Integrating VIKOR with DEA for Efficiency Performance Measurement

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Abstract - The present study transferred the raw data of DEA to five performance criteria and utilized the VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) methodology to produce S_j, R_j, and Q_j , where S_j and R_j represent the utility measure and the regret measure, respectively and Q_j represents the i^{th} alternative VIKOR value. The output variables are replaced by S_j, R_j, and Q_j and running DEA again (so-called 'VIKOR-DEA') to produce a more reliable efficiency value. A chain of fast food stores was chosen as the sample on which to test the performance of the proposed VIKOR-DEA model. The results of the study verify the VIKOR-DEA analytical method as a more reliable measure of efficiency for the chain stores than the DEA method.

Index Terms - performance measurement, DEA, VIKOR.

1. Introduction

If the data used in DEA are subject to statistical deviation, or if multiple decision-making units (DMUs) are analyzed, management and observational errors will occur. This can cause the output efficiency frontier to be distorted (Wang, 2003). In addition, selection of an appropriate DEA model is sometimes problematic. Even though the choice of input and output variables is unrestricted in DEA, the estimated efficiency for a DMU depends on the number of inputs plus outputs. The greater the number of variables included, the lower the level of discrimination (Fu and Ou, 2012). The discrimination capability of DEA is thus relatively weak in terms of performance measurement. To improve this shortcoming, the present study aims to improve the application of DEA in an efficiency analysis of chain stores by utilizing a tool based on performance criteria; that is, using the VIKOR methodology as an auxiliary tool in combination with DEA to produce a more reliable efficiency frontier and thus correct any deviation that might occur when using DEA. This can enhance the discrimination capability when DEA is used in the performance measurement. Empirical analysis of the efficiency of a chain of fast food stores is then undertaken to compare the results obtained from each of the methods ('VIKOR-DEA' and 'DEA').

2. Methodology

DEA models can be of two types: (i) output-based models, in which the aim is the maximization of output under conditions of constant input; and (ii) input-based models, in which the aim is minimization of input under conditions of constant output. The choice between an input-based model and an output-based one is determined by market conditions. An output-based model is desirable in a competitive market in which input is manipulated by the DMU; conversely, an input-based model is preferable in a monopolized market (Barros and Alves, 2003). In the present study, which investigated a chain of retail stores selling lifestyle accessories, the market was not monopolized. Therefore, the CCR output-based model (Charnes et al., 1978) and the BCC output-based model (Banker et al., 1984) were adopted.

VIKOR was developed as an MCDM method for solving discrete decision problems that have non-commensurable and conflicting criteria. The VIKOR method, which focuses on ranking and selecting from a set of alternatives, provides *compromise solutions* for problems with conflicting criteria (Opricovic & Tzeng, 2004). Such a 'compromise solution' is a feasible solution that is closest to the ideal solution after taking into account certain mutually agreed concessions. In providing such a compromise solution, VIKOR applies the concepts of 'acceptable advantage' and 'acceptable stability' to determine the maximum 'group utility of the majority' and the minimum 'individual regret of the opponent'. The negotiated compromise solution is thus likely to be perceived as acceptable by decision-makers.

3. Research design and data collection

A chain of 50 fast food stores located in Taipei city was chosen as the sample for data analysis in this study (Table 1). DEA SOLVER (Saitech, Inc.) which is a DEA analysis software, is used to run DEA, and a set of OE, TE and SE values are obtained. The results of the total efficiency analysis indicate that all stores in the chain were 'efficient' (OE=1) when using DEA alone. This paper found that the OE had been distorted, however, because the slack analysis table (Table 1) shows that some DMUs have characteristics which identify them as efficient, while some show room for improvement, and are thus inefficient DMUs.

TABLE 1 Raw data for this study (unit: New Taiwan Dollar, NT$)

