

Ranking industries using a hybrid of DEA-TOPSIS

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CHRONICLE

ABSTRACT

Article history:

Received May 12, 2013

Accepted June 22, 2013

Available online

June 30 2013

Keywords:

Data Envelopment Analysis

TOPSIS

DEA

Ranking

Ranking industry normally helps find hot sectors and attract potential investors to invest in appropriate plans. Ranking various industries is also a multiple criteria decision making problem. In this paper, we present an empirical investigation to rank different industries using the art of data envelopment analysis (DEA). The inputs of our proposed DEA model include capital, employment and importance coefficient and outputs are exports, ecological effects and added value. In addition, exports, value added and environmental investment are used as outputs of DEA method. Since the results of DEA may consider more than one efficient unit, so we implement Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) technique to rank efficient units. In our case study, there were 15 different sectors from various industries and the implementation of DEA technique recommends 8 efficient units. The implementation of TOPSIS among these efficient units has suggested that Chemical industry could be considered as the most attracting industry for investment.

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1. Introduction

Measuring the relative efficiency of various industries has been a major concern among researchers for a while and there have been variety of methods and techniques to accomplish this task. Wu and Ho (2007) evaluated the productivity and efficiency of Taiwan's integrated circuit (IC) industry using data envelopment analysis (DEA) (Charnes, 1978, 1994) and the Malmquist index (MI). In this study, the Malmquist index, as a total factor productivity index based on distance functions, was evaluated using DEA. Wong and Wong (2007) used DEA method for measuring the performance of internal supply chains. Wang (2008) implemented a fuzzy multiple criteria decision making technique to evaluate financial performance of domestic airlines in Taiwan. Taner and Sezen (2009) used a hybrid of Taguchi and DEA methods to reflect the diversity of inputs and outputs by incorporating the stepwise application of sensitivity, specificity, leveling threshold, and efficiency score. They implemented their hypothetical case study on eight readers of X-ray films in clinical radiology.

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Sengupta (2005) addressed an extension of the convex hull method of DEA for determining a production frontier in the presence of demand and supply uncertainty of outputs and inputs, respectively. DEA has been integrated with other useful techniques such as balance score card (BSC) (Kaplan & Norton, 1992, 1996) for measuring the relative efficiency of similar units (Rickards, 2003). De Koster et al. (2009) used DEA for benchmarking container terminals.

Technique for **Order Preference by Similarity to Ideal Solution (TOPSIS)** is another method for ranking different alternatives based on various criteria. The method first uses analytical hierarchy process (AHP) (Saaty, 1992) to rank criteria and then chooses a sophisticated method to rank various alternatives. TOPSIS, developed by Hwang and Yoon in 1981, is a simple but sophisticated ranking approach used in various real-world applications of science and engineering (Chang et al., 2010). The standard TOPSIS method selects alternatives, which simultaneously have the shortest distance from the positive ideal solutions and the longest distance from the negative-ideal solutions (Orougi et al., 2012). The positive ideal solution maximizes the desirable criteria and minimizes the undesirable criteria, whereas the negative ideal solution maximizes the undesirable criteria and minimizes the desirable criteria. TOPSIS makes full usage of attribute information, provides a cardinal ranking of alternatives, and does not need attribute preferences to be independent. To use this technique, attribute values must be numeric, monotonically increasing or decreasing, and have commensurable units (Chen & Hwang, 1992; Yoon & Hwang, 1995).

There are many applications of TOPSIS in various industries (Rostampour, 2012). Danaei and Haghighi (2013) implemented this technique for ranking different industries on Tehran Stock Exchange. They gathered the necessary data over the period of 2009-2010 from Tehran Stock Exchange and investigated the data in two stages. In the first stage, they performed fundamental analysis to select the most appropriate firms and in the second stage, they implemented TOPSIS to rank selected firms based on various criteria. The results of the study confirmed that information and communication technology, which was one of the biggest firms in this exchange was the best option for investment (relative ranking 0.88 in two years) followed by some Cement industry (with relative ranking of 0.26 in 2009 and 0.19 in 2010) and oil refinery units (with relative ranking of 0.23 in 2009 and 0.19 in 2010). The results also showed that other firms maintained low ratios varied from 0.23 to 0.01 and the lowest industry ranking belonged to marine industry.

