Presentation of a Model to Assess Organization's Efficiency

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Abstract There are various methods for measuring efficiency of organization with different fields of activities. One of the suitable, simple and efficient methods is Proportions Model which can help to rank service and industrial units and etc. by considering efficiency or other important factors by integrating other known methods of multi attribute decision making subgroups such as linear assignment & TOPSIS allocation with maximum efficiency. In this article we will apply above mentioned methods and comparing their results.

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Keywords CCR Model, Proportions Model, Entropy Method, Linear Assignment Technique, Decision Making Unit, TOPSIS Technique, Correlation Coefficient of Spearman Ranks.

1. Introduction

Primary methods were used the following proportion to compute system performance indicator in assessment of efficiency and partial efficiency of outputs proportion to inputs:

$$Efficiency = \frac{Output}{input}$$

But the result of it to help management in making decision was not suitable because of the shortages of this computing method in the level of microeconomics and economic agencies, so the comparison of homogenous units with each other to compute efficiency was used as a suitable method. In proportion model which is presented in this research first by applying output proportion to system inputs by integrating these two approaches, a proportion is computed which is the same as partial efficiency method. This proportion indicates the ability of the evaluated unit in converting a specific input to a specific output. The proportion obtained will have different scales such as selling goods to manpower, capital and etc. and since in efficiency evaluation of a unit it is necessary to evaluate all proportions in comparable conditions, in this article with one of the un-scaling methods, norm will go out of scale. The final techniques which are used for DMU1 will be TOPSIS and linear Assignment method. In this article the other point is the comparison of these methods result with CCR model to specify how the results of these methods are similar to above mentioned classic method in creating results [1].

2. CCR MODEL

This method is able to measure the efficiency of technique of decision making units as follows [1]:

$$Efficiency = \frac{U_1Y_1 + U_2Y_2 + \ldots + U_sY_{sj}}{V_1X_1 + V_2X_2 + \ldots + V_mX_{mj}} = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}}$$

Linear Programming method was proposed by Charles & Copper to make fractional model CCR linear in 1962 as follows [2]:

$$Max = U^T Y_0$$
$$Subject\ to:$$
$$V^T x_0 = 1$$
$$V^T y_j - V^T x_j \le 0 \quad and \quad j = 1,2,\ldots,n$$
$$U \ge 0 \ and \ V \ge 0$$

The above model is known as CCR model with multiple forms. The optimum weight of the above objective function which will be applied for the hypothesized units indicates the efficiency of DMU.

This model is presented as a logic and multi-step algorithm. In this model decision making units are ranked and compared with each other on the basis of relative efficiency [3].

First Phase: Forming input & output matrix

$$\begin{array}{c|cccc} & Y_1 & Y_2 & \cdots & Y_n \\ DMU_1 & y_{11} & y_{12} & \cdots & y_{1n} \\ DMU_2 & y_{21} & y_{22} & \cdots & y_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ DMU_m & y_{m1} & y_{m2} & \cdots & y_{mn} \end{array} \qquad \begin{array}{c|cccc} & X_1 & X_2 & \cdots & X_n \\ DMU_1 & x_{11} & x_{12} & \cdots & x_{1n} \\ DMU_2 & x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ DMU_m & x_{m1} & x_{m2} & \cdots & x_{mn} \end{array}$$

Output Matrix — *Matrix No.1*   *Input Matrix* — *Matrix No.2*

Input matrix will be completed by applying resources amount consumed for each decision making unit. Columns of these matrixes include system inputs differentiated such as materials,

1 . Decision Making Units

manpower and etc and their rows will be the amount of these resources for each agency. Output matrix will be completed by applying the amount of outputs for each decision making units. Columns of these matrixes include system output differentiated such as the amount of sale, quantity of productions and their rows will be the amount of these resources for each agency [3].

