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Evaluation of the Performance of Technology Companies using VIKOR Algorithm

Kah Fai Liew[1,*], Weng Siew Lam[1], Weng Hoe Lam[1]

[1] Department of Physical and Mathematical Science, Faculty of Science, Universiti Tunku Abdul Rahman, Kampar Campus, Jalan Universiti, Bandar Barat, 31900 Kampar, Perak, Malaysia

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ABSTRACT

Technology sector plays a central role in a country nowadays. The development of the current era where the contribution of technology cannot be denied and should be greatly concerned by the government indeed. The financial structure of the technology companies is needed to be improved so that they are more resistant to economic fluctuations. Moreover, the technology sector constitutes an essential part of global employment, and it can also contribute to world economic growth in an effective way. For nowadays' trends, the competitive environment forced companies to utilize their financial resources effectively. As a result, the financial performance (FP) of the technology companies is investigated in this study. The FP is assessed by the important financial factors, which are current assets, total assets, current liabilities, total liabilities, revenue and net income. The purpose of this research is to propose a research framework to determine the FP and ranking of Malaysia's technology companies using VIKOR algorithm. According to the results of this research, the five top-performing companies in terms of FP are MYEG, INARI, VSTECS, VITROX and PENTA. Based on the optimal solution of VIKOR algorithm, OMESTI is not able to show good financial performance as compared to other technology companies. This paper is also capable to provide insight into the technology companies for benchmarking in the future based on the ranking and current financial status of the companies. This study is significant to investigate the FP and ranking of technology companies with the proposed VIKOR algorithm.

1. Introduction

Nowadays, technology and equipment are broadly in developing due to the implication of industrial development initiatives [1,2]. Technology is accelerating its ability to assist businesses by providing better results. The main foundation of running a business is the development of technology [3]. Internet of things (IoT), big data and artificial intelligence (AI) are well-versed in creating programs that businesses can utilize to reduce the time from product idea to product creation and product creation to customer delivery. With the advanced development of technology, businessmen

* *Corresponding author.*
E-mail address: liewkf@utar.edu.my

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are able to promote their products online, and hence, it can attract customers to perform online transactions by purchasing the products. Moreover, customer relations can be enhanced by offering online services and providing product information to customers [4]. As a result, the technology companies should take the initiative to develop more modern and latest technology which can beneficial to society in a more secure environment. Furthermore, the rapidly expanding technology sector has boosted the dynamism of developing job opportunities and new revenue streams. Thus, the financial performance (FP) of the technology companies should be analyzed meticulously to ensure that the performance level of technology companies is up to par. In this study, a multiple criteria decision analysis mathematical model called VlseKriterijuska Optimizacija I Komoromisno Resenje (VIKOR) is proposed to evaluate the FP of the companies since the VIKOR algorithm is capable to identify the decision alternative that has the longest separation distance to the worst ideal solution (WIS) and the nearest separation distance to the best ideal solution (BIS). According to the past study, the financial indicators are vital to be adopted to assess the FP of the companies [5-7]. Hence, the financial factors utilized for the FP evaluation are revenue (RV), net income (NI), total liabilities (TL), current liabilities (CL), total assets (TA) and current assets (CA). With the VIKOR algorithm, the satisfaction level of the citizens toward municipality services is studied by Yildirim *et al.,* [8]. Bozanic *et al.,* [9] applied the VIKOR algorithm to select construction machines. Batrancea *et al.,* [10] utilized VIKOR algorithm in the evaluation of the FP of airline companies. Another research about the measurement of the performance of commercial banks with the proposed VIKOR algorithm is done by Ic *et al.,* [11]. Abdel-Basset *et al.,* [12] used the VIKOR algorithm to evaluate the FP of manufacturing companies. Based on the past literature, the researchers have utilized the VIKOR algorithm to assess the performance of the companies or the alternatives. As a result, VIKOR algorithm is a fabulous tool to determine the FP of the companies.