Store no.	Input variables				Output variables		
	Area	Average inventory cost	Labor cost	Rent cost	Total sales revenue	Gross margin	Net profit
1	48.3	407,409	5,273,420	3,761,007	24,784,049	15,319,729	2,559,104
2	105	397,121	5,410,858	3,076,510	24,158,220	15,111,253	2,352,564
3	74	343,949	5,581,419	2,118,432	20,923,580	12,987,075	1,874,102
4	120	209,150	3,090,993	204,755	12,723,265	7,671,706	2,266,235
5	21.4	265,279	4,024,942	1,933,338	16,137,813	10,059,452	1,566,773
6	90	338,169	5,087,060	1,453,716	20,571,920	12,611,005	2,220,894
7	63	275,082	4,145,823	2,008,716	16,734,171	10,429,630	562,105
8	56	371,252	4,979,367	2,933,716	22,584,499	14,178,178	1,673,327
9	56	286,607	4,498,046	1,179,495	17,435,274	10,935,165	1,484,224
10	43	243,642	3,425,142	1,331,810	14,821,547	9,257,578	1,739,561
11	65.7	489,686	6,514,073	2,869,716	29,789,235	17,751,241	3,659,833
12	34.7	363,496	5,235,240	3,448,000	22,112,667	13,902,051	2,062,404
13	10.5	249,434	3,511,978	1,988,632	15,173,922	9,832,792	2,028,087
14	40	328,442	4,876,126	1,557,122	19,980,198	12,480,972	2,668,963
15	45	280,858	4,378,051	1,006,951	17,085,545	10,584,646	2,399,445
16	40	318,612	4,817,869	1,560,000	19,382,231	12,024,167	1,920,478
17	36	180,138	3,111,127	1,265,000	10,958,395	6,804,073	326,672
18	41	290,281	5,126,285	2,640,000	17,658,757	10,961,976	(371,644)
19	32	208,597	3,488,154	1,180,287	12,689,669	7,920,090	1,068,028
20	36	269,516	4,094,478	1,460,340	16,395,563	10,257,076	1,513,451
21	49	204,052	3,308,442	1,213,716	12,413,142	7,594,657	991,168
22	70	335,499	4,645,457	2,584,791	20,409,517	12,515,382	1,846,706
23	35	222,316	3,907,043	2,156,625	13,524,225	8,423,494	297,506
24	60	300,410	4,336,476	1,986,797	18,274,919	11,450,717	1,872,851
25	52	434,954	5,985,907	2,816,305	26,459,703	16,400,581	3,599,375
26	16	305,181	3,993,206	2,771,479	18,565,151	11,483,939	1,063,707
27	63	461,910	6,613,087	2,316,384	28,099,500	17,512,562	4,624,423
28	55	264,039	4,089,710	1,753,716	16,062,386	10,111,135	792,340
29	80	216,593	3,629,672	2,587,900	13,176,046	8,206,114	1,733,170
30	97	341,836	4,781,435	1,916,316	20,795,025	12,943,097	2,069,939
31	106	415,639	6,294,739	1,809,716	25,284,708	15,682,230	2,816,758
32	62	294,818	4,382,477	308,379	17,934,757	10,783,199	2,710,220
33	53	396,250	5,536,092	2,084,828	24,105,226	15,106,199	3,448,215
34	67	378,265	5,835,979	2,113,716	23,011,094	14,290,540	2,326,746
35	95.5	272,433	4,616,997	1,502,087	16,573,014	10,215,033	422,283
36	57	311,908	4,588,944	1,071,495	18,974,422	11,621,292	2,799,463
37	54	562,181	6,956,650	3,184,292	34,199,334	21,405,536	6,492,306
38	94	483,818	6,946,503	1,845,478	29,432,259	18,458,449	5,047,358
39	28	197,161	2,967,506	1,256,192	11,993,950	7,614,427	1,266,230
40	69	276,578	4,036,650	1,358,334	16,825,161	10,520,869	1,809,132
41	69	377,460	5,206,713	1,789,698	22,962,137	14,272,250	2,874,706
42	33	157,662	2,980,506	692,280	9,591,114	6,068,894	618,472
43	51	292,203	4,295,475	2,011,902	17,775,670	11,083,859	1,040,923
44	38.5	365,867	5,354,600	1,755,000	22,256,931	13,893,278	2,579,476
45	50	408,154	6,186,629	1,647,996	24,829,385	15,593,933	3,345,068
46	85	226,886	3,591,118	875,676	13,802,206	8,672,981	692,102
47	72	328,172	4,867,490	2,779,539	19,963,808	12,549,332	886,947
48	25	238,483	3,049,393	1,841,078	14,507,730	9,357,169	1,454,914
49	35	164,876	2,541,325	1,225,453	10,029,981	5,993,114	(61,713)
50	52	266,893	4,379,301	1,200,000	16,235,995	10,156,048	1,371,476