Second Phase: Formation proportion matrix

In this phase a matrix will be formed the factors of which represent the proportion of outputs to individual inputs. The outputs are extracted from matrix no. 1 and inputs from matrix no. 2. In order to compute it , each output in each row we define individual inputs of that row and this should be done for all outputs; the result will be a matrix the rows of which will be the number of decision making units and its columns will be the product of the number of inputs multiplied by outputs[5]:

$$\begin{array}{cccccc} & A_1 & A_2 & \cdots & A_n \\ DMU_1 & \frac{y_{11}}{x_{11}} & \frac{y_{12}}{x_{12}} & \cdots & \frac{y_{1n}}{x_{1n}} \\ DMU_2 & \frac{y_{21}}{x_{21}} & \frac{y_{22}}{x_{22}} & \cdots & \frac{y_{2n}}{x_{2n}} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ DMU_M & \frac{y_{m1}}{x_{m1}} & \frac{y_{m2}}{x_{m2}} & \cdots & \frac{y_{mn}}{x_{mn}} \end{array}$$

proportion Matrix

Matrix No.3

The quotient of output of column n in row m in output matrix (matrix No. 1) to n column input, row m input (matrix No. 2) is as follows:

$$A_{mn} = \frac{y_{mn}}{x_{mn}}$$

Third Phase: Un-scaling proportion matrix by applying Normalize method

$$A_{ij} = \frac{n_{ij}}{\sum n_{ij}}, \forall i, j$$

Fourth Phase: Determining weights for attributes

4. Linear Assignment Method

As some of the weight determining methods depend on decision maker's idea and the strategy of this research is to ignore decision makers' relationship, so we choose the method in which the weights are determined by applying decision matrix without exchanging idea with DM. Among different techniques, Entropy Technique is more compatible with the logic of this research. Here the method to determine the weights of attributes by applying Entropy is presented [5].

Fifth Phase: Determining the Rank of Decision Making Unit (DMU)

In this method, first we use a zero- One linear programming and linear assignment to determine the final ranking of DMUs. In this method hypothesized alternatives of a problem will be ranked according to their scores in each existing attribute, and then the final ranking of alternatives through a linear recompense process will be specified for each possible exchange among attributes. The solution process is in a way that there will be no need for un-scaling quantitative& qualitative attributes [6].

The general model of this method will be as follows:

$$Max: \sum\sum r_{ik}.n_{ik}$$

$$s.t:$$

$$\sum_{k=1}^{m} n_{ik} = 1 \; ; \; i = 1,2,...,m$$

$$\sum_{i=1}^{m} n_{ik} = 1 \; ; \; k = 1,2,...,m$$

$$h_{ik} \begin{cases} = 1 \\ = 0 \end{cases}$$

By solving this model the results will be as a list of factors number which for every row and every column value one.

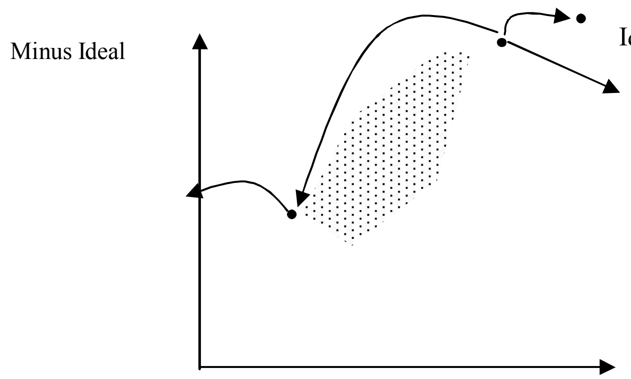
1. **5. TOPSIS Method**

This method is based on considering the distance of alternative A_j from ideal and minus ideal point. It means that the selected alternative should have the least distance from ideal solution and at the same time the farthest distance from the minus ideal solution [6].

6. Problem Statement

Science is principally based on cause and effect relation and being aware of independent variables as cause versus one effect (here ranking of units) is one of the early musts for a researcher. So the definition of independent and dependent variables has the main role in directing research. The independent variables considered for the present research are divided into groups, inputs and outputs of industrial activities

Which are as follows. In the following table, as it is seen, all inputs and outputs of the organization are used in the framework of observable inputs and outputs. So all sensible factors which have a role in organizational process whether in inputs or outputs sections are included in the model, cases such as leadership style, motivation, customer satisfaction, labor culture, organizational concern and etc which are classified as insensible factors and of course are effective in organization activity, are not considered in this research[3].



The alternative proposed by TOPSIS has the most distance from minus ideal and the least from ideal.