According to the past study, the VIKOR algorithm is remarkably successful method for tackling the decision making problems in various fields, such as energy systems, sustainable supply chain, water consumption behavior, rectification of the optical sight of the long-range rifle, solar photovoltaic power project site selection, new doctors ranking system, learning management systems , failure mode and effect analysis, material selection for automotive piston component, strategy selection problem on artificial intelligence, efficient and secure 5G core network slice provisioning, tool selection in lean management and integrated management systems [13-25]. The VIKOR algorithm is also practicable and applicable to this research as well. As a result, the VIKOR algorithm is proposed in this study to analyze the FP of companies and determine the ranking of the technology companies listed in Bursa Malaysia. Assessment of the companies in terms of FP is the main focus of this paper. The findings of this study are expected to provide useful and important information to the technology companies in adopting the necessary actions in light of the state of the technology sector. The underperformed companies could benefit from this study by addressing the performance of the companies with the VIKOR algorithm. The rest of the article is structured as follows. Section 2 depicts the data and methodology. Next, Section 3 describes the empirical results of this study. Lastly, the conclusion is formulated in Section 4.

2. Methodology

The proposed research framework to assess the FP of the technology companies listed in Bursa Malaysia with the VIKOR algorithm is displayed in Table 1. The duration of the study's period is 5 years, which is from the year 2017 to 2021. The data is gathered from the Refinitiv database. In this study, the crucial financial factors utilized to measure the FP of the companies are stated as follows: current assets (CA), total assets (TA), current liabilities (CL), total liabilities (TL), revenue (RV) and net

income (NI). According to our best understanding, there is no study to analyze the FP of the technology companies listed in Bursa Malaysia with these important financial factors by using the VIKOR algorithm [7,26]. As a result, by filling the research gap, this paper is able to determine the FP and ranking of the companies with the proposed VIKOR algorithm. Based on the outcomes generated, the companies can understand their financial status and take some remedial actions in order to enhance their FP in the future.

Table 1
Proposed research framework

Level	
Purpose	Assessment on the technology companies' FP
Decision criteria	Current assets (CA)
	Total assets (TA)
	Current liabilities (CL)
	Total liabilities (TL)
	Revenue (RV)
	Net income (NI)
Decision alternatives	CENSOF
	D&O
	DATAPRP
	DIGISTA
	DSONIC
	EDARAN
	EFORCE
	ELSOFT
	FRONTKN
	FSBM
	GHLSYS
	GREATEC
	GTRONIC
	HTPADU
	INARI
	ITRONIC
	JCY
	JHM
	KESM
	KEYASIC
	MI
	MMSV
	MPI
	MSNIAGA
	MYEG
	NOTION
	OMESTI
	PENTA
	REVENUE
	THETA
	TRIVE
	TURIYA
	UNISEM
	UWC
	VITROX
	VSTECS
	WILLOW

VIKOR algorithm was originally developed by Opricovic. VIKOR is one of the multiple criteria decision analysis models to help the decision maker to select a decision alternative that is the closest to the ideal [27]. VIKOR is contemplated as the most reliable decision-making model which based on closeness to the ideal objects and the optimal solutions are generated by considering the decision criteria [28]. The theory of the VIKOR algorithm is based on measurements of distance in order to seek a compromise solution [27]. VIKOR algorithm is capable to generate a compromise solution to measure FP measurement [29]. For VIKOR algorithm, the selection of distinguishing coefficient (*v*) as the strategy's weight of "the maximum group utility" for the final ranking stage by deviations from the space of the ideal solution is imperative to illustrate the measurement result of FP in a better manner [28,29]. VIKOR algorithm could yield a compromise strategy with a distinguishing coefficient of 0.5.

The mathematical procedures of the VIKOR algorithm are presented below.

Step 1: Establish the decision matrix with *m* decision alternatives with respect to the *n* criteria [30–32].

$$D=\begin{bmatrix} x_{11} & \cdots & x_{1j} & \cdots & x_{1n} \\ \vdots & & \vdots & & \vdots \\ x_{i1} & \cdots & x_{ij} & \cdots & x_{in} \\ \vdots & & \vdots & & \vdots \\ x_{m1} & \cdots & x_{mj} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

where x_{ij} represents the *j*th criterion value of the *i*th alternative of the matrix *D*.

