EFFICIENCY ANALYSIS OF ORGANIZED INDUSTRIAL ZONES IN TURKEY

(TÜRKİYE'DEKİ ORGANİZE SANAYİ BÖLGELERİNİN ETKİNLİK ANALİZİ)

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LIST OF SYMBOLS

BOD **:** Benefit of the Doubt

CCR **:** Charnes, Cooper and Rhodes

CZK **:** Czech Koruna

DEA **:** Data Envelopment Analysis

DMU **:** Decision Making Unit

EIP **:** Eco-Industrial Parks

EMS **:** Efficiency Measurement System

GAMS **:** General Algebraic Modeling System

GR **:** Geographical Region

IDA **:** Index Decomposition Analysis

OIZ **:** Organized Industrial Zone

OTE **:** Overall Technical Efficiency

Ph.D. **:** Doctor of Philosophy

PTE **:** Pure Technical Efficiency

R&D **:** Research & Development

SE **:** Scale Efficiency

STIP **:** Science and Technology Industrial Parks

U.S **:** United States

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ABSTRACT

Organized Industrial Zones (OIZ) are important structures of the ındustry and they began to be established and supported by the Turkish State since 1960s. At the present time there are one or more OIZs in all cities of Turkey. The low occupancy rates of these OIZs make the question of whether the OIZs work efficiently. Although the need to evaluate the efficiencies of Turkey's OIZs is stated on many sources, the studies related on this area are quite few and insufficient.

This study aims to evaluate the efficiencies of OIZs located in Turkey (on geographical region basis) by using a data envelopment analysis (DEA) based common weight decision model, which is a powerful method to measure the relative efficiencies of decision making units. Actually the conventional DEA – CCR model, a minsum efficiency and a minimax efficiency model were also used to measure the efficiencies of OIZs. But because of the advantages of DEA based common weight decision model, its results were taken as references.

The other aim of the study is to give an idea to the relevant institutions and organizations about which OIZs can be developed. Because determination of the zones with low efficiency scores means determination of the zones which have potential development areas.

ÖZET

Organize Sanayi Bölgeleri (OSB) sanayinin önemli yapılarıdır ve Türk Devleti tarafından 1960'lardan itibaren kurulmaya ve desteklenmeye başlamıştır. Günümüzde Türkiye'nin her ilinde bir ya da daha fazla OSB bulunmaktadır. Ancak düşük doluluk oranları OSBler etkin çalışıyor mu sorusunu akla getirmektedir. Birçok kaynakta Türkiye'deki OSBlerin etkinliklerinin değerlendirilmesi ihtiyacı belirtilmiş olsa da bu alanda yapılan çalışmalar oldukça az ve yetersizdir.

Bu çalışma karar verme birimlerinin göreli etkinliğinin belirlenmesinde güçlü bir metot olan veri zarflama analizi (VZA) temelli ortak ağırlıklı karar modeli ile Türkiye'de yer alan OSBlerin etkinliklerinin değerlendirilmesini (coğrafi bölgeler bazında) amaçlamaktadır. Çalışmada aynı zamanda geleneksel VZA – CCR modeli, toplamların minimizasyonu etkinlik modeli ve maksimumun minimizasyonu etkinlik modeli de etkinlik ölçümü için kullanılmıştır. Ancak VZA temelli ortak ağırlıklı karar modelinin avantajları sebebiyle bu modelin sonuçları referans alınmıştır.

Düşük etkinlik değerine sahip OSBlerin belirlenmesi potansiyel gelişim alanlarına sahip OSBlerin belirlenmesi anlamına geldiği için, çalışmanın bir diğer amacı da ilgili kurum ve kuruluşlara hangi OSBlerin geliştirilebileceğine dair fikir vermektir.

1. INTRODUCTION

Industrialization efforts in Turkey increased with the establishment of Republic and was seen as the base of economic development and newly acquired political independence. Industrialization was left to private sector initiatives in the first years of the Republic, but due to lack of financial power and lack of experience, the private sector could not fulfill this task as expected. Following the first efforts at industrialization, industrial infrastructure work was started within the frame of the "I. Five-Year Industrial Plan" which had been put into effect in 1931. And in the period of planned development, which started in 1960, it was clearly stated that the industry is the "locomotive" sector.[1]

Organized Industrial Zones (OIZs) and Small Industrial Sites have been started to be established by the government in 1960s for planned industrialization and planned urbanization (Cansiz, 2009).

Organized Industrial Zones are the production areas of goods and services that;

- are established to provide planned industrialization and planned urbanization by structuring the industry in suitable areas, to prevent environmental problems, to provide efficient use of resources,
- are equipped with necessary administrative, social and technical infrastructural areas and small manufacturing, repair, trade, education and health fields, technology development zones,
- and operated according to the provisions of "Organized Industrial Zones Law"[2].

[1] http://kss.sanayi.gov.tr/sayfa.html?sayfaId=a0e06476-55af-4d5e-8486-554958aba516
[2] Organized Industrial Zones Law, published in the 15/04/2016 dated and 24021 numbered Turkish official gazette

In Turkey, OIZ implementations were first started with the establishment of an OIZ in Bursa in 1962. The development graphs of completed OIZs (as number and area) in Turkey over the years since 1990 are given in Figure 1.1 and Figure 1.2.

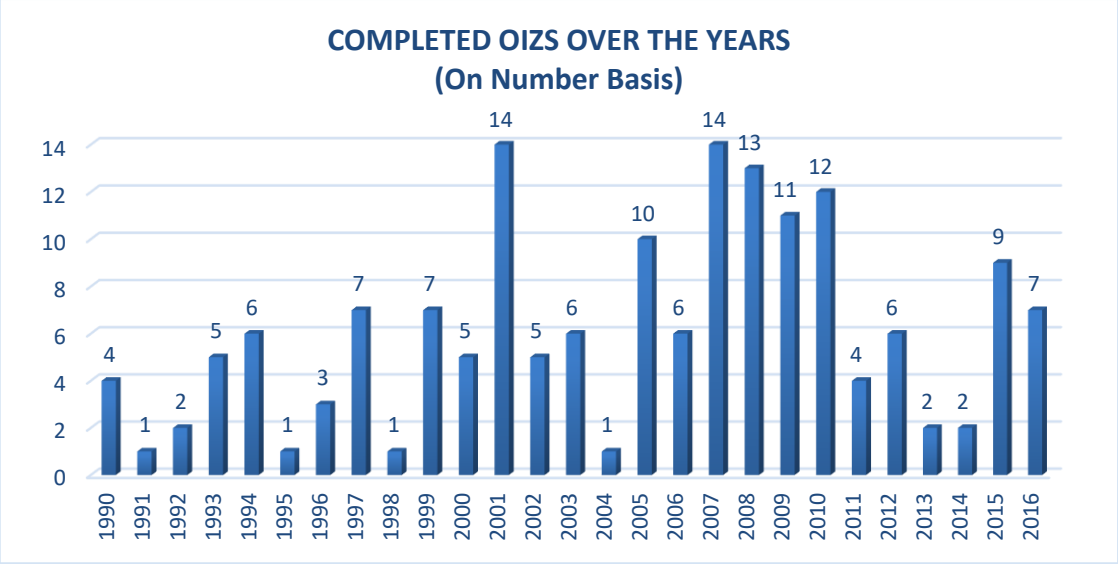

Figure 1.1: Completed OIZs over the years on number basis[3]

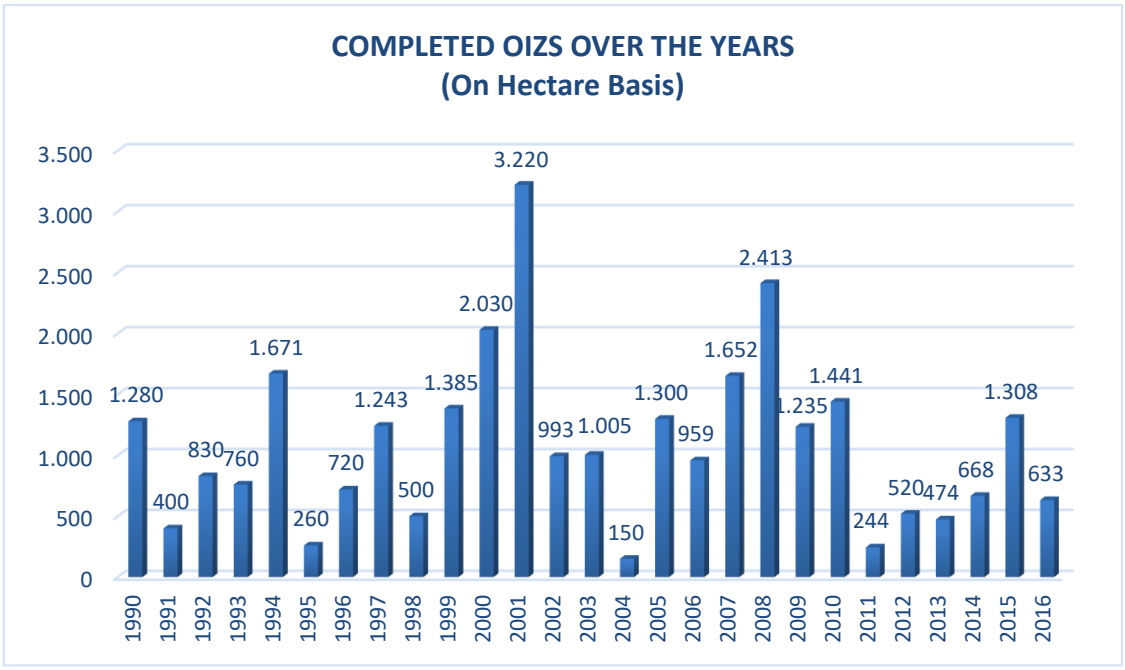

Figure 1.2: Completed OIZs over the years on hectare basis[3]

[3] http://www.sanayi.gov.tr/DokumanGetHandler.ashx?dokumanId=93ccb086-48ae-4300-984f-5a799461ac4e

All of the OIZs' monitoring and evaluation operations are carried out by Ministry of Science, Industry and Technology in Turkey. According to Ministry of Science, Industry and Technology's 01.03.2017 dated data in 297 OIZs and in 49.877 industrial parcels have been started production and 1.658.835 employment are provided. However, in existing OIZs there are also idle parcels except the parcels in production, and in some OIZs the ratio of idle parcels to total parcels is quite high. Total zone size, number of parcels, employment and occupancy rates for the OIZs in Turkey are given in Table 1.1.

Table 1.1: 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%

While the vast majority of the parcels in the total zone are industrial parcels, part of the zone parcels is for the common social areas and administrative areas. Some of the parcels that appear in the zoning(x) may be allocated partly to the zone (y). Number of Parcels (Zone) in the table refers to the existing parcels in the zones. In some zones, it is foreseen

that new parcels will be produced because the parcels are not enough. Total Number of Parcels in the Table 4.1. refers to the sum of parcels in the zoning area, allocated parcels to the zone and the foreseen parcels.

The industrial parcels allocated to the investors in the zone are defined as assigned parcels and they are separated as parcels in project, parcels in construction and parcels in production. Number of parcels in production refers to the number of existing firms in the zones.

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.

Besides, on the study of Cansiz (2009), "In order to increase the efficiency of OIZs in the coming period what should be done?" is asked to OIZ-related stakeholders in a questionnaire. It is seen that two of the four main responses are "In the case of the existence of idle parcels in the OIZ, new industrial areas opening in the same city or county must be prevented." and "Precaution should be taken to increase OIZs' occupancy rates."

Due to the above-mentioned reasons, the efficiencies of the OIZs in Turkey are tried to be evaluated in this thesis and the OIZs which have potential development areas are tried to be identified.

The rest of the thesis is organized as follows. Section 2 provides a literature review on the existing studies related to evaluation of organized industrial zones by using DEA method and other performance evaluation and efficiency analysis methods. In section 3, the conventional DEA-CCR model and the other DEA based models which are used in the implementation stage are explained. Section 4 presents the illustration of the methods via the OIZs efficiency analysis problem. Finally, concluding remarks are provided in Section 5.

2. LITERATURE REVIEW

When an institution's, an organization's or a department's efficiency is evaluated, several criteria have an effect on it. Data envelopment analysis (DEA) is a mathematical programming methodology, using common inputs and outputs as criteria to obtain the comparative efficiencies of homogeneous units. DEA does not require the same measurement units for the inputs and outputs and there is no need for predetermined weights of inputs and outputs.

In this study the Turkey's OIZs' comparative efficiencies are tried to be measured according to several criteria. The criteria have different measurement units and don't have any priori weight. For this reason to evaluate the efficiencies of OIZs, DEA is used in this study. First, the literature review is made by the "DEA" and "industrial zone/district/site/park" search words. In the following, there are some significant studies about the use of DEA methods to evaluate the industrial zones' or industrial zone's firms' efficiency.

Hu et al. (2009) applied DEA to analyze the performance of 57 industrial parks in Taiwan from 2000 to 2004. DEA approach was used to compute the overall technical efficiency (OTE), pure technical efficiency (PTE), and scale efficiency (SE) scores. In the study the discrepancy efficiency was compared and the benchmark in all industrial parks was listed. Moreover, this paper intended to understand the directions of area economic development by analyzing the influence of environmental factors toward the efficiency of Taiwan's industrial parks.

Hu et al. (2010) used the four-stage DEA proposed by Fried et al. (1999) to evaluate the performances of science and technology industrial parks (STIPs). The data related to 53 China STIPs from 2004 to 2006 were regarded. The four-stage DEA was implemented

by taking environmental factors into consideration besides input and output variables and to provide an accurate assessment of the STIPs' efficiencies.