Outputs			inputs		
Row	Factor	Code	Row	Factor	Code
1	Manpower	I_1	1	Product	Q_1
2	Raw Material of Parts	I_2	2	Other Incomes	Q_2
3	Other Expenses	I_3	-	-	-

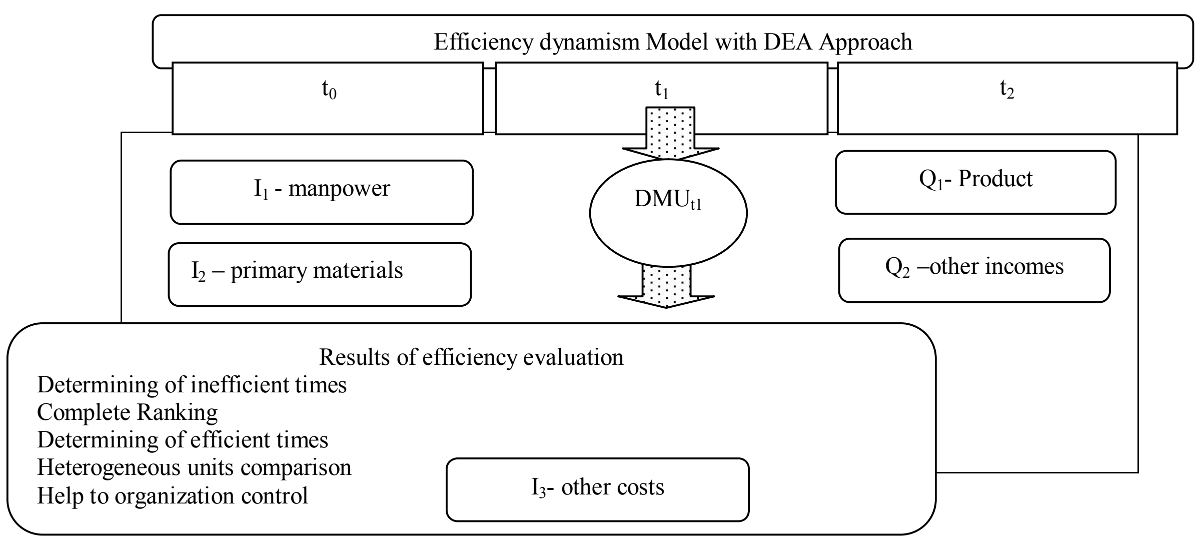
Manpower: includes employees of an organization (from Chief of staff to junior employee)

Raw material & parts: part of inventory which is purchased to be used in company operation, these items may include, bulk material, assembled parts, or fabricated goods.

Other expenses: all expenses which are necessary in the process of production and isn't included in the previous part such as electricity, water, restaurant and, etc expenses.

Product: final product, output of goods that are offered by the organization to be sold

Other incomes: All nonoperational incomes which are not defined in the normal process of the activity of the organization, such as profit due to bonds, or income resulted through investment in other companies, selling spoilage and etc [5].



Resource: [3]

7. Numerical Example

The main captions of classifying inputs based on research model in Arak Wagon Pars Company in a ten -year period is as follows:

1-manpower Input (I 1) = Direct Wage Expense+ Indirect Wage Expense +Staff Expense (Marketing, Sale, Administrative and financial).

2- Raw Materials Input (I 2) = Direct Raw Materials + Indirect Raw Materials

3-Othe expenses Inputs (I 3) = energy Expenses + Other Production Expenses

The table of manpower inputs, raw materials, and other expenses in money unit and also output of other incomes (the figures are in Million Tomans) and the product output (the numbers are in 100 sets) is as follows[1]:

Input & output / Year	I_1	I_2	I_3	Q_1	Q_2
1	35.70	40.00	37.00	80.00	65.00
2	33.00	36.40	34.40	25.00	48.00
3	34.20	35.00	33.00	45.00	64.00
4	34.80	37.00	35.00	70.00	65.00
5	34.00	37.00	35.00	45.00	65.00
6	34.40	34.00	32.00	45.00	40.00
7	33.50	37.00	35.00	65.00	25.00
8	36.40	34.00	34.00	38.00	18.00
9	31.50	33.00	32.00	20.00	50.00
10	36.00	36.00	33.00	38.00	20.00

8. Data Analysis:

Results extracted from DEA method, model CCR is as follows:

Year	1	2	3	4	5	6	7	8	9	10
Relative Efficiency	1	0.761	1	1	1	0.687	0.878	0.559	0.841	0.533