Step 2: Determine the worst f_j^- and the best f_j^* values of criterion *j* (financial factor), where $j=1,2,...,n$. The worst value f_j^- and the best value f_j^* of criterion *j* are determined according to the criterion *j*. The financial factors of CA, TA, RV and NI should be maximized by assigning the biggest value for x_{ij}. CL and TL seek to find the lowest value for x_{ij}.

Step 3: Determine the evaluation value of criterion *j* for alternative *i* (S_{ij}) for $i=1,...,m$, $j=1,...,n$. f_{ij} denotes the score for alternative *i* with criterion *j*. The normalized decision matrix is formulated by using the equation below.

$$S_{ij}=\frac{w_j(f_j^*-f_{ij})}{(f_j^*-f_j^-)}, i=1,...,m,\ j=1,...,n \quad (2)$$

where w_j is the weight of criterion *j*. w_j is set to be 0.16667 since the criteria are equally important to determine the FP of the companies [26].

Step 4: Compute the utility (S_i), regret (R_i) and VIKOR indices (Q_i) values, $i=1,...,m$. *v* denotes the weight for the strategy "majority of criteria". When $v=0.5$, the strategy could be compromised.

$$S_i=\sum_{j=1}^{n}\frac{w_j(f_j^*-f_{ij})}{(f_j^*-f_j^-)}, i=1,...,m \quad (3)$$

$$R_i=\max\frac{w_j(f_j^*-f_{ij})}{(f_j^*-f_j^-)}, i=1,...,m \quad (4)$$

$$Q_i = v\frac{(S_i - S^*)}{(S^- - S^*)} + (1-v)\frac{(R_i - R^*)}{(R^- - R^*)} \quad (5)$$

where:

$R^* = \min(R_i, i = 1,...,m)$

$R^- = \max(R_i, i = 1,...,m)$

$S^* = \min(S_i, i = 1,...,m)$

$S^- = \max(S_i, i = 1,...,m)$

Step 5: Based on the *Q* values, the ranking of the companies can be obtained [33–36]. The company with the smallest value of *Q* values is classified as the best company.

3. Results

The decision matrix of the technology companies with respect to financial factors is demonstrated in Table 2. The worst (f_j^-) and best (f_j^*) values for the financial factors are displayed in Table 3.

In this research, the financial factors such as CA, TA, RV and NI are required to undergo maximization. In contrast, CL and TL should be minimized. According to Table 3, the worst (f_j^-) for CA, TA, CL, TL, RV and NI are 8124.000, 8374.400, 335342.600, 456121.800, 879.800 and -27183.612, respectively. On the other hand, the best (f_j^*) for CA, TA, CL, TL, RV and NI are 1124756.400, 2095129.600, 5143.800, 5143.800, 1983234.600 and 243629.800, respectively. After that, the normalized decision matrix is established and displayed in Table 4.

According to the normalized decision matrix, the S_i and R_i values can be obtained. Table 5 presents the scores of S_i and R_i.

Based on the values of S_i and R_i, the scores of S^*, S^-, R^* and R^- are computed. Table 6 tabulates the scores of S^*, S^-, R^* and R^-.

From the Table 6, the S^*, S^-, R^* and R^- values are 0.382075, 0.763123, 0.120005 and 0.166667, respectively. After determining the S^*, S^-, R^* and R^-, the VIKOR score (Q_i) of the companies can be acquired. Moreover, the optimal ranking of the companies can be achieved as well.

