Organized Industrial Zones Efficiency Evaluation Considering Economic Factors

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Abstract

Organized industrial zones (OIZs) object to orient private sector investments to specific regions to augment existing investment incentives. They began to be established and supported by the Turkish government since 1960s and actually, there are one or more OIZs in all cities of Turkey (except Artvin). The average occupancy rate (Number of Assigned Parcels/Number of Parcels) of the Turkey's OIZs is 68% and cannot be said to be a high rate. On the other hand, the rate of parcels in production (Number of Parcels in Production/Number of Parcels) is lower and only 43%. Considering these ratios, it is an issue to be questioned whether the OIZs reach the desired level of activity. In this study, the efficiencies of OIZs located in the Aegean Region of Turkey is evaluated considering economic factors such as "employment", "net sales (TL)", "research and development expenditures ($)", and "expert volume ($)". The evaluation is conducted employing a data envelopment analysis (DEA) based common weight decision model, which is a powerful method to measure the relative efficiencies of decision making units.

Keywords: Data Envelopment Analysis; Decision support systems; Economic factors; Organized industrial zones; Performance evaluation

JEL Codes: C6: Mathematical Methods; Programming Models; Mathematical and Simulation Modeling; O250: Industrial Policy

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1. Introduction

Organized industrial zones are industrial facilities that are established to ensure the regular settlement in the city in order to minimize the negative effects of the industry on the environment. They are specially planned and included in the zoning plans and they implements waste management policies.

Establishment goals of OIZs are

- Discipline of industry,
- Contributing to the planned development of the city,
- Ensuring productivity and profit increase in production, with industrialists who complement each other and promote by-products of one another,
- Dissemination of industry in underdeveloped regions,
- Disciplining the use of agricultural areas in industry,
- Establishing a healthy, cheap, reliable infrastructure and common social facilities,
- Prevention of environmental pollution by joint treatment facilities,
- Ensuring the management of the regions by their own bodies under state supervision

Industrial infrastructure is prepared for the investments due to Organized Industrial Zones. Thus, industrialists come to these regions with their infrastructure ready to establish their enterprises.

In Turkey, OIZ implementations were first started with the establishment of an OIZ in Bursa in 1962. All of the OIZs' monitoring and evaluation operations are carried out by Ministry of Science, Industry and Technology in Turkey. Total zone size, number of parcels, employment and occupancy rates for the OIZs in Turkey are given in Table 1 (Dursun et al., article in press).

Table 1: Turkey's OIZs' total data

Zone Size (Ha)	89.160
Industrial Parcel Size (Ha)	51.126
Number of Parcels (Zoning) (x)	75.734
Number of Parcels (Zone) (y)	71.263
Total Number of Parcels (x+y)	77.792
Number of Assigned Parcels	58.144
Size of Assigned Parcels (Ha)	39.771
Number of Idle Parcels	13.119
Size of Idle Parcels (Ha)	11.355
Number of Parcels in Production	49.877
Number of Parcels in Construction	3.414
Number of Parcels in Project	4.853
Employment	1.658.835
Estimated Employment	2.409.323
Occupancy Rate (Number of Assigned Parcels / Number of Parcels (Zone))	68%
Rate of Parcels in Production (Number of Parcels in Production / Number of Parcels (Zone))	43%

To calculate the occupancy rate of the OIZs in Turkey, firstly the occupancy rate for each OIZ is obtained by dividing the number of assigned parcels to the number of parcels in the zone and then the average of the calculated occupancy rate for each OIZ is taken. In the same way to obtain the rate of parcels in production after dividing number of parcels in production by the number of parcels in the zone the average of these rates is calculated. 40 OIZs do not have parcels in the zone although there are parcels in the zoning plan. Therefore for these 40 OIZs, the occupancy rate and rate of parcels in production cannot be calculated and is not included in the calculation for Turkey.

As it is seen on the table, average occupancy rate of the Turkey's OIZs is 68% and cannot be said to be a high rate. On the other hand, the rate of parcels in production is lower and only 43%. When these rates are considered, it should be questioned whether the OIZs reach the desired efficiency.

In this study, the efficiencies of OIZs located in the Aegean Region of Turkey is evaluated considering economic factors such as "employment", "net sales (TL)", "research and development expenditures ($)", and "expert volume ($)".The evaluation is conducted employing a data envelopment analysis (DEA) based common weight decision model, which is a powerful method to measure the relative efficiencies of decision making units.

The rest of the study is organized as follows. In Section 2 the employed common weight DEA based method is explained. Section 3 presents the illustration of the method via the OIZs efficiency evaluation problem. Finally, concluding remarks are provided in Section 4.