Yenilmez & Girginer (2012) examined the efficiency of exporter textile firms' in Eskisehir Organized Industrial Zone by implementing DEA which aims output maximization. 5 exporter firms' input and output data for 2008 and 2009 was used to measure of the relative efficiencies of the firms.

Khodakarami et al. (2014) proposed a gradual efficiency improvement DEA model and performed an application of the model using 31 Iranian industrial parks data. It was aimed to analyze the sustainability of industrial parks in this study. Environmental performance was used to determine follower and pioneer DMUs and it is tried to direct the follower DMUs toward pioneer DMUs to gradually increase their performance and plan how to achieve this improvement.

Izadikhah & Farzipoor Saen (2015) proposed a new DEA approach to rank all efficient DMUs. The average of inefficient DMUs was defined as the virtual DMU. To overcome the drawbacks of the similar developed models which cannot differentiate the efficient DMUs, the influence of efficient DMUs on both virtual DMU and other efficient DMUs were considered in the proposed model. Developed new approach was applied to the 17 industrial parks in Iran.

Liu W. et al. (2015) used a DEA-based weighting approach which is defined as benefit of the doubt (BOD) method (Cherchye et al., 2007) to analyze the environmental performance of the eco-industrial parks (EIPs) in China. The environmental impact score was constructed by using weighted sum of different environmental variables and the weights of the variables were calculated by the DEA. The proposed approach was implemented to the data set of 34 EIPs in China from 2007 to 2010.

The inputs and outputs used on these studies are indicated in Table 2.1.

Table 2.1: Input and output variables used in literature

Ref.	Aim of the Study	Criteria
(Hu et al., 2009)	To measure the efficiency of industrial parks in Taiwan	Inputs
		Capital stock
		Number of workers
		Number of firms
		Area of the firms
		Utility maintenance fee
		Output
		Operating Value
(Hu et al., 2010)	To investigate the efficiency of STIPs in China	Inputs
		Number of firms set up in STIP
		Number of employees work in STIP
		Percentage of employees graduated from university to total employees
		Expenditure in R&D of STIP
		Percentage of science and technology personnel to total employees
		Outputs
		Technical and patent revenue of STIP
		Products sales revenue of STIP
		Commodity sales revenue of STIP
(Yenilmez & Girginer, 2012)	To analyze the efficiency of exporter firms in Eskisehir OIZ	Inputs
		Production amount
		Number of employees
		Net assets of the firms
		Output
		Export values
(Khodakarami et al., 2014)	To analyze the sustainability of industrial parks in Iran	Inputs
		Energy cost
		Material cost
		Labor cost
		Investment
		Area of operation
		Intermediate Output/Inputs
		Created companies
		Productions
		Environmental projects
		Outputs
		Number of graduates
		Revenue

Table 2.1: Input and output variables used in literature (cont.)

Ref.	Aim of the Study	Criteria
(Khodakarami et al., 2014) (Cont.)	To analyze the sustainability of industrial parks in Iran	Outputs (Cont.)
		Number of active companies
		Effluent
		CO_2 emission
		Welfare services
(Izadikhah & Saen, 2015)	To measure the efficiency of industrial parks in Iran	Inputs
		Number of workers
		Population
		Land area
		Working capital
		Outputs
		Number of signed contracts
		Volume of investment
		Number of created jobs
		Total revenue

As it was thought that it would contribute to the study, other performance evaluation and efficiency analysis studies related to industrial zones/parks/districts/sites are also examined.

Parrilli (2009) used a systematic approach to investigate the process of development of Forli furniture district in Italy and tried to reveal the bottlenecks which need to be overcome for potential development. The tree main factors 'social embeddedness', 'collective efficiency' and 'policy inducement' are considered together to evaluate the development, hence it is hypothesised that the impact on the development is greater. 'Self-realisation' and 'social cohesion' considered in 'social embeddedness' factor, 'external economies' and 'joint actions' are identified in 'collective efficiency' factor and local institutions and policies are included in 'policy inducement' factor. The developed approach was applied to the data of the firms in the furniture district.

Damborsky et al. (2013) focused on evaluating the effectiveness of promoting industrial zones in the Czech Republic. The evaluation included three steps: (i) empirical investigation on industrial zones, (ii) analyzing the financial indicators of the firms in the industrial zones, (iii) analyzing the effectiveness of the industrial zone supports. Based

on the implemented industrial zone support from 1998 to 2006, **total size of supported areas**, **jobs created**, **occupancy percantage** and **state budget funds spent to support of industrial zones** are observed and the change on these indicators are considered. Besides changes in "industrial restructuring and technological development", "higher export potential", "the focus on skilled strength", "positive impact on the labor market" titles are questioned to analyze the impact of support. The survey which involves these titles with related sub criteria defined on Table 2.2 was implemented in three variants; "pessimistic", "medium" and "optimistic" and the results were evaluated.

Table 2.2: Criteria used in literature

Restructuring and technological development	Total production (revenues) in industrial zones
	Amount of production
	Profit realized in industrial zones
	Effectiveness (profitability) of the firms
	Effect on the state budget (profit from taxes) with 20% of tax rate
	Effect on the state budget (indirect taxes) with 5% tax rate
	Additional profit
	Additional production
Higher export potential	Production (export)
	Effect on state budget (indirect taxes) with 5%... tax rate
	Additional production, resp. export
	Total export in industrial
Focus on skilled labor	Number of jobs
	Average wage in CR
	Average wage in industrial zone
	Wage per employee
	Total additional wages
	Effect on the state budget (thousands CZK) with 40% tax rate-expert assessment of the compound tax quota.
Positive impact on the labor market	Effect or the state budget
	Total additional jobs
	Additional wage available for taxation
	Estimated rate of employees within the total number of employees in industrial zones transferred from the unemployed category to employed
	Social benefits savings
	Effect on the state budget (social benefits savings)

Festel et al. (2013) analyzed the chemical/industrial parks in Europe based on their positioning and specialization situation and key performance indicators related to energy, steam and water supply and fire and security services. Examples of potential performance improvement areas are also provided, using good practice examples.

Koc & Bulmus (2014), analyzed the efficiency of OIZs founded in Sivas and Kayseri provinces and tried to determine the firms' perception about OIZs' advantages. Primary and secondary data were used in this study. To collect primary data 612 surveys were applied to the firms in the Kayseri and Sivas. Besides, statistical tests were applied to the data collected and differences and similarities were analyzed.

Liu Z. et al. (2016) focused on measuring an industrial park's sustainability in China. For this evaluation the key indicators were defined and Kaya formula and index decomposition analysis (IDA) were used together. Renewable empower density, nonrenewable empower density, economic efficiency of process and economic return on investment were defined as indicators. Through this method these environmental and economic factors were considered together and calculated.

3. MATERIALS AND METHODS

3.1. Data Envelopment Analysis

Data envelopment analysis (DEA) proposed by Charnes et al. (1978) is a mathematical programming methodology, using common inputs and outputs as criteria to obtain the comparative efficiencies of homogeneous units. The homogeneous units evaluated for efficiencies are usually called as decision-making units (DMU).

DEA creates efficiency frontiers using input and output values. If a unit is positioned on one of the frontiers it is characterized as efficient. If it is located inside the frontier, then identified as inefficient (Giokas & Pentzaropoulos, 2000). DEA aims maximize the ratio of sum of weighted outputs to sum of weighted inputs, under the constraint that none of the DMUs can be active beyond the efficiency frontier (Façanha & Resende, 2004).

Most of the efficiency analysis methods require same measurement units for the criteria and need predetermined weights for them. This method which can overcome these difficulties on efficiency analysis was first used to measure comparative efficiencies of non-profit-making businesses and then found a common usage area in profit-oriented production and service sectors (Yolalan, 1993).

DEA has so many advantages. Charnes et al. (1994) indicated these advantages of DEA as listed below:

- It considers individual DMUs instead of average of the population.
- All of the DMUs have a single aggregate measure to utilize inputs to provide desired outputs.
- The multiple inputs and multiple outputs can be evaluated even if they have different measurement units.
- Adjustments can be made for extraneous variables.
- It can involve categorical variables.

- It does not require any priori weights knowledge and specification for the inputs and outputs.
- It does not have the restriction on the functional form of the production relationship.
- Judgment accommodation is possible if it is desired.
- It can offer changes to raise the inefficient DMUs to the efficient frontier.
- It produces Pareto optimal results.
- It focuses on "best" instead of "center-tendency" when producing results.
- Equity criteria is satisfied for the each DMU's comparative efficiency evaluation.

These indicated advantages provides common usage of the method. Emrouznejad & Yang examined the 9881 DEA related articles published in journals between 1978 and 2016 and tried to reach some statistics about publications' growth, application fields of DEA, the key words used with DEA etc. The rapid growth of articles related to DEA by years can be seen on Figure 3.1.

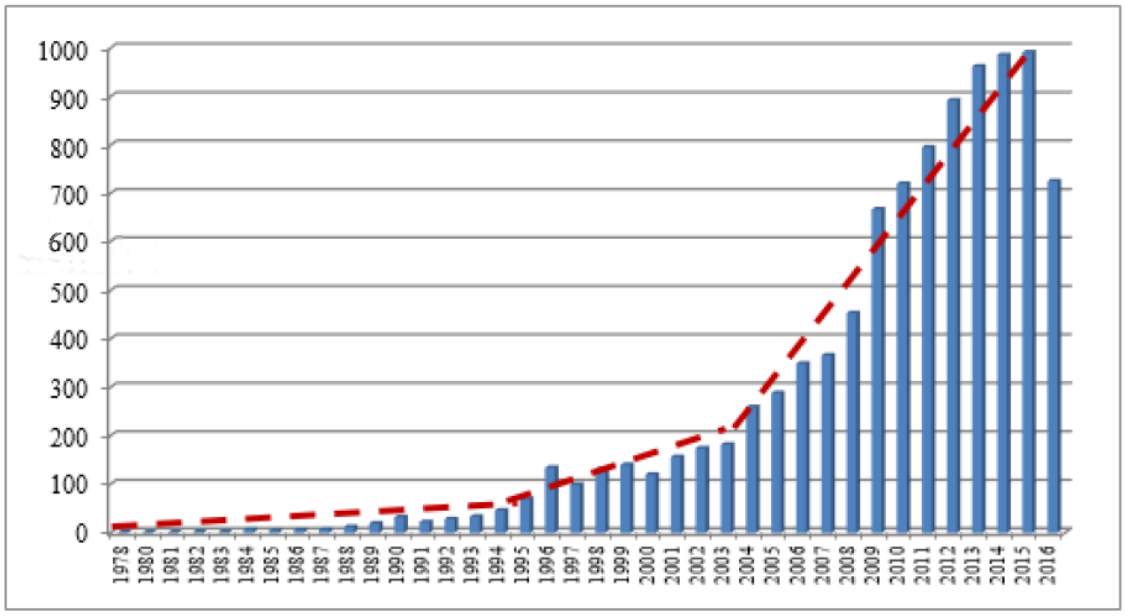

Figure 3.1: The growth of articles related to DEA

Besides the increase in the usage amount of the method, usage areas are also increasing. The method is applied in many area which includes healthcare, transportation, software

and financial industry and so on. According to Emrouznejad & Yang's study top 5 application areas of the method in 2015 and 2016 are Agriculture, Banking, Supply Chain, Transportation and Public Policy respectively.

This rapid growth and wide usage area shows that DEA is a really powerful and applicable method.

3.2. History of DEA

The story of DEA bases on Edwardo Rhodes's Ph.D. thesis supervised by W.W. Cooper. In this research an educational program (Program Follow Through) for disadvantaged students in the U.S. public schools which were supported by the government was wanted to be evaluated. In this analysis the schools which attended to this program and which not attended were compared. To evaluate the performance of the schools, multiple inputs and multiple outputs should had been used and there was not priori weights for them. Therefore it was a challenge to measure the comparative technical efficiency. To calculate these efficiency scores CCR (Charnes, Cooper and Rhodes) formulation was generated and first article related to DEA was published in European Journal of Operations Research in 1978 (Charnes et al., 1978 ; Charnes et al., 2013).

CCR used the mathematical programming optimization tool to generalize the single input and single output technical efficiency measurement method proposed by Farrell (1957) to multiple inputs and multiple outputs.

Farrell tried to develop better models for the measurement of productivity. The methods which attempted to evaluate productivity were restrictive because of their failure to convert the multiple input measurements to overall measure of efficiency. Farrell developed an activity analysis approach to overcome the inadequacies of different indices of capital productivity, labor productivity etc. Cooper and Rhodes created the scope of the "Efficiency - Extended Pareto Koopmans Definition" and "Relative Efficiency" definitions based on the Farrell's activity analysis approach and these definitions helped them for their next research. And CCR formulation was generated, hence Farrell's study

had been involving single output and it was not adequate for large data sets such as Program Follow Through's data (Cooper et al., 2011).

3.3. CCR Model

In the original DEA model, Charnes et al. (1978) defined the efficiency of any DMU as the maximum of the ratio of "sum of weighted outputs" and "sum of weighted inputs" under the constraint that the ratios of all DMUs cannot be greater than 1. The mathematical programming input oriented model is given below.

$$\max h_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}}$$

subject to:

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, \qquad j = 1, \dots, n,$$

$$u_r, v_i \geq 0\,; \qquad r = 1, \dots, s\,; \qquad i = 1, \dots, m. \tag{3.1}$$

In this formulation it is assumed that there are *n* DMU which uses *m* different inputs to obtain *s* different outputs. For the j_{th} DMU x_{ij}($i = 1,\dots,m$) represents the amount of input used and y_{rj}($r = 1,\dots,s$) represents the amount of output used. u_r, v_i are the weights of outputs and inputs respectively and they are obtained by the solution of the problem. The subscript '0' which were in h_0, x_{i0} and y_{r0} represents the evaluated DMU.