Table 2
Decision matrix of the technology companies with respect to financial factors

Companies	CA	TA	CL	TL	RV	NI
CENSOF	63490.800	170971.800	36841.000	55175.200	94227.400	-8442.600
D&O	438754.600	748662.600	233734.400	284481.200	576148.600	47502.600
DATAPRP	46653.400	52562.600	13365.600	14282.200	38664.800	-6819.600
DIGISTA	135159.798	369776.534	61715.972	308056.660	44053.192	-6387.728
DSONIC	214137.000	415063.600	87105.200	160536.400	236493.400	46811.400
EDARAN	35510.200	62744.222	28918.646	37362.152	76932.282	-198.218
EFORCE	45886.122	85458.258	7644.788	8503.812	27503.754	8479.588
ELSOFT	83643.306	119180.844	12197.384	12984.528	44155.366	19124.824
FRONTKN	351552.716	547756.726	121744.152	137460.710	356450.196	67551.278
FSBM	8124.000	8374.400	5143.800	5143.800	879.800	-2906.800
GHLSYS	379643.462	636777.158	184380.366	212664.424	319014.280	23085.192
GREATEC	253015.078	333137.280	110381.714	128389.706	238554.840	66533.792
GTRONIC	216271.600	355920.000	52126.800	60447.000	255430.800	53946.200
HTPADU	254627.600	350508.400	214719.200	231402.800	352402.200	-7687.000
INARI	984489.800	1431971.000	281071.200	301472.800	1238445.800	230994.600
ITRONIC	17462.804	29696.284	14058.104	14853.390	37365.146	-3265.256
JCY	799090.400	1196770.400	232742.600	254246.400	1231730.000	-26924.800
JHM	198278.100	300759.456	71777.848	105547.364	263026.744	30275.522
KESM	273923.200	450822.000	69925.800	97928.200	296874.600	19407.800
KEYASIC	16792.138	34142.666	7887.230	8187.392	20689.730	-6839.454
MI	344853.446	523864.496	54871.530	73463.152	225866.394	55734.598
MMSV	60707.666	69910.962	8593.624	9350.214	45420.364	9539.392
MPI	1124756.400	1921802.600	335342.600	354404.000	1625579.200	174703.000
MSNIAGA	171486.400	220479.400	95442.000	99563.400	231799.200	595.200
MYEG	466410.000	1215678.600	198360.400	314056.600	555880.600	243629.800
NOTION	209264.400	518820.800	68372.200	113757.800	272905.400	13319.600
OMESTI	207673.118	461109.410	203172.904	242583.076	301848.880	-27183.612
PENTA	558114.160	711494.530	149281.640	157171.792	424731.590	63984.598
REVENUE	59942.080	99451.560	29344.826	36420.800	56732.592	8255.968
THETA	73125.200	84824.200	15212.000	19470.000	80493.000	-2360.000
TRIVE	43070.858	88987.450	7936.276	17527.762	5134.924	-15371.846
TURIYA	9313.660	173498.636	10589.892	50979.330	19169.470	-926.506
UNISEM	847853.800	2095129.600	332226.400	456121.800	1359007.800	117262.800
UWC	136727.422	237682.794	41148.954	65046.878	175416.190	46324.656
VITROX	495973.400	677625.000	130036.000	176328.600	442453.500	108687.828
VSTECS	511242.800	549254.800	232392.200	233570.800	1983234.600	34447.800
WILLOW	155983.400	196469.800	29202.800	30819.600	149362.600	15565.600

Table 3
The worst (f_j^-) and best (f_j^*) values for the financial factors

Financial factors	Worst (f_j^-)	Best (f_j^*)
CA	8124.000	1124756.400
TA	8374.400	2095129.600
CL	335342.600	5143.800
TL	456121.800	5143.800
RV	879.800	1983234.600
NI	-27183.612	243629.800