2. Methodology

The original data envelopment analysis (DEA) model, also named as the CCR model, proposed by Charnes et al. (1978), computes the relative efficiency of a DMU by maximizing the ratio of its total weighted outputs to its total weighted inputs subject to the condition that the output to input ratio of every DMU be less than or equal to unity. The traditional DEA formulation can be represented as follows:

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

subject to (1)

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

$$u_r, v_i \ge \varepsilon, \quad \forall r, i,$$

where E_{j0} is the efficiency score of the evaluated DMU, u_r is the weight assigned to output *r*, v_i is the weight assigned to input *i*, y_{rj} is the quantity of output *r* generated and x_{ij} is the amount of input *i* consumed by DMU *j*, respectively, and ε is a small positive scalar.

Formulation (1) has nonlinear and nonconvex properties, however, it can be transformed into a linear programming model via a transformation. The linear programming model for calculating the relative efficiency of a DMU is given in the following set of equations.

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

subject to (3)

$$\sum_{i=1}^{m} v_i x_{ik} = 1,$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0, \quad j = 1,2,\ldots,n;\ j \ne k,$$

$$u_r, v_i \ge \varepsilon, \qquad \forall r, i,$$

Throughout the literature, common-weight DEA-based models have been proposed in order to avoid the shortcomings of classical DEA models. These models provide a common evaluation for all DMUs and do not require subjective assessment to determine input and output weights. Hence, the discriminating power is improved that restricts the selection of input and output weights in favour of respective DMUs (Karsak & Ahıska, 2005). For the cases where all the criteria are to be maximized, Toloo (2015) proposed the following DEA-based approach, which guarantees to yield the best performing DMU via solving a single mixed integer linear programming model.

$$\min d_{\max}$$

subject to (3)

$$d_{\max} - d_j \ge 0, \qquad \forall j,$$

$$\sum_{r=1}^{s} u_r y_{rj} + d_j = 1, \qquad \forall j,$$

$$\sum_{j=1}^{n} \theta_j = n - 1$$

$$d_j \le \theta_j, \qquad \forall j,$$

$$\theta_j \le M d_j, \qquad \forall j,$$

$$d_j \ge 0, \qquad \forall j,$$

$$\theta_j \in \{0,1\}, \qquad \forall j,$$

$$u_r \ge \varepsilon, \qquad \forall r.$$

where $d_{\max}$ represents the maximum deviation from efficiency, M is a large positive number.

3. Case study

In this study, the efficiency of organized industrial zones in the Aegean Region of Turkey is evaluated by data envelopment analysis. For this study two different data sources are used. One of these sources is the data of Directorate General for Industrial Zones. This directorate general is a department of Ministry of Science, Industry and Technology and it is responsible for industrial zones. The other source is Enterprise Information System, which is one of the important information systems of Ministry of Science, Industry and Technology. The most recent data in this information system related to OIZs is for the year 2015, hence the study is performed for 2015.

The numerical illustration involves evaluating 11 OIZs considering economic factors as "employment", "net sales (TL)", "export volume ($)", and "total number of brand, patent, utility model and industrial design" that are to be maximized. Data regarding OIZs are given Table 2.

Table 2: Output variables for OIZs

DMU(*j*)	OIZ	Output1	Output2	Output3	Output4
1	Afyonkarahisar	7.630	5.403.622.542	6.764	215.786.617
2	Afyonkarahisar-Emirdağ	492	33.845.838	8.859	1.401.413
3	Aydın- Astim	3.299	3.501.349.452	1.382.248	64.830.900
4	Aydın-Ortaklar	547	143.405.554	0	8.326.388
5	Denizli	25.000	5.028.617.905	3.235.471	225.309.589
6	Kütahya	5.517	4.011.179.047	24.989.366	192.644.829
7	Kütahya-Gediz	710	342.197.388	0	10.375.827
8	Kütahya-Tavşanlı	2.630	417.283.785	0	21.390.572
9	Manisa-Salihli	2.534	646.579.912	567.050	38.097.162
10	Manisa-Akhisar	2.674	1.913.154.931	125.254	24.912.335
11	Uşak-Karahallı	7.630	5.403.622.542	6.764	215.786.617

The DEA model proposed by Toloo (2015) yields Afyonkarahisar OIZ as the most efficient OIZ. Efficiency scores as well as ranking results regarding are reported in Table 3.

Table 3: Results of the evaluation

DMU(*j*)	Efficiency scores	Ranking
1	1	1
2	0.006	10
3	0.581	4
4	0.029	9
5	0.985	3
6	0.999	2
7	0.06	8
8	0.082	7
9	0.138	6
10	0.301	5
11	0.006	10

4. Conclusions

Organized industrial zones are structures that provide collective opportunities to the firms and aim to reduce the costs and facilitate the business of the companies with the special services they provide and thus contribute to the strengthening of the industry. These structures are supported by the government and investors are encouraged to prefer organized industrial zones. At this point, many ministries support the organized industrial zones through the privileges they recognize in their legislation and influence their activities in Turkey.

In this study, a common weight DEA-based mixed integer linear programming model is employed in order to evaluate relative efficiencies of OIZs, which performs in the cities in Aegean Region of Turkey. Future research will focus on the evaluation of the OIZs in other regions of Turkey.

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