By the Charnes-Cooper transformation (Charnes & Cooper, 1962 ; Charnes & Cooper, 1973) which uses the following conversion the formulation (3.1) is converted to linear programming form (3.2).

$$\omega_i = t v_i\,; \qquad i = 1, \dots, m,$$
$$\mu_r = t u_r\,; \qquad r = 1, \dots, s,$$

$$t^{-1} = \sum_{r} v_i x_{i0}$$

$$\max h_0 = \sum_{r=1}^{s} \mu_r y_{r0}$$

subject to:

$$\sum_{i=1}^{m} \omega_i x_{ij} - \sum_{r=1}^{s} \mu_r y_{rj} \geq 0,$$

$$\sum_{i=1}^{m} \omega_i x_{i0} = 1$$

$$\mu_r, \omega_i \geq 0 \qquad (3.2)$$

and linear programming dual problem is;

$$\theta^* = \min \theta$$

subject to:

$$\sum_{j=1}^{n} x_{ij} \lambda_j \leq \theta x_{i0} \qquad i = 1, \dots, m$$

$$\sum_{j=1}^{n} y_{rj} \lambda_j \leq y_{r0} \qquad r = 1, \dots, s$$

$$\lambda_j \geq 0 \qquad j = 1, \dots, n \qquad (3.3)$$

$z^* = \theta^*$ is the optimal solution and produces an efficiency score for a particular DMU. DMUs with $\theta^* < 1$ are inefficient and DMUs with $\theta^* = 1$ are boundary points. Some boundary points may be weakly efficient because there are nonzero slacks. To prevent possible negative case, slacks (s_i^-, s_r^+) which are determined by the model are involved and maximized (Cooper et al., 2011).

$$\max \sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+$$

subject to:

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta^* x_{i0} \qquad i = 1, \dots, m$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{r0} \qquad r = 1, \dots, s$$

$$\lambda_j, s_i^-, s_r^+ \geq 0 \; \forall \, i, j, r \tag{3.4}$$

If $\theta^* = 1$ and $s_i^{-*} = s_r^{+*} = 0$, DMU_0 is called as "DEA efficient". But if $\theta^* = 1$ and $s_i^{-*} \neq 0$ and/or $s_r^{+*} \neq 0$ for some i or r in some alternate optima, DMU_0 is called as "weakly DEA efficient".

The preceding formulations can be developed as envelopment model;

$$\min \theta - \varepsilon \left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \right)$$

subject to:

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{i0} \qquad i = 1, \dots, m$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{r0} \qquad r = 1, \dots, s$$

$$\lambda_j, s_i^-, s_r^+ \geq 0 \; \forall \, i, j, r \tag{3.5}$$

ε is non-Archimedean element which is greater than 0 and smaller than any positive real number.

If the CCR model is wanted to be applied as output oriented, the development of the models will be as indicated below.

$$\min f_0 = \frac{\sum_{i=1}^{m} v_i x_{i0}}{\sum_{r=1}^{s} u_r y_{r0}}$$

subject to:

$$\frac{\sum_{i=1}^{m} v_i x_{ij}}{\sum_{r=1}^{s} u_r y_{rj}} \geq 1;\ j = 1, \dots, n,$$

$$u_r, v_i \geq 0\ ; \quad r = 1, \dots, s\ ; \quad i = 1, \dots, m. \tag{3.6}$$

$$\min g_0 = \sum_{i=1}^{m} \omega_i x_{i0}$$

subject to:

$$\sum_{i=1}^{m} \omega_i x_{ij} - \sum_{r=1}^{s} \mu_r y_{rj} \geq 0\ ,$$

$$\sum_{r=1}^{s} \mu_r y_{r0} = 1\ ,$$

$$\mu_r, \omega_i \geq 0 \tag{3.7}$$

After the slacks are not involved and ϑ^* is calculated, the problem is developed similar to the input oriented version by involving the slacks.

$$\max \sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+$$

subject to:

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = x_{i0} \qquad i = 1, \dots, m$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = \vartheta^* y_{r0} \qquad r = 1, \dots, s$$

$$\lambda_j, s_i^-, s_r^+ \geq 0 \; \forall \; i, j, r \tag{3.8}$$

And the CCR envelopment model for output oriented version is reached.

$$\max \vartheta + \varepsilon \left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \right)$$

subject to:

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = x_{i0} \qquad i = 1, \dots, m$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = \vartheta y_{r0} \qquad r = 1, \dots, s$$

$$\lambda_j, s_i^-, s_r^+ \geq 0 \; \forall \; i, j, r \tag{3.9}$$

3.4. DEA-Based Models

While conventional DEA – CCR Model (Charnes et al., 1978) has many positive aspects in terms of efficiency measurement, it also has some shortcomings. Many new approaches / models have been proposed in order to overcome these disadvantages.

One of the shortcomings of conventional DEA model is that it assigns unrealistic weights to the inputs and outputs to produce high efficiency score for the evaluated DMU and therefore the number of efficient DMUs can be quite high. Mimsum and minimax efficiency models (Li & Reeves, 2011) are two of the proposed models which are developed to overcome this problem. Minsum efficiency model aims to minimize the sum of the deviations from efficiency for each DMU and represented as follows:

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

subject to:

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

$$\sum_{i=1}^{m} v_i x_{i0} = 1,$$

$$u_r, v_i, d_j \geq 0 , \qquad \forall r, i , j \tag{3.10}$$

where d_j is the deviation variable for the j_{th} DMU. DMU_0 is minsum efficient if and only if the value of d_0 (the deviation variable for DMU_0) corresponding to the solution that minimizes sum of the deviations from efficiency is zero. It means that DMU_0 is efficient if and only if $d_0 = 0$ or, equivalently $h_0 = 1$. (h_0 is the efficiency score of DMU_0) If DMU_0 is not efficient, its efficiency score is $h_0 = 1 - d_0$.

Minimax efficiency model aims to minimize maximum deviation from efficiency and represented as follows:

$$\min M$$

subject to:

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

$$\sum_{i=1}^{m} v_i x_{i0} = 1,$$

$$M - d_j \geq 0, \qquad \forall j$$

$$u_r, v_i, d_j \geq 0 , \qquad \forall r, i , j \tag{3.11}$$

where *M* is the maximum deviation from efficiency. Efficiency score calculation is the same with the minsum efficiency model.

DMUs are classified as efficient DMUs and inefficient DMUs in mimimax and minsum models as conventional DEA model and they reduces the number of efficient DMUs but cannot reduce to "1" in general. Efficiency ranking can be obtained for inefficient DMUs, whereas ranking is not possible for the efficient DMUs and it means that discriminating power is low.

The other shortcoming of these models is that they require "*n*" computations. It means that if there is 100 DMU in the data set, the model should be solved 100 times to obtain efficiency scores for all DMUs.

Most importantly, the model, which is solved separately for each DMU in the classical DEA method, assigns different weights to the variables in order to maximize the efficiency score for the evaluated DMU. DMU efficiency scores which are determined by different weights assigned to variables affect the comparison's success. It is difficult to evaluate all of these DMUs on the same basis.

In order to eliminate these weaknesses "common weight DEA-based models" are developed. These models creates common weights for all DMUs' input and output variables and they require fewer computations. One of these common weight DEA-based models is the model which is proposed by Sun et al. (2013).

Sun et al. (2013) developed a common-weight DEA-based decision model to obtain the efficiency values of the alternatives and ranking them. Initially, they proposed the following linear programming model.

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

subject to,

$$\sum_{i=1}^{m} \omega_i x_{ij} - d_j = \sum_{r=1}^{s} \mu_r y_{rj}, \quad \forall j,$$

$$\sum_{i=1}^{m} \omega_i x_{\boldsymbol{min}} = 1,$$

$$\sum_{r=1}^{s} \mu_r y_{max} = 1,$$

$$\mu_r, \omega_i \geq \varepsilon, \ \ \forall r, i$$

$$d_j \geq 0, \ \ \forall j \qquad (3.12)$$

In this model the input data of all DMUs form a matrix having *m* rows and *n* columns, and output data form a matrix having *s* rows and *n* columns. The smallest data of each row of input matrix is selected to be the input of the virtual positive ideal DMU, and the biggest data of each row of output matrix is selected to be the output of the virtual positive ideal DMU. Positive ideal DMU can be showed with DMUI = (x_{min}, y_{max}), $x_{min} = min\{x_{ij} | j = 1, \dots, n\}, \ \ (i = 1, \dots, m)$ and $y_{max} = max\{y_{rj} | j = 1, \dots, n\}, \ \ (r = 1, \dots, s)$

Second, they developed the following non-linear programming model because the optimal weights calculated by the Formulation (3.12) are generally not unique.

$$max \sum_{i=1}^{m} \omega_i^2 + \sum_{r=1}^{s} \mu_r^2$$

subject to,

$$\sum_{j=1}^{m} \left(\sum_{i=1}^{m} \omega_i x_{ij} - \sum_{r=1}^{s} \mu_r y_{rj} \right) = D^*,$$

$$\sum_{i=1}^{m} \omega_i x_{ij} - \sum_{r=1}^{s} \mu_r y_{rj} \geq 0, \quad \forall j,$$

$$\sum_{i=1}^{m} \omega_i x_{\boldsymbol{min}} = 1,$$

$$\sum_{r=1}^{s} \mu_r y_{max} = 1,$$

$$\mu_r, \omega_i \geq \varepsilon, \quad \forall r, i \tag{3.13}$$

where D^* is the optimal objective function value of Formulation (3.12).

To calculate the efficiency scores the weights for inputs and outputs which are determined by the model are multiplied by the related inputs and outputs values and $\sum_{r=1}^{s} \mu_r y_{rj} \ / \ \sum_{i=1}^{m} \omega_i x_{ij}$ formulation is used for each DMU.

3.5. Implementation Steps of DEA

3.5.1. Determination of Decision Making Units

The first step in DEA involves the selection of the decision making units. It is important that these units stated in other words observation set should be "homogeneous" in terms of the significance of the results. The homogeneity of this group means that the decision - making units have the same input - output mixes and the external factors are not very different from each other (Bektas, 2007).

3.5.2. Determination of Input – Output Sets

To be able to use the DEA, decision-making units must be selected first. Input and output variables for these units must be specified in order to measure the efficiencies. Different input and output groups can receive different efficiency scores for the same decision making unit. If an important variable is ignored in the model, the efficiency of decision making units that are effectively using this out-of-context variable will be low. In the literature applications, it is seen that the decision making units which appear to be inefficient may be placed on the border by adding new inputs and outputs to the model. However, adding too much input and output is not the solution, as the number increases, the ability of discrimination of DEA decreases (Cooper et al., 2000).

There are different opinions in the literature about the relationship between the number of DMUs and the number of variables:

- The number of DMUs should be at least twice the number of inputs and outputs (Dyson et al., 2001).
- The sum of inputs and outputs must be less than the number of decision making units (Sherman, 1984).

However, such a rule is neither imperative, nor does it have a statistical basis, but rather is often imposed for convenience (Cook et al., 2014).

One way to reduce input and output numbers in DEA is to examine correlations. If there is perfect correlation between the two variables, one of them can be removed from the model without changing the efficiency scores (Ulutas, 2006).

3.5.3. Obtaining Reliable Data

Once the inputs and outputs for the DEA have been defined, it is necessary to obtain these input and output data for all DMUs. If reliable data cannot be obtained for any unit, the related unit is removed from the model since the efficiency values of the units will become controversial. For this reason, selection of inputs and outputs which the data reliability and quality are high is important for the reliable analysis results.

3.5.4. Relative Efficiency Measurement by DEA

After the inputs, outputs and DMUs have been determined and reliable data has been obtained, efficiency values for the application is calculated. The implementer uses the most appropriate DEA model for the problem studied. Any of the linear programming package programs (LINDO, GAMS, etc.) can be used to solve the model. In recent years there are also special DEA programs such as DEA Solver, Frontier Analysist, EMS which can run under Windows. The growth of such programs has also pointed to the increasing use of the DEA approach.

3.5.5. Evaluation of Efficiency Scores

As Charnes and Cooper have formulated, 100% efficiency for any decision making unit is the case in the following situations:

No output can be increased except in the following cases:

- Increasing one or more inputs or
- Reduction of some from other outputs.

No input can be reduced except in the following cases:

- Reducing some of the outputs or
- Increasing some other inputs.

For each DMU an efficiency score is calculated. Units with an efficiency score equal to 1 form the "best set of observations". Decision making units which have efficiency score smaller than 1 are relatively inefficient and the deviation rate from 1 gives a relative inefficiency measure (Aydemir, 2002).

4. EFFICIENCY ANALYSIS OF ORGANIZED INDUSTRIAL ZONES IN TURKEY

In this study, the efficiency of organized industrial zones in 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.

According to Ministry of Science, Industry and Technology's data there are 285 OIZs in Turkey by the end of 2015. In these 285 OIZs in 48.631 industrial parcels are started production and 1.575.842 employment are provided. Total zone size, number of parcels, employment and occupancy rates for the OIZs in Turkey by the end of 2015 are given in Table 4.1.

Table 4.1: Turkey's OIZs' total data by the end of 2015

Zone Size (Ha)	83.356
Industrial Parcel Size (Ha)	52.362
Number of Parcels (Zoning) (x)	75.125
Number of Parcels (Zone) (y)	70.513
Total Number of Parcels (Zone + Foresight)	75.538
Number of Assigned Parcels	57.089
Size of Assigned Parcels (Ha)	38.705
Number of Idle Parcels	13.424

Table 4.1. Turkey's OIZs' total data by the end of 2015 (cont.)