Table 4
The normalized decision matrix

Companies	CA	TA	CL	TL	RV	NI
CENSOF	0.158403	0.153680	0.015999	0.018490	0.158818	0.155133
D&O	0.102391	0.107541	0.115380	0.103234	0.118301	0.120703
DATAPRP	0.160916	0.163137	0.004150	0.003377	0.163490	0.154134
DIGISTA	0.147706	0.137802	0.028555	0.111947	0.163037	0.153868
DSONIC	0.135918	0.134185	0.041370	0.057428	0.146857	0.121128
EDARAN	0.162579	0.162324	0.012000	0.011907	0.160273	0.150059
EFORCE	0.161030	0.160510	0.001262	0.001242	0.164428	0.144718
ELSOFT	0.155395	0.157817	0.003560	0.002898	0.163028	0.138167
FRONTKN	0.115407	0.123587	0.058854	0.048900	0.136772	0.108364
FSBM	0.166667	0.166667	0.000000	0.000000	0.166667	0.151726
GHLSYS	0.111214	0.116477	0.090469	0.076693	0.139919	0.135730
GREATEC	0.130115	0.140728	0.053118	0.045548	0.146684	0.108990
GTRONIC	0.135599	0.138909	0.023715	0.020438	0.145265	0.116737
HTPADU	0.129874	0.139341	0.105782	0.083618	0.137112	0.154668
INARI	0.020936	0.052966	0.139273	0.109513	0.062618	0.007776
ITRONIC	0.165273	0.164964	0.004499	0.003588	0.163599	0.151947
JCY	0.048608	0.071751	0.114880	0.092060	0.063183	0.166507
JHM	0.138285	0.143314	0.033633	0.037106	0.144627	0.131305
KESM	0.126994	0.131329	0.032698	0.034290	0.141781	0.137993
KEYASIC	0.165373	0.164609	0.001385	0.001125	0.165001	0.154146
MI	0.116407	0.125495	0.025100	0.025249	0.147751	0.115636
MMSV	0.158818	0.161752	0.001741	0.001555	0.162922	0.144066
MPI	0.000000	0.013843	0.166667	0.129075	0.030070	0.042420
MSNIAGA	0.142283	0.149726	0.045578	0.034894	0.147252	0.149571
MYEG	0.098264	0.070241	0.097525	0.114164	0.120005	0.000000
NOTION	0.136645	0.125898	0.031914	0.040140	0.143796	0.141740
OMESTI	0.136882	0.130507	0.099954	0.087750	0.141363	0.166667
PENTA	0.084576	0.110509	0.072753	0.056185	0.131031	0.110559
REVENUE	0.158932	0.159392	0.012215	0.011559	0.161971	0.144856
THETA	0.156965	0.160561	0.005082	0.005294	0.159973	0.151389
TRIVE	0.161451	0.160228	0.001409	0.004577	0.166309	0.159397
TURIYA	0.166489	0.153478	0.002749	0.016939	0.165129	0.150507
UNISEM	0.041330	0.000000	0.165094	0.166667	0.052482	0.077770
UWC	0.147472	0.148352	0.018173	0.022138	0.151993	0.121427
VITROX	0.093851	0.113214	0.063039	0.063264	0.129541	0.083047
VSTECS	0.091572	0.123467	0.114703	0.084419	0.000000	0.128737
WILLOW	0.144597	0.151644	0.012144	0.009489	0.154183	0.140358

Table 5
The scores of S_i and R_i

Companies	S_i	R_i
CENSOF	0.660523	0.158818
D&O	0.667550	0.120703
DATAPRP	0.649204	0.163490
DIGISTA	0.742914	0.163037
DSONIC	0.636885	0.146857
EDARAN	0.659142	0.162579
EFORCE	0.633191	0.164428
ELSOFT	0.620865	0.163028
FRONTKN	0.591884	0.136772
FSBM	0.651726	0.166667
GHLSYS	0.670502	0.139919
GREATEC	0.625183	0.146684
GTRONIC	0.580662	0.145265
HTPADU	0.750395	0.154668
INARI	0.393083	0.139273
ITRONIC	0.653870	0.165273
JCY	0.556989	0.166507
JHM	0.628269	0.144627
KESM	0.605085	0.141781
KEYASIC	0.651638	0.165373
MI	0.555638	0.147751
MMSV	0.630854	0.162922
MPI	0.382075	0.166667
MSNIAGA	0.669304	0.149726
MYEG	0.500199	0.120005
NOTION	0.620133	0.143796
OMESTI	0.763123	0.166667
PENTA	0.565613	0.131031
REVENUE	0.648926	0.161971
THETA	0.639264	0.160561
TRIVE	0.653371	0.166309
TURIYA	0.655292	0.166489
UNISEM	0.503342	0.166667
UWC	0.609555	0.151993
VITROX	0.545957	0.129541
VSTECS	0.542898	0.128737
WILLOW	0.612414	0.154183

