A Comparative Efficiency Evaluation of OIZs Located in The Aegean Region of Turkey

MEHTAP DURSUN, NAZLI GOKER
Industrial Engineering Department
Galatasaray University
Çırağan Caddesi No:36 Ortaköy, Beşiktaş, İstanbul
TURKEY

Abstract: - With the planned development era began in the early 1960s in Turkey, Organized Industrial Zone (OIZs) began to be established in each province. The main objective in the establishment of OIZs is to achieve a balanced industrial development in the country as a whole, to eliminate the differences between regions, to increase employment and qualified labor force in the regions. OIZs with low occupancy rates lead the question of if the OIZs perform efficiently. In this work, rank-order according to the efficiency scores of OIZs located in the Aegean Region of Turkey is obtained by employing four different data envelopment analysis models, and the ranking results are compared.

Key-Words: - Data Envelopment Analysis, Decision making, Decision support systems, Organized industrial zones, Performance evaluation

1 Introduction

Organized industrial zones (OIZs) has been the zones of production for the goods and services, which are formed by allocating the land parcels. According to the Law on Organized Industrial Zones (Law No:4562) [1] the objective of the OIZs are preventing industrialization and environmental problems that are not planned, guiding urbanization, using resources rationally, benefitting from information and informatics technologies, and ensuring that the types of industries are placed and developed within the framework of a certain plan.

The need to increase the level of international competition in order to switch to sustainable development momentum in Turkey is obvious. Efficiency and technological development are the basic rules of competing on a global scale. The main elements of technological development are research and development and innovation. The notion of establishing OIZs in Turkey dates back to 1960s, and they have major roles to boost economic parameters [2].

According to the data of the Ministry of Science, Industry and Technology dated 01.03.2017, a total of 297 units of OIZ have been put into production in 49.877 industrial parcels and 1,658,835 people are employed. Conversely, there are empty areas in the existing OIZs except parcels in production and some OIZs have high parcels. Considering these data, it is an issue to be questioned whether the OIZs obtain the desired level of activity.

Data envelopment analysis (DEA) is a mathematical programming based technique which utilizes common inputs and outputs as factors in order to identify the relative efficiencies of decision making units (DMUs). In this paper, the efficiency scores of OIZs in the Aegean Region of Turkey are evaluated and compared using DEA based decision models.

The remaining parts of the paper are planned as follows. In Section 2 the explanation of DEA and employed models are provided. Section 3 introduces the illustration of the methodology through OIZs ranking problem with regard to their efficiency scores. Finally, concluding remarks and future researches are delineated in Section 4.

2 Methodology

The initial data envelopment analysis (DEA) model, called as the CCR model, developed by Charnes et al. [3], calculates the efficiency value of DMUs. It maximizes the ratio of its total weighted outputs to its total weighted inputs. There is a condition that ensures that the output to input ratio of every DMU should be less than or equal to unity. The conventional DEA formulation can be given as

$$\max E_{j_0} = \frac{\sum_{r=1}^{s} u_r y_{rj_0}}{\sum_{i=1}^{m} v_i x_{ij_0}}$$

subject to (1)

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, \quad \forall j,$$
$$u_r, v_i \geq \varepsilon, \quad \forall r, i.$$

where E_{j_0} is the efficiency value of the DMU that is under evaluation, u_r is the weight of output r, v_i is the weight of input i, y_{rj} is the amount of output r formed and y_{ij} is the quantity of input i utilized by DMU j, respectively, and ϵ is a small positive number.

Formulation (1) has nonlinear and nonconvex properties but it can be converted into a linear programming model through a transformation. The linear programming model to compute the efficiency of a DMU is represented in the following formulation.

$$\max E_{j_0} = \sum_{r=1}^{s} u_r \ y_{rj_0}$$

subject to (2)

$$\sum_{i=1}^{m} v_i x_{ij_0} = 1$$
$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0, \quad \forall j,$$
$$u_r, v_i \geq \varepsilon, \quad \forall r, i.$$

Besides, minimax and minsum efficiencformulations do not give favourable consider to the evaluated performing unlike the DEA-CCR model. Minimizing the maximum deviation from efficiency is provided by minimax efficiency formulation, while minimizing the total deviation from efficiency is ensured by minsum efficiency formulation [4]. The minimax efficiency formulation can be given as

$$\min M$$

subject to (3)

$$\sum_{i=1}^{m} v_i x_{ij_0} = 1,$$
$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + d_j = 0, \quad \forall j,$$
$$M - d_j \geq 0, \quad \forall j,$$
$$u_r, v_i, d_j \geq 0, \quad \forall r, i, j.$$

where d_j denotes the deviation from efficiency for DMU$_j$, (i.e. d_j = 1 - E_j when E_j is the efficiency value of DMU$_j$), and M denotes the maximum deviation from efficiency. In addition, minsum model is as

$$\min \sum_{j=1}^{n} d_j$$

subject to (4)

$$\sum_{i=1}^{m} v_i x_{ij_0} = 1,$$
$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + d_j = 0, \quad \forall j,$$
$$u_r, v_i, d_j \geq 0, \quad \forall r, i, j.$$