Size of Idle Parcels (Ha)	13.657
Number of Parcels in Production	48.631
Number of Parcels in Construction	3.406
Number of Parcels in Project	5.052
Employment	1.575.842
Estimated Employment	2.166.769
Occupancy Rate (Number of Assigned Parcels / Number of Parcels (Zone))	66%
Rate of Parcels in Production (Number of Parcels in Production / Number of Parcels (Zone))	40%

As it is seen on the table, average occupancy rate of the Turkey's OIZs is 66% by the end of 2015 and cannot be said to be a high rate. On the other hand, the rate of parcels in production is lower and only 40%. 38 OIZs do not have parcels in the zone although there are parcels in the zoning plan. Therefore for these 38 OIZs, the occupancy rate and rate of parcels in production cannot be calculated and is not included in the calculation for Turkey.

It is wanted to evaluate the efficiencies of the OIZs as these rates are not at the desired level and it is aimed to identify the OIZs which can be developed.

4.1. Determination of Decision Making Units

According to the 2015 year-end data there are 285 OIZs in Turkey. When these data are examined in detail, it is seen that 38 OIZs do not have parcels in the zone and no firm is in production in 79 OIZs. Besides, there are 94 OIZs less than 3 firms in the production, and 122 OIZs less than 10. Some data related to these 122 OIZs is shared in Table 4.2.

Table 4.2: OIZs with less than 10 parcels in production

Geographical Region	OIZ Name	Number of Parcels (Zone)	Number of Assigned Parcels	Number of Parcels in Production	Number of Parcels in Construction	Number of Parcels in Project	Number of Idle Parcels	Employment	Estimated Employment	OIZ Establishment Year
Mediterranean	Antalya-Kumluca Food Specialty	30	0	0	0	0	30	0	960	2008
Mediterranean	Burdur II.	24	12	0	0	12	12	0	864	2009
Mediterranean	Hatay-Erzin	0	0	0	0	0	0	0	0	2001
Mediterranean	Hatay-İskenderun II	8	8	0	0	8	0	0	320	2006
Mediterranean	Isparta-Yalvaç	108	0	0	0	0	108	0	3.456	2000
Mediterranean	Kahramanmaraş-Türkoğlu	29	28	0	1	27	1	0	1.152	2009
Mediterranean	Kahramanmaraş-Elbistan	84	0	0	0	0	84	0	2.688	2015
Mediterranean	Kahramanmaraş-Textile Specialty	0	0	0	0	0	0	0	0	2009
Eastern Anatolia	Ağrı	103	7	3	2	2	96	50	3.282	2000
Eastern Anatolia	Ardahan	30	2	1	0	1	28	10	946	2001
Eastern Anatolia	Bitlis	55	0	0	0	0	55	0	1.760	2001
Eastern Anatolia	Erzurum-Merkez II	38	0	0	0	0	38	0	1.216	2001
Eastern Anatolia	Erzurum-Oltu	0	0	0	0	0	0	0	0	2002
Eastern Anatolia	Hakkari	0	0	0	0	0	0	0	0	2001
Eastern Anatolia	Malatya-Darende	35	5	0	0	5	30	0	1.160	2001

Table 4.2: OIZs with less than 10 parcels in production (cont.)

Geographical Region	OIZ Name	Number of Parcels (Zone)	Number of Assigned Parcels	Number of Parcels in Production	Number of Parcels in Construction	Number of Parcels in Project	Number of Idle Parcels	Employment	Estimated Employment	OIZ Establishment Year
Eastern Anatolia	Malatya-Akçadağ Marble Specialty	0	0	0	0	0	0	0	0	2001
Eastern Anatolia	Muş	54	39	3	8	28	15	44	1.964	2001
Eastern Anatolia	Tunceli	43	21	9	10	2	22	90	1.274	2000
Eastern Anatolia	Van-Erciş	34	0	0	0	0	34	0	1.088	2013
Aegean	Afyonkarahisar-Bolvadin	67	4	4	0	0	63	20	2.036	2000
Aegean	Afyonkarahisar-Şuhut	158	32	2	8	22	126	10	5.242	2006
Aegean	Afyonkarahisar-Emirdağ	31	14	9	3	2	17	492	1.236	2001
Aegean	Afyonkarahisar-Merkez II	0	0	0	0	0	0	0	0	2000
Aegean	Afyonkarahisar-Sandıklı	42	19	7	2	10	23	80	1.296	2001
Aegean	Afyonkarahisar-Dinar	76	9	1	4	4	67	0	2.464	2008
Aegean	Afyonkarahisar-Dazkırı Weaving and Garment Industry	65	0	0	0	0	65	0	2.080	2001
Aegean	Aydın-Buharkent	56	0	0	0	0	56	0	1.792	2001
Aegean	Aydın-Çine	51	5	0	1	4	46	0	1.672	2002

Table 4.2: OIZs with less than 10 parcels in production (cont.)

Geographical Region	OIZ Name	Number of Parcels (Zone)	Number of Assigned Parcels	Number of Parcels in Production	Number of Parcels in Construction	Number of Parcels in Project	Number of Idle Parcels	Employment	Estimated Employment	OIZ Establishment Year
Aegean	Aydın-Ortaklar	35	27	8	7	12	8	547	1.563	2001
Aegean	Aydın-Söke	89	10	0	1	9	79	0	2.928	2000
Aegean	Denizli-Çardak Özdemir Sabancı	85	84	1	0	83	1	63	3.415	2000
Aegean	İzmir-Bergama	96	4	1	0	3	92	45	3.109	2001
Aegean	İzmir-Kınık	41	38	6	1	31	3	95	1.471	2008
Aegean	İzmir-Ödemiş	46	0	0	0	0	46	0	1.472	2001
Aegean	İzmir-Bayosb (Bağyurdu)	47	6	2	3	1	41	100	1.572	2011
Aegean	İzmir-Torbalı	43	43	1	5	37	0	9	1.689	2001
Aegean	İzmir-Menemen Plastic Specialty	40	34	0	1	33	6	0	1.552	2004
Aegean	Kütahya-Merkez 2	31	15	5	5	5	16	235	1.147	2006
Aegean	Kütahya-Simav	0	0	0	0	0	0	0	0	2001
Aegean	Manisa-Soma	0	0	0	0	0	0	0	0	2001
Aegean	Manisa-Kula Leather Specialty	0	0	0	0	0	0	0	0	2013
Aegean	Manisa Akhisar Oil and Oliveoil Specialty	0	0	0	0	0	0	0	0	2001

Table 4.2: OIZs with less than 10 parcels in production (cont.)

Geographical Region	OIZ Name	Number of Parcels (Zone)	Number of Assigned Parcels	Number of Parcels in Production	Number of Parcels in Construction	Number of Parcels in Project	Number of Idle Parcels	Employment	Estimated Employment	OIZ Establishment Year
Aegean	Muğla-Milas	73	0	0	0	0	73	0	2.336	2001
Aegean	Uşak-Karahallı	86	36	7	6	23	50	98	2.858	2001
Southeastern Anatolia	Adıyaman-Gölbaşı	35	11	7	3	1	24	80	1.008	2005
Southeastern Anatolia	Adıyaman-Besni	40	18	2	3	13	22	350	1.694	2005
Southeastern Anatolia	Gaziantep İslahiye	73	0	0	0	0	73	0	2.336	2002
Southeastern Anatolia	Mardin 2.	0	0	0	0	0	0	0	0	2013
Southeastern Anatolia	Siirt	76	11	4	5	2	65	70	2.430	2001
Southeastern Anatolia	Şanlıurfa-Birecik	41	0	0	0	0	41	0	1.312	2011
Southeastern Anatolia	Şırnak-Cizre	57	31	6	10	15	26	95	1.927	2001
Southeastern Anatolia	Şırnak	24	4	1	1	2	20	12	772	2001
Central Anatolia	Ankara-Polatlı Ticaret Odası	128	10	0	2	8	118	0	4.176	2000
Central Anatolia	Ankara-Şereflikoçhisar	0	0	0	0	0	0	0	0	2015
Central Anatolia	Ankara Founders Specialty	104	0	0	0	0	104	0	3.328	2008
Central Anatolia	Ankara Aeronautics and Space Specialty	0	0	0	0	0	0	0	0	2001

Table 4.2: OIZs with less than 10 parcels in production (cont.)

Geographical Region	OIZ Name	Number of Parcels (Zone)	Number of Assigned Parcels	Number of Parcels in Production	Number of Parcels in Construction	Number of Parcels in Project	Number of Idle Parcels	Employment	Estimated Employment	OIZ Establishment Year
Central Anatolia	Çankırı-Çerkeş	40	13	3	9	1	27	75	1.339	2001
Central Anatolia	Çankırı-Kurşunlu (Çavundur)	0	0	0	0	0	0	0	0	2005
Central Anatolia	Çankırı-Yakınkent	130	0	0	0	0	130	0	4.160	2012
Central Anatolia	Eskişehir-Sivrihisar	0	0	0	0	0	0	0	0	2002
Central Anatolia	Kırıkkale-Keskin	83	13	4	8	1	70	146	2.746	2013
Central Anatolia	Kırıkkale Arms Industry Specialty	64	0	0	0	0	64	0	2.048	2001
Central Anatolia	Kırşehir-Kaman	112	2	2	0	0	110	6	3.526	2002
Central Anatolia	Kırşehir-Mucur	0	0	0	0	0	0	0	0	2006
Central Anatolia	Konya-Çumra	41	41	5	5	31	0	50	1.490	2000
Central Anatolia	Konya-Kulu	0	0	0	0	0	0	0	0	2001
Central Anatolia	Konya-Seydişehir	55	47	2	4	41	8	24	2.080	2000
Central Anatolia	Nevşehir-Acıgöl	94	32	5	5	22	62	170	3.234	2001
Central Anatolia	Nevşehir-Islah	0	0	0	0	0	0	0	0	2014
Central Anatolia	Sivas Gemerek	43	0	0	0	0	43	0	1.376	2000
Central Anatolia	Sivas-Merkez II	0	0	0	0	0	0	0	0	2001
Central Anatolia	Yozgat-Kaleseramik Private	22	2	2	0	0	20	210	850	2007

Table 4.2: OIZs with less than 10 parcels in production (cont.)

Geographical Region	OIZ Name	Number of Parcels (Zone)	Number of Assigned Parcels	Number of Parcels in Production	Number of Parcels in Construction	Number of Parcels in Project	Number of Idle Parcels	Employment	Estimated Employment	OIZ Establishment Year
Black Sea	Amasya-Suluova	65	26	9	6	11	39	150	2.078	2005
Black Sea	Bayburt	127	25	6	13	6	102	41	4.065	2003
Black Sea	Bolu-Yeniçağa	50	0	0	0	0	50	0	1.600	2001
Black Sea	Bolu-Gerede Leather Specialty	127	1	0	0	1	126	0	4.072	2001
Black Sea	Çorum-Sungurlu	83	14	3	0	11	69	33	2.681	2015
Black Sea	Çorum-Osmancık	0	0	0	0	0	0	0	0	2001
Black Sea	Düzce II	11	11	9	2	0	0	647	727	2015
Black Sea	Düzce Çilimli	0	0	0	0	0	0	0	0	2014
Black Sea	Düzce Gümüşova Reclamation	0	0	0	0	0	0	0	0	2005
Black Sea	Giresun 2.	73	0	0	0	0	73	0	2.336	2012
Black Sea	Kastamonu-Seydiler	45	45	8	2	35	0	150	1.630	2013
Black Sea	Kastamonu-Taşköprü	0	0	0	0	0	0	0	0	2000
Black Sea	Rize-Ardeşen	0	0	0	0	0	0	0	0	2000
Black Sea	Rize	27	22	0	0	22	5	0	1.040	2005
Black Sea	Samsun- Havza Agricultural Machinery Specialty	61	0	0	0	0	61	0	1.952	2000

Table 4.2: OIZs with less than 10 parcels in production (cont.)

Geographical Region	OIZ Name	Number of Parcels (Zone)	Number of Assigned Parcels	Number of Parcels in Production	Number of Parcels in Construction	Number of Parcels in Project	Number of Idle Parcels	Employment	Estimated Employment	OIZ Establishment Year
Black Sea	Sinop-Boyabat	24	4	0	2	2	20	0	800	2001
Black Sea	Tokat-Niksar	23	8	2	1	5	15	241	961	2001
Black Sea	Tokat-Turhal	33	22	8	1	13	11	250	1.162	2001
Black Sea	Tokat-Zile	70	16	2	2	12	54	105	2.393	2000
Black Sea	Trabzon-Vakfıkebir	0	0	0	0	0	0	0	0	2008
Black Sea	Trabzon-Şinik Akçaabat	49	45	0	2	43	4	0	1.928	2000
Black Sea	Zonguldak-Alaplı	0	0	0	0	0	0	0	0	2001
Marmara	Balıkesir-Gönen Leather Specialty	55	31	0	1	30	24	0	2.008	2010
Marmara	Balıkesir-Burhaniye Olive and Olive Products Specialty	43	0	0	0	0	43	0	1.376	2001
Marmara	Bilecik-Osmaneli	17	17	4	6	7	0	76	596	2001
Marmara	Bilecik-Pazaryeri	29	11	6	0	5	18	447	1.223	2001
Marmara	Bilecik-Söğüt	41	4	0	0	4	37	0	1.344	2001
Marmara	Bursa-Yenişehir	44	2	2	0	0	42	1.197	2.541	2006

Table 4.2: OIZs with less than 10 parcels in production (cont.)

