclusion, the investors can generate the expected return at minimum risk with the two-phase MAD model. The significance of this paper is to contribute to the development of portfolio optimization in academic by integrating the Fuzzy TOPSIS and MAD model. Besides that, it is a pioneer study in Malaysia. For the future research, it is recommended to study the two-phase MAD model in other countries.

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