2. The proposed model

The proposed model of this paper uses standard DEA method developed by Charles et al. (1978) for ranking 16 different industries, which are active in province of Semnan, Iran.

2.1. Data envelopment analysis

The constant return to scale DEA (CCR) proposed by Charnes, et al. (1978, 1994) is a method for measuring the relative efficiency of decision making units (DMU). In this model, we form a set of production feasibility as follows,

$$T_C = \left\{ (X, Y) \left| X \geq \sum_{j=1}^n \lambda_j X_j, Y \leq \sum_{j=1}^n \lambda_j Y_j, \lambda_j \geq 0, j = 1, \dots, n \right. \right\}, \quad (1)$$

where X and Y are the input and output vectors, respectively. The CCR production feasibility set border defines the relative efficiency in which any off-border DMU is stated as inefficient. (See Chares et al., 1978, 1994 for more details).

2.2. TOPSIS method

For the implementation of TOPSIS method let x_{ij} be the inputs for matrix of priorities where there are $i = 1, \dots, m$ alternatives and $j = 1, \dots, n$ criteria. TOPSIS method has size step as follows,

Step 1. Form normalized decision matrix

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m \sum_{j=1}^n x_{ij}^2}} \quad (1)$$

Step 2. Build the weight normalized matrix

$$v_{ij} = w_i r_{ij}, i = 1, \dots, m \quad j = 1, \dots, n \quad (2)$$

Step 3. Calculate the positive and negative ideal solutions

$$A^+ = \{v_1^+, \dots, v_n^+\}, \text{ where } v_j^+ = \{\max(v_{ij}) \text{ if } j \in J; \min(v_{ij}) \text{ if } j \in J'\} \quad (3)$$

$$A^- = \{v_1^-, \dots, v_n^-\}, \text{ where } v_j^- = \{\min(v_{ij}) \text{ if } j \in J; \max(v_{ij}) \text{ if } j \in J'\}$$

Step 4. Measure separation (positive and negative) measures for each alternative

$$S_i^+ = \sqrt{\sum_{j=1}^n (v_j^+ - v_{ij})^2}, S_i^- = \sqrt{\sum_{j=1}^n (v_j^- - v_{ij})^2}, i = 1, \dots, m \quad (4)$$

Step 5. Finalize the relative closeness to the ideal solution

$$C_i^+ = \frac{S_i^-}{S_i^- + S_i^+}, 0 < C_i^+ < 1, i = 1, \dots, m \quad (5)$$

The proposed model of this paper first uses DEA method to rank all 16 different industries and then it uses TOPSIS to rank the efficient units. Next, we present details of our findings.

3. The results

In this section, we first present details of our finding on the implementation of DEA technique on ranking 16 different industries. The inputs of our proposed DEA model include capital, employment and importance coefficient and outputs are exports, ecological effects and added value. In addition, exports, value added and environmental investment are used as outputs of DEA method.

Table 1 demonstrates the summary of our results. As we can observe from the results of Table 1, some of the factors are qualitative types and need to be quantified using a Likert scale (1-9) and we show these Likert numbers inside some brackets. After normalizing the information of Table 1 and applying DEA method, we find efficient and inefficient units demonstrated in Fig. 1. Note that the order of units shown on Fig. 1 is the same as shown on Table 1. In addition, there is more than one efficient unit, which creates motivation to use TOPSIS method for ranking them.