Geographical Region	OIZ Name	Number of Parcels (Zone)	Number of Assigned Parcels	Number of Parcels in Production	Number of Parcels in Construction	Number of Parcels in Project	Number of Idle Parcels	Employment	Estimated Employment	OIZ Establishment Year
Marmara	Bursa-Teknosab	0	0	0	0	0	0	0	0	2014
Marmara	Bursa-Mustafakemalpaşa Marble Specialty	32	0	0	0	0	32	0	1.024	2001
Marmara	Bursa-Tosab Textile Dyeing Plants Specialty	71	0	0	0	0	71	0	2.272	2001
Marmara	Bursa-Yenice Reclamation	0	0	0	0	0	0	0	0	2005
Marmara	Bursa-Akçalar Reclamation	0	0	0	0	0	0	0	0	2015
Marmara	Bursa-Barakfakih Reclamation	0	0	0	0	0	0	0	0	2004
Marmara	Kırklareli-Pagder-Aslan Plastic Specialty	0	0	0	0	0	0	0	0	2014
Marmara	Kırklareli-Lüleburgaz Evrensekiz Reclamation	63	15	9	0	6	48	1.207	2.983	2002
Marmara	Kocaeli-Alikahya	60	27	0	0	27	33	0	2.136	2003
Marmara	Kocaeli-Asım Kibar	38	6	6	0	0	32	4.426	5.450	2004
Marmara	Kocaeli-Kandıra Food Specialty	0	0	0	0	0	0	0	0	2001
Marmara	Sakarya-Karasu	6	6	0	1	5	0	162	402	2009

Table 4.2: OIZs with less than 10 parcels in production (cont.)

Geographical Region	OIZ Name	Number of Parcels (Zone)	Number of Assigned Parcels	Number of Parcels in Production	Number of Parcels in Construction	Number of Parcels in Project	Number of Idle Parcels	Employment	Estimated Employment	OIZ Establishment Year
Marmara	Sakarya-Ferizli	36	36	0	4	32	0	0	1.440	2007
Marmara	Sakarya-Kaynarca Furniture Specialty	48	48	0	0	48	0	0	1.920	2015
Marmara	Sakarya-Kaynarca East Marmara Machine Manifacturers Specialty	0	0	0	0	0	0	0	0	2010
Marmara	Tekirdağ	0	0	0	0	0	0	0	0	2014
Marmara	Tekirdağ-Malkara	49	49	8	37	4	0	297	1.937	2000
Marmara	Tekirdağ-Yalıboyu	34	0	0	0	0	34	0	1.088	2012
Marmara	Yalova-Mould Manufacturing Specialty	0	0	0	0	0	0	0	0	2015
Marmara	Yalova-Ship Specialty	0	0	0	0	0	0	0	0	2011
Marmara	Yalova-Vehicle Sub-Industry Specialty	0	0	0	0	0	0	0	0	2003
Marmara	Yalova Composite and Chemistry Specialty Reclamation	0	0	0	0	0	0	0	0	2014

As it is seen on the table, even though it has been 10 years since the foundation year, there are still OIZs which do not have any parcels in production.

In the Enterprise Information System the OIZ's data cannot be shared if there is less than 3 firms in the OIZ. After all some of the OIZs' firms' data were not entered in the system. Taking into account all of these factors, 109 OIZs in Turkey could be included to the study.

These 109 OIZs aren't classed in an only one group since the homogeneity of the decision-making units is important in the DEA. In Turkey, geographical regions are formed by considering natural factors, human factors and economic factors. These factors and sub-factors are given in Figure 4.1[4] In this context, 109 OIZs used in the study were classified according to geographical regions where they were in and their efficiencies were examined accordingly.

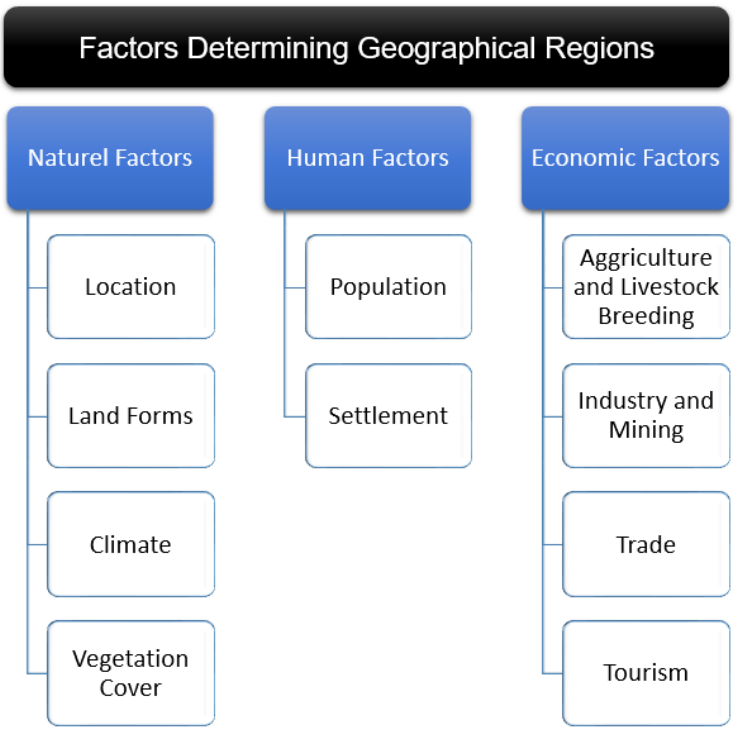

Figure 4.1: Factors determining geographical regions of Turkey[4]

[4] Archived from the "Mekansal Bir Sentez: Türkiye" source on 31 January 2012. Access date: April 15, 2010.

The 7 geographical regions of Turkey are:

- The Mediterranean Region
- The Aegean Region
- The Marmara Region
- The Black Sea Region
- The Central Anatolia Region
- The Eastern Anatolia Region
- The Southeastern Anatolia Region

The 109 OIZs classified on the basis of Turkey's geographical regions (GR) and the general data related to these OIZs is shared in the following tables.

Table 4.3: OIZs used in the study in Mediterranean Region

ID	GR	OIZ Name	Number of Parcels (Zone)	Number of Assigned Parcels	Number of Parcels in Production	Number of Parcels in Construction	Number of Parcels in Project	Number of Idle Parcels	Employment	Estimated Employment	OIZ Establishment Year
1	Mediterranean	Adana-Hacı Sabancı	522	521	340	69	112	1	33.430	40.702	2001
2	Mediterranean	Adana-Kozan	74	61	43	11	7	13	942	2.078	2001
3	Mediterranean	Antalya	327	323	216	37	70	4	10.397	14.805	2001
4	Mediterranean	Burdur	56	55	55	0	0	1	1.708	1.740	2001
5	Mediterranean	Hatay-Antakya	82	82	49	8	25	0	1.925	3.245	2001
6	Mediterranean	Kahramanmaraş	57	57	51	6	0	0	8.451	8.691	2002
7	Mediterranean	Mersin-Tarsus	198	197	163	26	8	1	10.571	11.963	2000
8	Mediterranean	Mersin-Silifke	55	52	34	8	10	3	733	1.549	2001
9	Mediterranean	Osmaniye	136	136	114	9	13	0	10.202	11.082	2001
10	Mediterranean	Osmaniye-Kadirli	36	34	29	3	2	2	1.260	1.524	2000

Table 4.4: OIZs used in the study in Aegean Region

ID	GR	OIZ Name	Number of Parcels (Zone)	Number of Assigned Parcels	Number of Parcels in Production	Number of Parcels in Construction	Number of Parcels in Project	Number of Idle Parcels	Employment	Estimated Employment	OIZ Establishment Year
1	Aegean	Afyonkarahisar	314	312	303	6	3	2	7.630	8.054	2001
2	Aegean	Afyonkarahisar-Emirdağ	31	14	9	3	2	17	492	1.236	2001
3	Aegean	Aydın- ASTİM	256	119	87	13	19	137	3.299	8.963	2003
4	Aegean	Aydın-Ortaklar	35	27	8	7	12	8	547	1.563	2001
5	Aegean	Denizli	179	178	129	2	47	1	25.000	26.992	2000
6	Aegean	Kütahya	84	84	76	2	6	0	5.517	5.837	2001
7	Aegean	Kütahya-Gediz	33	26	20	4	2	7	710	1.174	2001
8	Aegean	Kütahya-Tavşanlı	25	18	11	7	0	7	2.630	3.134	2001
9	Aegean	Manisa-Salihli	159	60	40	9	11	99	2.534	6.502	2012
10	Aegean	Manisa-Akhisar	76	76	41	16	19	0	2.674	4.074	2001
11	Aegean	Uşak-Karahallı	86	36	7	6	23	50	98	2.858	2001

Table 4.5: OIZs used in the study in Marmara Region

ID	GR	OIZ Name	Number of Parcels (Zone)	Number of Assigned Parcels	Number of Parcels in Production	Number of Parcels in Construction	Number of Parcels in Project	Number of Idle Parcels	Employment	Estimated Employment	OIZ Establishment Year
1	Marmara	Balıkesir	144	134	91	29	14	10	5.731	7.771	2001
2	Marmara	Bilecik-Bozüyük	80	38	26	4	8	42	1.655	3.479	2001
3	Marmara	Bilecik II	83	28	22	1	5	55	2.450	4.450	2003
4	Marmara	Bilecik-Osmaneli	17	17	4	6	7	0	76	596	2001
5	Marmara	Bilecik-Pazaryeri	29	11	6	0	5	18	447	1.223	2001
6	Marmara	Bursa	295	274	265	7	2	21	50.155	51.187	2000
7	Marmara	Bursa-Demirtaş	348	348	296	8	44	0	41.455	43.535	2015
8	Marmara	Bursa-Mustafakemalpaşa	64	64	18	11	35	0	496	2.336	2001
9	Marmara	Bursa-Kestel	93	76	76	0	0	17	3.600	4.144	2003
10	Marmara	Bursa-Nilüfer	289	269	260	9	0	20	21.522	22.522	2001
11	Marmara	Bursa-Hasanağa	105	82	77	5	0	23	7.915	8.851	2001
12	Marmara	Bursa-Leather Specialty	137	53	40	13	0	84	1.250	4.458	2001
13	Marmara	Çanakkale-Biga	49	47	27	15	5	2	562	1.426	2001
14	Marmara	Edirne	41	41	14	18	9	0	446	1.526	2001

Table 4.5: OIZs used in the study in Marmara Region (cont.)

ID	GR	OIZ Name	Number of Parcels (Zone)	Number of Assigned Parcels	Number of Parcels in Production	Number of Parcels in Construction	Number of Parcels in Project	Number of Idle Parcels	Employment	Estimated Employment	OIZ Establishment Year
15	Marmara	İstanbul-Tuzla	166	149	90	14	45	17	3.420	6.324	2002
16	Marmara	İstanbul-Birlik	85	85	80	2	3	0	3.298	3.498	2000
17	Marmara	İstanbul-Tuzla Chemical Industrialists	164	162	161	1	0	2	5.808	5.912	2000
18	Marmara	İstanbul-Anadolu Yakası	156	156	148	5	3	0	7.487	7.807	2001
19	Marmara	Kırklareli	86	57	26	11	20	29	2.550	4.718	2003
20	Marmara	Kırklareli-Lüleburgaz Evrensekiz Reclamation	63	15	9	0	6	48	1.207	2.983	2002
21	Marmara	Kocaeli-Gebze	191	189	154	15	20	2	22.328	23.792	2004
22	Marmara	Kocaeli-Asım Kibar	38	6	6	0	0	32	4.426	5.450	2004
23	Marmara	Kocaeli-Gebze Güzeller	72	72	59	10	3	0	5.298	5.818	2001
24	Marmara	Kocaeli-Gebze Plastic Specialty	147	147	109	16	22	0	10.020	11.540	2003
25	Marmara	Kocaeli-Gebze Coal Specialty	22	22	20	2	0	0	322	402	2001
26	Marmara	Kocaeli-TOSB-Automotive Supply Industry Specialty	90	90	74	7	9	0	16.000	16.640	2000

Table 4.5: OIZs used in the study in Marmara Region (cont.)