Table 6
S^*, S^-, R^* and R^-

	Scores
S^*	0.382075
S^-	0.763123
R^*	0.120005
R^-	0.166667

As presented in Table 7, the optimal ranking of the companies is achieved based on the VIKOR scores (Q_i). Based on the optimal solution of the VIKOR algorithm, the range of Q_i is from 0.154999 to 1.000000. The company with the lowest value of Q_i will be identified as the best technology company in terms of FP. On the other hand, the company which shows the worst FP will achieve the

largest value of Q_i. Based on the findings of the study, MYEG obtains a Q_i score of 0.154999, which is the lowest among the technology companies. Hence, MYEG achieves the first ranking and it indicates that MYEF outperforms the other companies in terms of FP. Therefore, MYEG is classified as the best technology company. The second ranking goes to INARI with the Q_i score of 0.220914, followed by VSTECS, VITROX, PENTA, D&O, FRONTKN, MPI, MI, KESM, GTRONIC, NOTION, JHM, GHLSYS, GREATEC, DSONIC, UWC, UNISEM, WILLOW, MSNIAGA, JCY, THETA, ELSOFT, CENSOF, MMSV, REVENUE, EFORCE, DATAPRP, EDARAN, KEYASIC, ITRONIC, TRIVE, FSBM, HTPADU, TURIYA, DIGISTA and lastly OMESTI. From here, OMESTI with a 1.000000 Q_i value will be identified as the worst company in terms of FP.

Table 7
Scores and ranking of companies

Companies	VIKOR Scores (Q_i)	Optimal ranking
CENSOF	0.781275	24
D&O	0.382067	6
DATAPRP	0.816479	28
DIGISTA	0.934587	36
DSONIC	0.622091	16
EDARAN	0.819759	29
EFORCE	0.805522	27
ELSOFT	0.774346	23
FRONTKN	0.454971	7
FSBM	0.853828	33
GHLSYS	0.591858	14
GREATEC	0.604878	15
GTRONIC	0.531256	11
HTPADU	0.854727	34
INARI	0.220914	2
ITRONIC	0.841705	31
JCY	0.727811	21
JHM	0.586881	13
KESM	0.525966	10
KEYASIC	0.839850	30
MI	0.525054	9
MMSV	0.786314	25
MPI	0.500000	8
MSNIAGA	0.695369	20
MYEG	0.154999	1
NOTION	0.567305	12
OMESTI	1.000000	37
PENTA	0.358986	5
REVENUE	0.799836	26
THETA	0.772049	22
TRIVE	0.852153	32
TURIYA	0.856604	35
UNISEM	0.659124	18
UWC	0.641253	17
VITROX	0.317228	4
VSTECS	0.304594	3
WILLOW	0.668476	19

As a result, OMESTI obtains the last ranking. The findings of the paper are also able to give an insight into the technology companies for benchmarking based on their ranking and current financial status. For instance, OMESTI can take well-performing companies such as MYEG, INARI, VSTECS and VITROX as a reference for further improvement on the FP. Due to the vigorous competition between technology companies, there is a need to know the ranking and current financial status of the companies in order to improve, sustain and compete with other companies.

4. Conclusions

The ultimate goal of this study is achieved by assessing the technology companies and providing the ranking of the companies with the proposed research framework based on VIKOR algorithm. The FP of the companies is measured by six crucial financial factors. These financial factors include CA, TA, CL, TL, RV and NI. The major findings of this research depict that MYEG is a high-performing company in terms of FP. This study is significant to assess the FP of technology companies with the proposed research framework based on VIKOR algorithm. The VIKOR algorithm is not able to set the weights for the decision criteria. This is because the weights are subjectively determined by the decision maker. This study can be served as a reference for other companies for continuous improvement in terms of FP in the future.

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