The stages of proportions model and getting weights

1-Proportion Matrix Formation

index / Year	$X_1 = Q_1/I_1$	$X_2 = Q_1/I_2$	$X_3 = Q_1/I_3$	$X_4 = Q_2/I_1$	$X_5 = Q_2/I_2$	$X_6 = Q_2/I_3$
1	2.240896	2.000000	2.162162	1.820728	1.625000	1.756757
2	0.757576	0.686813	0.726744	1.454545	1.318681	1.395349
3	1.315789	1.285714	1.363636	1.871345	1.828571	1.939394
4	2.011494	1.891892	2.000000	1.867816	1.756757	1.857143
5	1.323529	1.216216	1.285714	1.911765	1.756757	1.857143
6	1.308140	1.323529	1.406250	1.162791	1.176471	1.250000
7	1.940299	1.756757	1.857143	0.746269	0.675676	0.714286
8	1.043956	1.117647	1.117647	0.494505	0.529412	0.529412
9	0.634921	0.606061	0.625000	1.587302	1.515152	1.562500
10	1.055556	1.055556	1.151515	0.555556	0.555556	0.606061

2-Un-scaling Proportion Matrix by Applying Normalize Method

index / Year	$X_1 = Q_1/I_1$	$X_2 = Q_1/I_2$	$X_3 = Q_1/I_3$	$X_4 = Q_2/I_1$	$X_5 = Q_2/I_2$	$X_6 = Q_2/I_3$
1	0.164383	0.154557	0.157870	0.135143	0.127571	0.130439
2	0.055573	0.053076	0.053063	0.107963	0.103523	0.103604
3	0.096521	0.099358	0.099566	0.138900	0.143552	0.144000
4	0.147555	0.146203	0.146030	0.138638	0.137914	0.137892
5	0.097089	0.093987	0.093876	0.141900	0.137914	0.137892
6	0.095961	0.102280	0.102677	0.086308	0.092359	0.092812
7	0.142332	0.135760	0.135599	0.055392	0.053044	0.053036
8	0.076580	0.086370	0.081605	0.036704	0.041562	0.039309
9	0.046575	0.046836	0.045634	0.117817	0.118947	0.116015
10	0.077431	0.081572	0.084078	0.041236	0.043614	0.045000

3-Determining weights for Attributes through Entropy Technique

	X_1	X_2	X_3	X_4	X_5	X_6
E_j	0.969325	0.973182	0.972021	0.960856	0.964302	0.963741
d_j	0.030675	0.026818	0.027979	0.039144	0.035698	0.036259

And Finally

W_j	0.156048	0.**136427**	0.142333	0.**199132**	0.**181603**	0.**184457**

4- Formation of weighted Un-scaled Matrix

index / Year	$X_1 = Q_1 / I_1$	$X_2 = Q_1 / I_2$	$X_3 = Q_1 / I_3$	$X_4 = Q_2 / I_1$	$X_5 = Q_2 / I_2$	$X_6 = Q_2 / I_3$
1	0.1701510	0.126020	0.144831	0.143854	0.111130	0.124658
2	0.0194470	0.014861	0.016362	0.091809	0.073182	0.078644
3	0.0586650	0.052080	0.057608	0.151964	0.140717	0.151925
4	0.1371030	0.112765	0.123921	0.151391	0.129881	0.139312
5	0.0593580	0.046602	0.051212	0.158599	0.129881	0.139312
6	0.0579850	0.055188	0.061265	0.058673	0.058249	0.063113
7	0.127569	0.097231	0.106850	0.024167	0.019213	0.020608
8	0.036930	0.039354	0.038699	0.010611	0.011795	0.011321
9	0.013660	0.011572	0.012102	0.109333	0.096613	0.098614
10	0.037755	0.035103	0.041079	0.010182	0.012989	0.014836

Units ranking by applying TOPSIS Method

1- Specifying Ideal & Minus Ideal Solution from weighted Un-scaled Matrix [6]

A_j^+	0 17015 0.1	0 12602 0.	14483 0.1	15859 0.9	14071 0.7	6 15192 0.5
A_j^-	0 01366 0.	01157 0.2	01210 0.2	01018 0.2	01179 0.5	01132 0.1

2-Calculation of Separation Amount

Year	d_j^+		Year	d_j^-
1	0.042852		1	0.309496
2	0.256839		2	0.122581
3	0.159843		3	0.249459
4	0.045100		4	0.297065
5	0.166208		5	0.239162
6	0.221940		6	0.116085
7	0.232733		7	0.172125
8	0.307922		8	0.044954
9	0.249843		9	0.156987
10	0.306099		10	0.044584

3- Calculation of Relative Closeness of Alternatives from Ideal and Negative Ideal Answer