Furthermore, super efficiency measure is introduced for ranking DEA-efficient DMUs as [5]

$$\max \sum_{r=1}^{s} u_r y_{rk}$$

subject to (5)

$$\sum_{i=1}^{m} v_i x_{ik} = 1,$$
$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0, \ \ j = 1, 2, ..., n; \ j \neq k,$$
$$u_r, v_i \geq \varepsilon, \quad \forall r, i,$$

3 Case Study

Table 1. Input and output variables for OIZs

DMU(*j*)	OIZ	Input1	Input2	Output1	Output2	Output3	Output4	Output5
1	Afyonkarahisar	292,20	314	303	7.630	5.403.622.542	6.764	215.786.617
2	Afyonkarahisar-Emirdağ	52,40	31	9	492	33.845.838	8.859	1.401.413
3	Aydın- Astim	330,00	256	87	3.299	3.501.349.452	1.382.248	64.830.900
4	Aydın-Ortaklar	72,72	35	8	547	143.405.554	0	8.326.388
5	Denizli	297,00	179	129	25.000	5.028.617.905	3.235.471	225.309.589
6	Kütahya	152,30	84	76	5.517	4.011.179.047	24.989.366	192.644.829
7	Kütahya-Gediz	66,03	33	20	710	342.197.388	0	10.375.827
8	Kütahya-Tavşanlı	67,76	25	11	2.630	417.283.785	0	21.390.572
9	Manisa-Salihli	159,00	159	40	2.534	646.579.912	567.050	38.097.162
10	Manisa-Akhisar	196,00	76	41	2.674	1.913.154.931	125.254	24.912.335
11	Uşak-Karahallı	47,00	86	303	7.630	5.403.622.542	6.764	215.786.617

This section introduces a case study related to the evaluation of OIZs located in the Aegean Region by employing DEA-CCR, minimax, minsum, and super efficiency models.

The numerical illustration involves evaluating 11 OIZ with “total industrial parcel area (Ha)”, and “total number of parcels” as inputs, “total number of parcels in production”, “employment”, “net sales (TL)”, “R&D expenditures ($)”, and “expert volume ($)”. Data with regard to OIZs for 2015 are provided Table 1.

DEA-CCR formulation presented by Charnes et al. [3] and minsum efficiency formulation result in three efficient DMUs which are DMU1 (Afyonkarahisar OIZ), DMU5 (Denizli OIZ) and DMU6 (Kütahya OIZ). Besides, minimax efficiency model yields two efficient DMUs that are DMU1 and DMU6. In addition, super efficiency model, which has an enhanced power of discrimination rather than DEA-CCR, minsum, and minimax efficiency models, obtains a single efficient DMU that is DMU6. Ranking results are reported in Table

Table 2. Results of the evaluation

DMU(*j*)	Ranking of DEA-CCR model	Ranking of minimax efficiency model	Ranking of minsum efficiency model	Ranking of super efficiency model
1	1	1	1	3
2	9	10	9	9
3	7	4	6	7
4	10	9	10	10
5	1	3	1	2
6	1	1	1	1
7	5	6	7	5
8	4	8	4	4
9	8	7	8	8
10	6	5	5	6
11	11	11	11	11

4 Concluding Regards

With the development process, industrial investments increase and the negative effects of industrial investments on urban areas are become more important. Turkey aims to increase the number of OIZs, which is accepted as the beginning of industrial investments. At this point, many ministries support the organized industrial zones through the privileges they recognize in their legislation and influence their activities in Turkey. As a result, OIZs are established in underdeveloped regions but empty industrial parcels remain in these OIZs, which are not attractive for investors.

In this study, DEA-CCR, minimax, minsum, and super efficiency models are employed in order to assess efficiencies of OIZs, which performs in the cities in Aegean Region of Turkey. The CCR and minsum efficiency models result in three efficient DMU, minimax efficiency measure yields two efficient DMUs, and super efficiency model identifies a single efficient OIZ. Researches in future will concentrate on the evaluation of the OIZs in other regions of Turkey.

Acknowledgment

This study has been financially supported by Galatasaray University Research Fund FBA-2020-1024.

References:

[1] Author, Title of the Paper, *International Journal of Science and Technology*, Vol.X, No.X, 200X, pp. XXX-XXX.

[2] “Mevzuat Bilgi Sistemi.” [Online]. Available: http://www.mevzuat.gov.tr/Metin1.Aspx?MevzuatKod=1.5.4562&MevzuatIliski=0&sourceXmlSearch=&Tur=1&Tertip=5&No=4562.

[3] www.guzeloglu.legal

[4] A. Charnes, W. W.Cooper, E. Rhodes, “Measuring the efficiency of decision making units,” European Journal of Operational Research, 2(6), 1978, pp. 429-444.

[5] X. B. Li, G. R. Reeves, “A multiple criteria approach to data envelopment analysis,” European Journal of Operational Research, 115, 1999, pp. 507-517.

[6] P. Andersen, N. C. Petersen, “A procedure for ranking efficient units in data envelopment analysis,” Management Science, 39, 1993, pp.1261-1264.