ID	GR	OIZ Name	Number of Parcels (Zone)	Number of Assigned Parcels	Number of Parcels in Production	Number of Parcels in Construction	Number of Parcels in Project	Number of Idle Parcels	Employment	Estimated Employment	OIZ Establishment Year
27	Marmara	Kocaeli-Machine Specialty	92	77	23	12	42	15	3.380	6.020	2001
28	Marmara	Kocaeli-Gebze V Chemistry Specialty	66	59	16	14	29	7	888	2.832	2010
29	Marmara	Kocaeli-Gebze VI (İMES) Machine Specialty	276	175	66	79	30	101	1.913	9.505	2001
30	Marmara	Sakarya I	103	68	54	2	12	35	8.151	9.831	2001
31	Marmara	Sakarya II	93	92	68	22	2	1	6.189	7.181	2001
32	Marmara	Tekirdağ-Hayrabolu	53	52	13	31	8	1	284	1.876	2000
33	Marmara	Tekirdağ-Malkara	49	49	8	37	4	0	297	1.937	2000
34	Marmara	Tekirdağ-Velimeşe	453	195	184	11	0	258	20.673	29.369	2012
35	Marmara	Tekirdağ-Veliköy	185	105	78	22	5	80	4.379	8.019	2000
36	Marmara	Tekirdağ-Ergene 2	259	130	116	4	10	129	13.744	18.432	2001
37	Marmara	Tekirdağ-Türkgücü	154	51	49	2	0	103	4.800	8.176	2012

Table 4.6: OIZs used in the study in Black Sea Region

ID	GR	OIZ Name	Number of Parcels (Zone)	Number of Assigned Parcels	Number of Parcels in Production	Number of Parcels in Construction	Number of Parcels in Project	Number of Idle Parcels	Employment	Estimated Employment	OIZ Establishment Year
1	Black Sea	Amasya	32	32	23	3	6	0	477	837	2001
2	Black Sea	Amasya-Merzifon	51	49	42	5	2	2	3.272	3.616	2001
3	Black Sea	Amasya-Suluova	65	26	9	6	11	39	150	2.078	2005
4	Black Sea	Bartın-Center I	30	30	30	0	0	0	3.631	3.631	2001
5	Black Sea	Bayburt	127	25	6	13	6	102	41	4.065	2003
6	Black Sea	Bolu-Mixed and Textile Specialty	85	71	55	7	9	14	4.050	5.138	2001
7	Black Sea	Çorum	266	137	88	25	24	129	5.847	11.935	2001
8	Black Sea	Düzce	60	59	54	5	0	1	5.553	5.785	2001
9	Black Sea	Düzce II	11	11	9	2	0	0	647	727	2015
10	Black Sea	Giresun	37	37	21	6	10	0	729	1.369	2001
11	Black Sea	Kastamonu-Seydiler	45	45	8	2	35	0	150	1.630	2013
12	Black Sea	Ordu-Fatsa	30	30	29	1	0	0	2.824	2.864	2001
13	Black Sea	Samsun-Center	105	105	99	5	1	0	5.115	5.355	2007
14	Black Sea	Samsun-Bafra	145	31	19	7	5	114	240	4.368	2001

Table 4.6: OIZs used in the study in Black Sea Region (cont.)

ID	GR	OIZ Name	Number of Parcels (Zone)	Number of Assigned Parcels	Number of Parcels in Production	Number of Parcels in Construction	Number of Parcels in Project	Number of Idle Parcels	Employment	Estimated Employment	OIZ Establishment Year
15	Black Sea	Samsun-Kavak	61	47	23	10	14	14	614	2.022	2000
16	Black Sea	Samsun-Food Specialty	24	24	12	11	1	0	168	648	2000
17	Black Sea	Sinop	67	46	29	10	7	21	1.400	2.752	2001
18	Black Sea	Tokat-Erbaa	104	22	12	7	3	82	1.575	4.599	2001
19	Black Sea	Trabzon-Arsin	87	87	78	8	1	0	4.447	4.807	2001
20	Black Sea	Trabzon-Beşikdüzü	35	35	16	10	9	0	255	1.015	2001
21	Black Sea	Zonguldak-Çaycuma	65	58	41	7	10	7	2.624	3.528	2001

Table 4.7: OIZs used in the study in Central Anatolia Region

ID	GR	OIZ Name	Number of Parcels (Zone)	Number of Assigned Parcels	Number of Parcels in Production	Number of Parcels in Construction	Number of Parcels in Project	Number of Idle Parcels	Employment	Estimated Employment	OIZ Establishment Year
1	Central Anatolia	Aksaray	313	313	185	107	21	0	8.250	13.370	2001
2	Central Anatolia	Ankara Başkent	620	541	85	126	330	79	7.000	27.768	2001
3	Central Anatolia	Ankara Chamber of Industry 2.-3.	321	293	34	35	224	28	1.900	13.156	2001
4	Central Anatolia	Ankara-Anadolu	144	75	11	64	0	69	424	5.192	2001
5	Central Anatolia	Ankara-Polatlı	76	65	24	38	3	11	865	2.857	2000
6	Central Anatolia	Ankara OSTİM	4.586	4.097	3.899	184	14	489	60.000	60.990	2002
7	Central Anatolia	Çankırı-Korgun	77	54	40	8	6	23	1.010	2.306	2005
8	Central Anatolia	Çankırı-Şabanözü	24	22	13	4	5	2	2.325	2.749	2006
9	Central Anatolia	Eskişehir Chamber of Industry	697	640	478	67	95	57	39.097	47.401	2001
10	Central Anatolia	Kayseri-İncesu	150	145	11	35	99	5	1.000	6.520	2001
11	Central Anatolia	Kayseri-Mimarsinan	372	360	88	154	118	12	2.417	13.681	2001
12	Central Anatolia	Kırıkkale I	68	61	35	7	19	7	1.800	3.064	2000
13	Central Anatolia	Kırıkkale-Keskin	83	13	4	8	1	70	146	2.746	2013
14	Central Anatolia	Konya-Ereğli	119	91	43	5	43	28	780	3.596	2001
15	Central Anatolia	Niğde	111	105	89	8	8	6	4.558	5.390	2001

Table 4.8: OIZs used in the study in Eastern Anatolia Region

ID	GR	OIZ Name	Number of Parcels (Zone)	Number of Assigned Parcels	Number of Parcels in Production	Number of Parcels in Construction	Number of Parcels in Project	Number of Idle Parcels	Employment	Estimated Employment	OIZ Establishment Year
1	Eastern Anatolia	Bingöl	45	41	21	5	15	4	600	1.528	2001
2	Eastern Anatolia	Elazığ	219	200	114	30	56	19	2.645	6.693	2001
3	Eastern Anatolia	Erzincan	213	103	63	15	25	110	1.430	6.550	2001
4	Eastern Anatolia	Erzurum-Center I	117	117	98	6	13	0	4.177	4.937	2001
5	Eastern Anatolia	Iğdır	105	31	15	4	12	74	165	3.173	2000
6	Eastern Anatolia	Kars	93	85	52	18	15	8	530	2.106	2001
7	Eastern Anatolia	Malatya Center I	510	204	147	16	41	306	8.850	20.922	2001
8	Eastern Anatolia	Malatya II	156	156	121	34	1	0	6.588	7.988	2011
9	Eastern Anatolia	Van	137	137	86	40	11	0	1.750	3.790	2000

Table 4.9: OIZs used in the study in Southeastern Anatolia Region

ID	GR	OIZ Name	Number of Parcels (Zone)	Number of Assigned Parcels	Number of Parcels in Production	Number of Parcels in Construction	Number of Parcels in Project	Number of Idle Parcels	Employment	Estimated Employment	OIZ Establishment Year
1	Southeastern Anatolia	Adıyaman-Kahta	78	37	16	10	11	41	512	2.664	2008
2	Southeastern Anatolia	Adıyaman-Gölbaşı	35	11	7	3	1	24	80	1.008	2005
3	Southeastern Anatolia	Batman	98	65	45	13	7	33	1.249	3.105	2001
4	Southeastern Anatolia	Gaziantep-Nizip	32	32	25	4	3	0	750	1.030	2014
5	Southeastern Anatolia	Kilis	37	35	29	1	5	2	1.200	1.504	2001
6	Southeastern Anatolia	Şanlıurfa-Viranşehir	133	46	33	7	6	87	350	3.654	2005

4.2. Determination of Input – Output Sets

In a performance comparison study, evaluation is made according to certain criteria. Factors such as screen size and resolution, memory size, process speed, hard disk size, and others are considered when choosing a computer, for example. One would then have to classify these criteria into "inputs" and "outputs" in order to apply a proper DEA analysis (Cook et al., 2014).

When the criteria were set in the study, the data kept for each OIZ by the Ministry of Science, Industry and Technology and the criteria used in the literature were examined and care was taken to select the ones that could have the greatest effect on determining the efficiency. As a result, the criteria for the evaluation of the efficiencies of OIZs in Turkey were determined as the "total industrial parcel area (Ha)", "total number of parcels (zone)", "total number of parcels in production (number of existing firms)", "employment of firms", "net sales of firms (TL)", "export volume of firms ($)", and "R&D expenses of firms".

Areas with a certain size and a certain number of parcels are assigned to the OIZs by the government and it is aimed to attract as many investors as possible. The OIZs aims to contribute to country employment, R&D work, sales and export volume through the firms in production on these parcels. Firms' R&D expenses shows how high they value R&D studies and the increase is considered positive. The parcels that are not allocated to the firms remain idle and show that the OIZs do not work efficiently.

When all these factors are considered, the inputs and outputs for the study are determined as follows:

Inputs:

- Total industrial parcel area (Ha)
- Total number of parcels (zone)

Outputs:

- Total number of parcels in production (number of existing firms)
- Employment of firms
- Net sales of firms (TL)
- Export volume of firms ($)
- R&D expenses of firms (TL)

4.3. Obtaining Reliable Data

As it is mentioned before 2015 year-end data of “Directorate General for Industrial Zones of Ministry of Science, Industry and Technology” and “Enterprise Information System of Ministry of Science, Industry and Technology” is used in the study. For all of the OIZs which could be included to study each input and output variable data are shared by the regions in Table 4.10 - Table 4.16.

Table 4.10: Input-output data for the OIZs in Mediterranean Region

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
1	Mediterranean	Adana-Hacı Sabancı	1.068,78	522	340	33.430	19.272.712.473	18.506.010	848.324.406
2	Mediterranean	Adana-Kozan	82,00	74	43	942	155.763.326	0	27.576.418
3	Mediterranean	Antalya	499,42	327	216	10.397	6.247.297.531	6.058.156	203.624.413
4	Mediterranean	Burdur	58,17	56	55	1.708	593.091.158	1.825	20.970.074
5	Mediterranean	Hatay-Antakya	99,50	82	49	1.925	520.841.628	170.964	18.249.122
6	Mediterranean	Kahramanmaraş	181,00	57	51	8.451	3.251.353.535	3.282.967	76.688.557
7	Mediterranean	Mersin-Tarsus	404,00	198	163	10.571	7.580.646.524	9.882.555	380.467.403
8	Mediterranean	Mersin-Silifke	55,78	55	34	733	262.798.915	0	21.795.393
9	Mediterranean	Osmaniye	431,00	136	114	10.202	11.059.123.761	2.311.696	226.056.791
10	Mediterranean	Osmaniye-Kadirli	51,95	36	29	1.260	806.204.744	862.490	42.190.553

Table 4.11: Input-output data for the OIZs in Aegean Region

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
1	Aegean	Afyonkarahisar	292,20	314	303	7.630	5.403.622.542	6.764	215.786.617
2	Aegean	Afyonkarahisar-Emirdağ	52,40	31	9	492	33.845.838	8.859	1.401.413
3	Aegean	Aydın- ASTİM	330,00	256	87	3.299	3.501.349.452	1.382.248	64.830.900
4	Aegean	Aydın-Ortaklar	72,72	35	8	547	143.405.554	0	8.326.388
5	Aegean	Denizli	297,00	179	129	25.000	5.028.617.905	3.235.471	225.309.589

Table 4.11: Input-output data for the OIZs in Aegean Region (cont.)

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
6	Aegean	Kütahya	152,30	84	76	5.517	4.011.179.047	24.989.366	192.644.829
7	Aegean	Kütahya-Gediz	66,03	33	20	710	342.197.388	0	10.375.827
8	Aegean	Kütahya-Tavşanlı	67,76	25	11	2.630	417.283.785	0	21.390.572
9	Aegean	Manisa-Salihli	159,00	159	40	2.534	646.579.912	567.050	38.097.162
10	Aegean	Manisa-Akhisar	196,00	76	41	2.674	1.913.154.931	125.254	24.912.335
11	Aegean	Uşak-Karahallı	47,00	86	7	98	41.262.818	0	477.012

Table 4.12: Input-output data for the OIZs in Marmara Region

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
1	Marmara	Balıkesir	374,50	144	91	5.731	5.821.002.616	13.283.878	304.754.910
2	Marmara	Bilecik-Bozüyük	340,00	80	26	1.655	795.849.748	319.172	62.205.539
3	Marmara	Bilecik II	238,00	83	22	2.450	637.292.039	7.216.845	20.150.567
4	Marmara	Bilecik-Osmaneli	61,00	17	4	76	457.742.307	103.135	49.839.456
5	Marmara	Bilecik-Pazaryeri	104,00	29	6	447	33.010.439	86.588	2.305.893
6	Marmara	Bursa	458,00	295	265	50.155	38.140.687.072	161.279.555	5.145.987.485
7	Marmara	Bursa-Demirtaş	382,00	348	296	41.455	24.899.031.185	34.901.597	2.712.553.488
8	Marmara	Bursa-Mustafakemalpaşa	148,00	64	18	496	368.016.815	914.580	12.431.213

Table 4.12: Input-output data for the OIZs in Marmara Region (cont.)