Year	cl_i^+
1	0.878
2	0.323
3	0.609
4	0.868
5	0.589
6	0.343
7	0.425
8	0.127
9	0.383
10	0.127

4-Units Rank by Applying TOPSIS Technique

Year	Rank
1	1
2	8
3	3
4	2
5	4
6	7
7	5
8	9
9	6
10	10

Ranking Units by Applying Linear assignment Method

1 -Specifying Ranking of Each Alternative for Each Attribute (Year)

Rank \ Index	$X_1 = Q_1 / I_1$	$X_2 = Q_1 / I_2$	$X_3 = Q_1 / I_3$	$X_4 = Q_2 / I_1$	$X_5 = Q_2 / I_2$	$X_6 = Q_2 / I_3$
1	Year 1	Year 1	Year 1	Year 5	Year 3	Year 3
2	Year 4	Year 4	Year 4	Year 3	Year 4 & Year 5	Year 4 & Year 5
3	Year 7	Year 7	Year 7	Year 4	Year 1	Year 1
4	Year 5	Year 6	Year 6	Year 1	Year 9	Year 9
5	Year 3	Year 3	Year 3	Year 9	Year 2	Year 2
6	Year 6	Year 5	Year 5	Year 2	Year 6	Year 6
7	Year 10	Year 8	Year 10	Year 6	Year 7	Year 7
8	Year 8	Year 10	Year 8	Year 7	Year 10	Year 10
9	Year 2	Year 2	Year 2	Year 10	Year 8	Year 8
10	Year 9	Year 9	Year 9	Year 8	-	-

2-Matrix Representing Absolute Frequency of Each Alternative in Kth Rank

Year \ Rank	1	2	3	4	5	6	7	8	9	10
1	0.43	0	0.37	0.20	0	0	0	0	0	0
2	0	0	0	0	0.37	0.20	0	0	0.43	0
3	0.37	0.20	0	0	0.43	0	0	0	0	0
4	0	0.80	0.20	0	0	0	0	0	0	0
5	0.20	0.37	0	0.16	0	0.27	0	0	0	0
6	0	0	0	0.28	0	0.52	0.20	0	0	0
7	0	0	0.43	0	0	0	0.37	0.20	0	0
8	0	0	0	0	0	0	0.13	0.30	0.37	0.20
9	0	0	0	0.37	0.20	0	0	0	0	0.43
10	0	0	0	0	0	0	0.14	0.50	0.20	0.16

3-Presentation of Linear Programming Model (Linear Assignment) [6]:

4- Rank of Units by Applying Linear assignment Technique

Year	Rank
1	1
2	9
3	5
4	2
5	4
6	6
7	3
8	8
9	10
10	8

Results of Three Methods DEA (CCR), TOPSIS and Linear assignment:

Year \ Model	L.A	DEA	TOPSIS
1	1	1	1
2	9	0.761	8
3	5	1	3
4	2	1	2
5	4	1	4
6	6	0.687	7
7	3	0.878	5
8	8	0.559	9
9	10	0.841	6
10	8	0.533	10

Ranks Resulted from Three Methods DEA (CCR), TOPSIS and Linear assignment

Year \ Model	L.A	DEA	TOPSIS
1	1	1	1
2	9	7	8
3	5	1	3
4	2	1	2
5	4	1	4
6	6	8	7
7	3	5	5
8	7	9	9
9	10	6	6
10	8	10	10

9. Conclusion:

In this article three models, DEA (CCR), TOPSIS and Linear allocation, were used to measure and assess efficiency in Arak Wagon Pars Company in a period of ten years. But the question is, “which one of these models is suitable for efficiency measurement and ranking?” The important point in this research is to identify model or models out of these three models to be able to measure efficiency and at the same time to be simple and economical for user. The concluded results from these three models have some differences and the results concluded did not coincided completely, but when the above three models were evaluated by ranking correlation coefficient of Spearman, the highest correlation was between two models, CCR & TOPSIS, integrated with proportions model. Of course if in this research, the number of years were more than the number used, it could be expected to achieve higher correlation coefficient. But due to results concluded, it is possible to comprehend that CCR and TOPSIS models are suitable models for ranking in this organization [2].

Row	Measurement Models	Spearman Coefficient Correlation
1	TOPSIS-DEA	0.957
2	TOPSIS-L.A	0.794
3	L.A-DEA	0.707

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