Table 1
The inputs and outputs used for DEA model

Industry	Capital	employment	export	added value	Importance coefficient	ecological effects
Food industry	169332	770	3145111	126675	Middle(5)	Middle(5)
Garment	140336	454	47780020	24796	Low(3)	High(7)
Wood and woody production	6612	109	0	5100	Very low(1)	High(7)
Paper production	45692	67	1175739	15869	High(7)	High(7)
Coke coal industries	76225	69	0	15118	High(7)	Very high(9)
Chemical Material Production	994032	448	86766279	562574	Very high(9)	Very high(9)
Rubber and Tier products	188399	316	13199657	27940	Low(3)	Very high(9)
Non-metallic mineral products	408908	1029	74458796	195017	Middle(5)	Very high(9)
Production of basic metals	119323	331	76318036	24961	Low(3)	Very high(9)
Original metal products	43538	656	0	72948	Middle(5)	High(7)
Machinery and equipment products	41730	1038	144204	119848	Middle(5)	High(7)
Machines generating electricity transmission	99754	186	0	59427	High(7)	Very low(1)
Production of motor vehicles	194956	425	152163	20797	Very low(1)	Middle(5)
Production of other transport equipment	4845	120	0	14036	Middle(5)	Middle(5)
production of furniture and unclassified manufactures	12340	268	0	40054	Middle(5)	Middle(5)

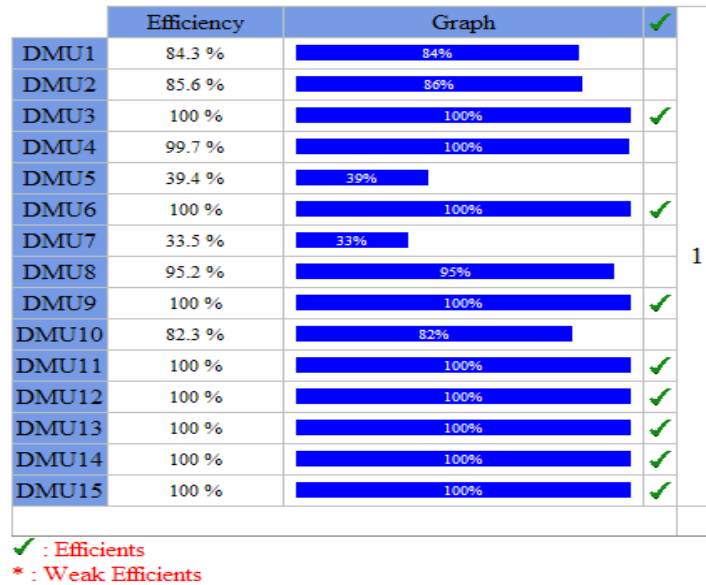


Fig. 1. The results of the implementation of DEA method

Table 2 demonstrates the results of TOPSIS ranking method using the same inputs/outputs of DEA model by considering equal weights.

Table 2
The summary of the implementation of TOPSIS method

	M_1	M_2	M_3	M_4	M_5	M_6	C_i	Rank
DMU3	0.001619338	0.005377654	0	0.002048565	0.00325793	0.01119626	0.017	8
DMU6	0.243447273	0.022102653	0.265626831	0.225974415	0.02932134	0.00373209	0.501	1
DMU9	0.029223263	0.016330308	0.233640515	0.010026321	0.00977378	0.00373209	0.42	5
DMU11	0.029223263	0.016330308	0.233640515	0.010026321	0.00977378	0.00373209	0.5	2
DMU12	0.024430641	0.009176548	0	0.023870605	0.022805	0.033589	0.452	3
DMU13	0.047746457	0.020967919	0.000465833	0.008353728	0.003258	0.01866	0.441	4
DMU14	0.001186584	0.005920354	0	0.005637973	0.01629	0.01866	0.406	6
DMU15	0.003022176	0.013222123	0	0.016088869	0.01629	0.01866	0.132	7

5. Conclusion

Ranking different industries has many advantages such as redirecting investments towards opportunities with better outlooks, attracting more people for investment, taking care of environment, etc. In this paper, we have presented an empirical investigation on ranking different industries in one Iranian province. The proposed model of this paper has implemented DEA method for ranking various industries. The results of DEA provided more than one efficient unit and the study implemented TOPSIS technique to rank the remaining efficient units. The study has concluded that Chemical industry preserved the best choice for investment purposes.

This study can be extended for more sophisticated MCDM applications. For instance, we may consider uncertainty on input/output parameters and we leave it for interested researchers as future study.

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