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
9	Marmara	Bursa-Kestel	59,44	93	76	3.600	1.669.277.202	2.145.468	37.028.857
10	Marmara	Bursa-Nilüfer	136,00	289	260	21.522	11.863.614.652	55.904.428	530.025.872
11	Marmara	Bursa-Hasanağa	74,92	105	77	7.915	3.190.288.450	788.996	227.496.007
12	Marmara	Bursa-Leather Specialty	63,93	137	40	1.250	269.624.084	0	8.415.340
13	Marmara	Çanakkale-Biga	47,14	49	27	562	344.087.628	15.085	2.141.024
14	Marmara	Edirne	58,97	41	14	446	274.521.384	27.144	24.941.994
15	Marmara	İstanbul-Tuzla	43,40	166	90	3.420	2.383.825.476	3.158.307	129.141.863
16	Marmara	İstanbul-Birlik	38,25	85	80	3.298	2.759.080.046	4.669.409	124.867.670
17	Marmara	İstanbul-Tuzla Chemical Industrialists	55,00	164	161	5.808	3.198.001.732	8.009.806	126.348.877
18	Marmara	İstanbul-Anadolu Yakası	63,82	156	148	7.487	5.347.160.880	5.188.340	304.363.613
19	Marmara	Kırklareli	397,00	86	26	2.550	1.140.915.777	158.884	129.292.653
20	Marmara	Kırklareli-Lüleburgaz Evrensekiz Reclamation	169,00	63	9	1.207	1.697.509.884	3.960.263	89.897.623
21	Marmara	Kocaeli-Gebze	411,84	191	154	22.328	31.348.334.064	98.777.502	1.621.648.067
22	Marmara	Kocaeli-Asım Kibar	163,00	38	6	4.426	9.333.731.451	4.158.502	217.515.803
23	Marmara	Kocaeli-Gebze Güzeller	93,50	72	59	5.298	6.293.298.954	306.751	125.018.388
24	Marmara	Kocaeli-Gebze Plastic Specialty	96,01	147	109	10.020	8.536.030.213	7.326.540	348.418.303
25	Marmara	Kocaeli-Gebze Coal Specialty	62,20	22	20	322	4.702.956.200	0	30.025.067
26	Marmara	Kocaeli-Tosb-Automotive Supply Industry Specialty	1.740,00	90	74	16.000	9.159.185.787	41.203.079	913.157.417
27	Marmara	Kocaeli-Machine Specialty	353,80	92	23	3.380	3.847.469.098	9.630.267	228.989.948

Table 4.12: Input-output data for the OIZs in Marmara Region (cont.)

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
28	Marmara	Kocaeli-Gebze V Chemistry Specialty	162,00	66	16	888	3.010.302.237	4.940.349	59.588.310
29	Marmara	Kocaeli-Gebze VI (İMES) Machine Specialty	177,00	276	66	1.913	2.003.684.202	2.332.151	48.866.026
30	Marmara	Sakarya I	190,00	103	54	8.151	2.580.822.275	8.578.937	119.661.767
31	Marmara	Sakarya II	258,00	93	68	6.189	4.045.884.966	4.094.336	272.455.605
32	Marmara	Tekirdağ-Hayrabolu	61,00	53	13	284	329.670.755	7.212	1.270.449
33	Marmara	Tekirdağ-Malkara	65,24	49	8	297	72.112.814	0	5.986.159
34	Marmara	Tekirdağ-Velimeşe	773,34	453	184	20.673	10.828.342.566	2.803.601	569.783.262
35	Marmara	Tekirdağ-Veliköy	304,66	185	78	4.379	2.935.529.215	654.472	219.048.939
36	Marmara	Tekirdağ-Ergene 2	612,29	259	116	13.744	8.680.311.933	9.038.311	279.182.546
37	Marmara	Tekirdağ-Türkgücü	271,88	154	49	4.800	1.999.924.696	675.000	157.256.833

Table 4.13: Input-output data for the OIZs in Black Sea Region

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
1	Black Sea	Amasya	37,40	32	23	477	217.911.824	0	20.309.548
2	Black Sea	Amasya-Merzifon	72,30	51	42	3.272	693.832.364	3.289.039	52.457.390
3	Black Sea	Amasya-Suluova	34,40	65	9	150	44.693.536	0	17.032
4	Black Sea	Bartın-Center I	63,00	30	30	3.631	1.310.842.117	0	61.084.100

Table 4.13: Input-output data for the OIZs in Black Sea Region (cont.)

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
5	Black Sea	Bayburt	203,00	127	6	41	50.864.366	0	341.508
6	Black Sea	Bolu-Mixed and Textile Specialty	81,00	85	55	4.050	1.699.804.396	584.509	92.914.068
7	Black Sea	Çorum	460,00	266	88	5.847	1.599.198.364	3.980.805	109.699.334
8	Black Sea	Düzce	109,00	60	54	5.553	2.284.281.826	5.289.618	192.455.163
9	Black Sea	Düzce II	47,84	11	9	647	386.700.462	0	13.362.971
10	Black Sea	Giresun	33,87	37	21	729	288.495.640	0	17.596.475
11	Black Sea	Kastamonu-Seydiler	55,00	45	8	150	33.683.882	0	1.215.706
12	Black Sea	Ordu-Fatsa	24,00	30	29	2.824	171.319.670	0	7.473.183
13	Black Sea	Samsun-Center	96,00	105	99	5.115	5.214.333.748	988.502	198.172.416
14	Black Sea	Samsun-Bafra	122,63	145	19	240	1.893.295.932	926.961	53.098.111
15	Black Sea	Samsun-Kavak	77,28	61	23	614	330.460.818	766.783	2.707.725
16	Black Sea	Samsun-Food Specialty	26,00	24	12	168	946.637.805	0	2.149.405
17	Black Sea	Sinop	60,04	67	29	1.400	140.975.618	0	4.472.038
18	Black Sea	Tokat-Erbaa	75,00	104	12	1.575	377.368.736	0	1.930.290
19	Black Sea	Trabzon-Arsin	72,50	87	78	4.447	5.343.850.821	425.477	108.554.977
20	Black Sea	Trabzon-Beşikdüzü	20,60	35	16	255	71.063.511	0	1.594.795
21	Black Sea	Zonguldak-Çaycuma	87,52	65	41	2.624	610.811.285	0	50.673.444

Table 4.14: Input-output data for the OIZs in Central Anatolia Region

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
1	Central Anatolia	Aksaray	574,80	313	185	8.250	5.719.287.749	9.210.801	66.824.756
2	Central Anatolia	Ankara Başkent	611,41	620	85	7.000	3.165.011.500	1.334.450	122.132.475
3	Central Anatolia	Ankara Chamber of Industry 2.-3.	401,00	321	34	1.900	1.260.503.348	1.194.781	52.157.229
4	Central Anatolia	Ankara-Anadolu	118,70	144	11	424	88.287.045	44.898	2.428.053
5	Central Anatolia	Ankara-Polatlı	185,72	76	24	865	2.775.688.308	2.196.755	89.973.065
6	Central Anatolia	Ankara OSTİM	179,00	4.586	3.899	60.000	42.988.582.492	41.677.027	727.038.744
7	Central Anatolia	Çankırı-Korgun	60,00	77	40	1.010	298.155.887	14.907	23.798.449
8	Central Anatolia	Çankırı-Şabanözü	33,92	24	13	2.325	546.388.823	1.297.146	29.594.074
9	Central Anatolia	Eskişehir Chamber of Industry	2.203,00	697	478	39.097	20.497.133.743	50.567.860	617.214.679
10	Central Anatolia	Kayseri-İncesu	391,10	150	11	1.000	1.446.537.569	9.989.118	28.063.115
11	Central Anatolia	Kayseri-Mimarsinan	429,17	372	88	2.417	1.105.299.600	236.779	12.124.166
12	Central Anatolia	Kırıkkale I	120,00	68	35	1.800	1.119.201.105	0	32.079.502
13	Central Anatolia	Kırıkkale-Keskin	79,27	83	4	146	51.493.205	0	970.433
14	Central Anatolia	Konya-Ereğli	177,80	119	43	780	488.347.056	0	15.881.795
15	Central Anatolia	Niğde	279,19	111	89	4.558	3.218.438.070	37.332	75.148.870

Table 4.15: Input-output data for the OIZs in Eastern Anatolia Region

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
1	Eastern Anatolia	Bingöl	38,53	45	21	600	53.670.669	0	186.901
2	Eastern Anatolia	Elazığ	304,10	219	114	2.645	816.716.123	0	10.954.104
3	Eastern Anatolia	Erzincan	310,64	213	63	1.430	1.838.069.842	0	7.465.403
4	Eastern Anatolia	Erzurum-Center I	107,00	117	98	4.177	3.616.575.314	17.367.801	42.515.144
5	Eastern Anatolia	Iğdır	83,65	105	15	165	57.472.776	0	747.874
6	Eastern Anatolia	Kars	103,79	93	52	530	499.842.564	0	21.919
7	Eastern Anatolia	Malatya Center I	1.099,00	510	147	8.850	2.269.074.784	45	153.413.164
8	Eastern Anatolia	Malatya II	300,00	156	121	6.588	1.192.030.117	6.418.615	108.473.377
9	Eastern Anatolia	Van	85,20	137	86	1.750	441.521.400	0	2.914.561

Table 4.16: Input-output data for the OIZs in Southeastern Anatolia Region

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
1	Southeastern Anatolia(SEA)	Adıyaman-Kahta	70,92	78	16	512	151.586.221	437.079	25.739.047
2	SEA	Adıyaman-Gölbaşı	52,06	35	7	80	2.503.290	0	201.000
3	SEA	Batman-İli	91,80	98	45	1.249	1.618.245.018	5.634.681	255.180.340
4	SEA	Gaziantep-Nizip	48,80	32	25	750	227.537.605	0	2.127.266
5	SEA	Kilis	42,30	37	29	1.200	383.135.183	0	6.701.002
6	SEA	Şanlıurfa-Viranşehir	102,64	133	33	350	366.583.166	0	1.592.691

4.4. Relative Efficiency Measurement by DEA

In this study the conventional DEA model (Formulation 3.2), minsum (Formulation 3.10) and minimax (Formulation 3.11) efficiency models and Sun et al.'s model (Formulation 3.12 and Formulation 3.13) are applied to the data set. For the application ε is choosen as 10^{-6}.

First data are normalized using a linear normalization procedure. Input data are normalized as x_{ij}/x_i^*, where $x_i^* = \max_j x_{ij}$ for $\forall i$ while output data are normalized as y_{rj}/y_r^* , where $y_r^* = \max_j y_{rj}$ for $\forall r$. The normalized data tables are given in Table 4.17 - Table 4.23.

In this case n = 10, 11, 37, 21, 15, 9 and 6 (number of DMUs) for the Mediterranean, Aegean, Marmara, Black Sea, Central Anatolia, Eastern Anatolia and Southeastern Anatolia Regions respectively. m = 2 (number of inputs) and s = 5 (number of outputs) for all regions.

The models are applied through the GAMS program. Efficiency scores and rankings for each DMU are shared in Table 4.24 – Table 4.30 on geographical region basis.

Table 4.17: Normalized input-output data for the OIZs in Mediterranean Region

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
1	Mediterranean	Adana-Hacı Sabancı	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
2	Mediterranean	Adana-Kozan	0.076723	0.141762	0.126471	0.028178	0.008082	0.000000	0.032507
3	Mediterranean	Antalya	0.467280	0.626437	0.635294	0.311008	0.324152	0.327362	0.240031
4	Mediterranean	Burdur	0.054427	0.107280	0.161765	0.051092	0.030774	0.000099	0.024719
5	Mediterranean	Hatay-Antakya	0.093097	0.157088	0.144118	0.057583	0.027025	0.009238	0.021512
6	Mediterranean	Kahramanmaraş	0.169352	0.109195	0.150000	0.252797	0.168702	0.177400	0.090400
7	Mediterranean	Mersin-Tarsus	0.378001	0.379310	0.479412	0.316213	0.393336	0.534019	0.448493
8	Mediterranean	Mersin-Silifke	0.052190	0.105364	0.100000	0.021926	0.013636	0.000000	0.025692
9	Mediterranean	Osmaniye	0.403264	0.260536	0.335294	0.305175	0.573823	0.124916	0.266474
10	Mediterranean	Osmaniye-Kadirli	0.048607	0.068966	0.085294	0.037691	0.041831	0.046606	0.049734

Table 4.18: Normalized input-output data for the OIZs in Aegean Region

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
1	Aegean	Afyonkarahisar	0.885455	1.000000	1.000000	0.305200	1.000000	0.000271	0.957734
2	Aegean	Afyonkarahisar-Emirdağ	0.158788	0.098726	0.029703	0.019680	0.006264	0.000354	0.006220
3	Aegean	Aydın- ASTİM	1.000000	0.815287	0.287129	0.131960	0.647963	0.055313	0.287741
4	Aegean	Aydın-Ortaklar	0.220364	0.111465	0.026403	0.021880	0.026539	0.000000	0.036955
5	Aegean	Denizli	0.900000	0.570064	0.425743	1.000000	0.930601	0.129474	1.000000

Table 4.18: Normalized input-output data for the OIZs in Aegean Region (cont.)

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
6	Aegean	Kütahya	0.461521	0.267516	0.250825	0.220680	0.742313	1.000000	0.855023
7	Aegean	Kütahya-Gediz	0.200091	0.105096	0.066007	0.028400	0.063327	0.000000	0.046051
8	Aegean	Kütahya-Tavşanlı	0.205333	0.079618	0.036304	0.105200	0.077223	0.000000	0.094939
9	Aegean	Manisa-Salihli	0.481818	0.506369	0.132013	0.101360	0.119657	0.022692	0.169088
10	Aegean	Manisa-Akhisar	0.593939	0.242038	0.135314	0.106960	0.354050	0.005012	0.110569
11	Aegean	Uşak-Karahallı	0.142424	0.273885	0.023102	0.003920	0.007636	0.000000	0.002117

Table 4.19: Normalized input-output data for the OIZs in Marmara Region

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
1	Marmara	Balıkesir	0.215230	0.317881	0.307432	0.114266	0.152619	0.082366	0.059222
2	Marmara	Bilecik-Bozüyük	0.195402	0.176600	0.087838	0.032998	0.020866	0.001979	0.012088
3	Marmara	Bilecik II	0.136782	0.183223	0.074324	0.048849	0.016709	0.044747	0.003916
4	Marmara	Bilecik-Osmaneli	0.035057	0.037528	0.013514	0.001515	0.012001	0.000639	0.009685
5	Marmara	Bilecik-Pazaryeri	0.059770	0.064018	0.020270	0.008912	0.000865	0.000537	0.000448
6	Marmara	Bursa	0.263218	0.651214	0.895270	1.000000	1.000000	1.000000	1.000000
7	Marmara	Bursa-Demirtaş	0.219540	0.768212	1.000000	0.826538	0.652821	0.216404	0.527120
8	Marmara	Bursa-Mustafakemalpaşa	0.085057	0.141280	0.060811	0.009889	0.009649	0.005671	0.002416

Table 4.19: Normalized input-output data for the OIZs in Marmara Region (cont.)