TABLE 2 OE, TE and SE of DEA and VIKOR-DEA

DMU	DEA		VIKOR-DEA			
	OE	TE	OE	TE	SE	RTS
1	1	0.8603023	0.7871402	0.8713744	0.903332	Constant
2	1	0.8573665	0.7204309	0.8348875	0.862908	Constant
3	1	0.7783611	0.7175111	0.8401244	0.854053	Decreasing
4	1	1	1	1	1	Constant
5	1	0.8864837	0.8417971	0.9184848	0.916506	Decreasing
6	1	0.8745075	0.766134	0.872569	0.878021	Decreasing
7	1	0.8048612	0.6462623	0.7688146	0.840596	Decreasing
8	1	0.8690614	0.6969686	0.8086134	0.861931	Constant
9	1	0.8672122	0.7806596	0.8675971	0.899795	Constant
10	1	0.9577391	0.9402118	0.9622635	0.977084	Constant
11	1	0.9166019	0.7930021	0.892307	0.88871	Constant
12	1	0.8382324	0.7564524	0.8640076	0.875516	Decreasing
13	1	1	1	1	1	Constant
14	1	0.9112826	0.9124652	0.9661945	0.944391	Decreasing
15	1	0.9072828	0.9645369	0.9873872	0.976858	Constant
16	1	0.8875909	0.8046484	0.8921853	0.901885	Decreasing
17	1	0.8035928	0.8825928	0.9030716	0.977323	Constant
18	1	0.6808891	0.515496	0.6620115	0.778681	Decreasing
19	1	0.8330359	0.8972394	0.9485733	0.945883	Constant
20	1	0.8878631	0.8272852	0.9008189	0.91837	Constant
21	1	0.832416	0.8808022	0.926749	0.950422	Constant
22	1	0.8471474	0.7290602	0.8497243	0.857996	Constant
23	1	0.6977144	0.7304134	0.8178646	0.893074	Constant
24	1	0.8592541	0.7733826	0.8905436	0.868439	Decreasing
25	1	0.8923533	0.8673624	0.9398043	0.922918	Decreasing
26	1	1	0.7667356	0.8401213	0.912649	Constant
27	1	0.9023631	0.9816262	1	0.981626	Decreasing
28	1	0.8148466	0.6988289	0.8098131	0.862951	Decreasing
29	1	0.6673814	0.9311225	0.9617623	0.968142	Constant
30	1	0.8960359	0.7381218	0.8521789	0.866158	Constant
31	1	0.8700757	0.7546893	0.855388	0.882277	Constant
32	1	1	1	1	1	Constant
33	1	0.9229253	0.9101406	0.9614242	0.946659	Decreasing
34	1	0.8268642	0.7486387	0.8580282	0.872511	Decreasing
35	1	0.7553736	0.6076657	0.7390182	0.822261	Decreasing
36	1	0.9378042	0.9580787	0.9862393	0.971446	Constant
37	1	1	1	1	1	Constant
38	1	0.9371284	1	1	1	Constant
39	1	1	1	1	1	Constant
40	1	0.897465	0.8045979	0.9033127	0.890719	Decreasing
41	1	0.9382782	0.8296903	0.9152824	0.906486	Constant
42	1	0.8987728	1	1	1	Constant
43	1	0.8442143	0.6863343	0.8124887	0.844731	Decreasing
44	1	0.915185	0.8928897	0.9400478	0.949834	Constant
45	1	0.893773	0.946336	0.9750074	0.970594	Constant
46	1	0.8577791	0.7520122	0.8184129	0.918867	Decreasing
47	1	0.7848421	0.6034697	0.7526162	0.801829	Decreasing
48	1	1	1	1	1	Constant
49	1	1	0.961879	1	0.961879	Increasing
50	1	0.8303197	0.7965915	0.8775327	0.907763	Constant

To address the above problem, VIKOR methodology are used to obtain a set of functions (S_j , R_j , and Q_j). However, higher values for the performance criteria have a better performance in terms of the output values of DEA. Therefore, the output variables are replaced by 1- S_j , 1- R_j , and 1- Q_j , and DEA SOLVER is used to run the CCR model and BBC model again. Therefore, a set of new OE, TE and SE are obtained. The RTS, OE, TE and SE of 50 chain stores using the DEA method and VIKOR-DEA method, respectively, are shown in Table 2.

4. Data Analysis

This result indicated that the VIKOR-DEA method has more reliable discrimination capability than the DEA method. The important findings can be summarized as follows:

- The mean of OE was 0.832, the mean of TE was 0.9009, and the mean of SE was 0.9187, which suggests that there remains room for improvement.
- Eight stores (stores 4, 13, 32, 37, 38, 39, 42, and 48) achieved a most productive scale size (MPS), and their RTS is constant.
- One store (store 49), which was at the stage of increasing RTS, had not achieved an MPS because it was efficient in TE but inefficient in SE. This suggests that, using the techniques at hand, expansion of the scale of this chain store would enhance their efficiency.
- 19 of the remaining 41 stores (stores 3, 5, 6, 7, 12, 14, 16, 18, 24, 25, 27, 28, 33, 34, 35, 40, 43, 46 and 47) had a decreasing RTS. The TE and SE of these stores could be enhanced by decreasing their input variables and their scale.
- The remaining 22 stores (stores 1, 2, 8, 9, 10, 11, 15, 17, 19, 20, 21, 22, 23, 26, 29, 30, 31, 36, 41, 44, 45 and 50) were at a constant RTS. Their efficiency does not indicate a need to change their scale and input variables unless a major change occurs. No inputs or outputs increased or decreased, and maintenance of the scale is adequate.

5. Conclusions

The results obtained from the DEA and VIKOR-DEA models differ. The former assesses the efficiency of stores only as ostensibly efficient; as such, the technique is unable to rank the relative operational efficiency of efficient stores accurately. In contrast, by using VIKOR-DEA, the efficiency value of individual stores can be identified, thus enabling the chain to ascertain the differences between stores and hence rank them accurately. The results of this study demonstrate that VIKOR-DEA is an effective auxiliary tool for enhancing the discrimination capability of DEA. Although this paper verified that DEA in combination with VIKOR can provide a more reliable overall efficient value.

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