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
9	Marmara	Bursa-Kestel	0.034161	0.205298	0.256757	0.071777	0.043766	0.013303	0.007196
10	Marmara	Bursa-Nilüfer	0.078161	0.637969	0.878378	0.429110	0.311049	0.346631	0.102998
11	Marmara	Bursa-Hasanağa	0.043057	0.231788	0.260135	0.157811	0.083645	0.004892	0.044208
12	Marmara	Bursa-Leather Specialty	0.036741	0.302428	0.135135	0.024923	0.007069	0.000000	0.001635
13	Marmara	Çanakkale-Biga	0.027092	0.108168	0.091216	0.011205	0.009022	0.000094	0.000416
14	Marmara	Edirne	0.033891	0.090508	0.047297	0.008892	0.007198	0.000168	0.004847
15	Marmara	İstanbul-Tuzla	0.024943	0.366446	0.304054	0.068189	0.062501	0.019583	0.025096
16	Marmara	İstanbul-Birlik	0.021983	0.187638	0.270270	0.065756	0.072340	0.028952	0.024265
17	Marmara	İstanbul-Tuzla Chemical Industrialists	0.031609	0.362031	0.543919	0.115801	0.083848	0.049664	0.024553
18	Marmara	İstanbul-Anadolu Yakası	0.036678	0.344371	0.500000	0.149277	0.140196	0.032170	0.059146
19	Marmara	Kırklareli	0.228161	0.189845	0.087838	0.050842	0.029913	0.000985	0.025125
20	Marmara	Kırklareli-Lüleburgaz Evrensekiz Reclamation	0.097126	0.139073	0.030405	0.024065	0.044507	0.024555	0.017469
21	Marmara	Kocaeli-Gebze	0.236690	0.421634	0.520270	0.445180	0.821913	0.612461	0.315129
22	Marmara	Kocaeli-Asım Kibar	0.093678	0.083885	0.020270	0.088246	0.244718	0.025784	0.042269
23	Marmara	Kocaeli-Gebze Güzeller	0.053736	0.158940	0.199324	0.105633	0.165002	0.001902	0.024294
24	Marmara	Kocaeli-Gebze Plastic Specialty	0.055178	0.324503	0.368243	0.199781	0.223804	0.045428	0.067707
25	Marmara	Kocaeli-Gebze Coal Specialty	0.035747	0.048565	0.067568	0.006420	0.123305	0.000000	0.005835
26	Marmara	Kocaeli-TOSB-Automotive Supply Industry Specialty	1.000000	0.198675	0.250000	0.319011	0.240142	0.255476	0.177450
27	Marmara	Kocaeli-Machine Specialty	0.203333	0.203091	0.077703	0.067391	0.100876	0.059712	0.044499

Table 4.19: Normalized input-output data for the OIZs in Marmara Region (cont.)

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
28	Marmara	Kocaeli-Gebze V Chemistry Specialty	0.093103	0.145695	0.054054	0.017705	0.078926	0.030632	0.011580
29	Marmara	Kocaeli-Gebze VI (İMES) Machine Specialty	0.101724	0.609272	0.222973	0.038142	0.052534	0.014460	0.009496
30	Marmara	Sakarya I	0.109195	0.227373	0.182432	0.162516	0.067666	0.053193	0.023253
31	Marmara	Sakarya II	0.148276	0.205298	0.229730	0.123397	0.106078	0.025387	0.052945
32	Marmara	Tekirdağ-Hayrabolu	0.035057	0.116998	0.043919	0.005662	0.008644	0.000045	0.000247
33	Marmara	Tekirdağ-Malkara	0.037494	0.108168	0.027027	0.005922	0.001891	0.000000	0.001163
34	Marmara	Tekirdağ-Velimeşe	0.444448	1.000000	0.621622	0.412182	0.283905	0.017383	0.110724
35	Marmara	Tekirdağ-Veliköy	0.175092	0.408389	0.263514	0.087309	0.076966	0.004058	0.042567
36	Marmara	Tekirdağ-Ergene 2	0.351891	0.571744	0.391892	0.274031	0.227587	0.056041	0.054252
37	Marmara	Tekirdağ-Türkgücü	0.156253	0.339956	0.165541	0.095703	0.052435	0.004185	0.030559

Table 4.20: Normalized input-output data for the OIZs in Black Sea Region

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
1	Black Sea	Amasya	0.081304	0.120301	0.232323	0.081580	0.040778	0.000000	0.102484
2	Black Sea	Amasya-Merzifon	0.157174	0.191729	0.424242	0.559603	0.129838	0.621791	0.264706
3	Black Sea	Amasya-Suluova	0.074783	0.244361	0.090909	0.025654	0.008364	0.000000	0.000086
4	Black Sea	Bartın-Center I	0.136957	0.112782	0.303030	0.621002	0.245299	0.000000	0.308237

Table 4.20: Normalized input-output data for the OIZs in Black Sea Region (cont.)

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
5	Black Sea	Bayburt	0.441304	0.477444	0.060606	0.007012	0.009518	0.000000	0.001723
6	Black Sea	Bolu-Mixed and Textile Specialty	0.176087	0.319549	0.555556	0.692663	0.318086	0.110501	0.468855
7	Black Sea	Çorum	1.000000	1.000000	0.888889	1.000000	0.299260	0.752569	0.553555
8	Black Sea	Düzce	0.236957	0.225564	0.545455	0.949718	0.427460	1.000000	0.971150
9	Black Sea	Düzce II	0.104000	0.041353	0.090909	0.110655	0.072364	0.000000	0.067431
10	Black Sea	Giresun	0.073630	0.139098	0.212121	0.124679	0.053986	0.000000	0.088794
11	Black Sea	Kastamonu-Seydiler	0.119565	0.169173	0.080808	0.025654	0.006303	0.000000	0.006135
12	Black Sea	Ordu-Fatsa	0.052174	0.112782	0.292929	0.482983	0.032059	0.000000	0.037711
13	Black Sea	Samsun-Center	0.208696	0.394737	1.000000	0.874808	0.975763	0.186876	1.000000
14	Black Sea	Samsun-Bafra	0.266587	0.545113	0.191919	0.041047	0.354294	0.175242	0.267939
15	Black Sea	Samsun-Kavak	0.168000	0.229323	0.232323	0.105011	0.061839	0.144960	0.013663
16	Black Sea	Samsun-Food Specialty	0.056522	0.090226	0.121212	0.028733	0.177145	0.000000	0.010846
17	Black Sea	Sinop	0.130522	0.251880	0.292929	0.239439	0.026381	0.000000	0.022566
18	Black Sea	Tokat-Erbaa	0.163043	0.390977	0.121212	0.269369	0.070617	0.000000	0.009740
19	Black Sea	Trabzon-Arsin	0.157609	0.327068	0.787879	0.760561	1.000000	0.080436	0.547780
20	Black Sea	Trabzon-Beşikdüzü	0.044783	0.131579	0.161616	0.043612	0.013298	0.000000	0.008048
21	Black Sea	Zonguldak-Çaycuma	0.190261	0.244361	0.414141	0.448777	0.114302	0.000000	0.255704

Table 4.21: Normalized input-output data for the OIZs in Central Anatolia Region

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
1	Central Anatolia	Aksaray	0.260917	0.068251	0.047448	0.137500	0.133042	0.182147	0.091914
2	Central Anatolia	Ankara Başkent	0.277535	0.135194	0.021800	0.116667	0.073624	0.026389	0.167986
3	Central Anatolia	Ankara Chamber of Industry 2.-3.	0.182025	0.069996	0.008720	0.031667	0.029322	0.023627	0.071739
4	Central Anatolia	Ankara-Anadolu	0.053881	0.031400	0.002821	0.007067	0.002054	0.000888	0.003340
5	Central Anatolia	Ankara-Polatlı	0.084303	0.016572	0.006155	0.014417	0.064568	0.043442	0.123753
6	Central Anatolia	Ankara OSTİM	0.081253	1.000000	1.000000	1.000000	1.000000	0.824180	1.000000
7	Central Anatolia	Çankırı-Korgun	0.027236	0.016790	0.010259	0.016833	0.006936	0.000295	0.032733
8	Central Anatolia	Çankırı-Şabanözü	0.015397	0.005233	0.003334	0.038750	0.012710	0.025652	0.040705
9	Central Anatolia	Eskişehir Chamber of Industry	1.000000	0.151984	0.122596	0.651617	0.476804	1.000000	0.848943
10	Central Anatolia	Kayseri-İncesu	0.177531	0.032708	0.002821	0.016667	0.033649	0.197539	0.038599
11	Central Anatolia	Kayseri-Mimarsinan	0.194812	0.081116	0.022570	0.040283	0.025711	0.004682	0.016676
12	Central Anatolia	Kırıkkale I	0.054471	0.014828	0.008977	0.030000	0.026035	0.000000	0.044124
13	Central Anatolia	Kırıkkale-Keskin	0.035983	0.018099	0.001026	0.002433	0.001198	0.000000	0.001335
14	Central Anatolia	Konya-Ereğli	0.080708	0.025949	0.011028	0.013000	0.011360	0.000000	0.021844
15	Central Anatolia	Niğde	0.126732	0.024204	0.022826	0.075967	0.074867	0.000738	0.103363

Table 4.22: Normalized input-output data for the OIZs in Eastern Anatolia Region

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
1	Eastern Anatolia	Bingöl	0.035059	0.088235	0.142857	0.067797	0.014840	0.000000	0.001218
2	Eastern Anatolia	Elazığ	0.276706	0.429412	0.775510	0.298870	0.225826	0.000000	0.071403
3	Eastern Anatolia	Erzincan	0.282657	0.417647	0.428571	0.161582	0.508235	0.000000	0.048662
4	Eastern Anatolia	Erzurum-Center I	0.097361	0.229412	0.666667	0.471977	1.000000	1.000000	0.277128
5	Eastern Anatolia	Iğdır	0.076115	0.205882	0.102041	0.018644	0.015891	0.000000	0.004875
6	Eastern Anatolia	Kars	0.094440	0.182353	0.353741	0.059887	0.138209	0.000000	0.000143
7	Eastern Anatolia	Malatya Center I	1.000000	1.000000	1.000000	1.000000	0.627410	0.000003	1.000000
8	Eastern Anatolia	Malatya II	0.272975	0.305882	0.823129	0.744407	0.329602	0.369570	0.707067
9	Eastern Anatolia	Van	0.077525	0.268627	0.585034	0.197740	0.122083	0.000000	0.018998

Table 4.23: Normalized input-output data for the OIZs in Southeastern Anatolia Region

ID	GR	OIZ	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5
			Total Industrial Parcel Area (Ha)	Total Number of Parcels (Zone)	Number of Existing Firms	Employment	Net Sales (TL)	R&D Expenses (TL)	Export Volume ($)
1	Southeastern Anatolia (SEA)	Adıyaman-Kahta	0.690959	0.586466	0.355556	0.409928	0.093673	0.077569	0.100866
2	SEA	Adıyaman-Gölbaşı	0.507210	0.263158	0.155556	0.064051	0.001547	0.000000	0.000788
3	SEA	Batman-İli	0.894388	0.736842	1.000000	1.000000	1.000000	1.000000	1.000000
4	SEA	Gaziantep-Nizip	0.475448	0.240602	0.555556	0.600480	0.140608	0.000000	0.008336
5	SEA	Kilis	0.412120	0.278195	0.644444	0.960769	0.236760	0.000000	0.026260
6	SEA	Şanlıurfa-Viranşehir	1.000000	1.000000	0.733333	0.280224	0.226531	0.000000	0.006241

Table 4.24: Efficiency scores and rankings of DMUs in Mediterranean Region

Mediterranean									
ID	**OIZ**	**Conventional DEA (F3.2) Efficiency**	**Conventional DEA (F3.2) Ranking**	**MinSum (F3.10) Efficiency**	**MinSum (F3.10) Ranking**	**MiniMax (F3.11) Efficiency**	**MiniMax (F3.11) Ranking**	**Common Weight Model (F3.12-3.13) Efficiency**	**Common Weight Model (F3.12-3.13) Ranking**
1	Adana-Hacı Sabancı	0.988160	6	0.957311	6	0.928351	6	0.068966	7
2	Adana-Kozan	0.647819	9	0.452336	10	0.509543	10	0.061526	10
3	Antalya	0.763876	7	0.738091	7	0.763876	7	0.069941	6
4	Burdur	1	1	1	1	1	1	0.103992	1
5	Hatay-Antakya	0.612061	10	0.551026	9	0.577722	9	0.063271	9
6	Kahramanmaraş	1	1	1	1	1	1	0.094738	2
7	Mersin-Tarsus	1	1	1	1	1	1	0.087166	4
8	Mersin-Silifke	0.752895	8	0.644037	8	0.638762	8	0.065455	8
9	Osmaniye	1	1	1	1	1	1	0.088755	3
10	Osmaniye-Kadirli	1	1	0.964935	5	0.958120	5	0.085295	5

Table 4.25: Efficiency scores and rankings of DMUs in Aegean Region

Aegean									
ID	**OIZ**	**Conventional DEA (F3.2) Efficiency**	**Conventional DEA (F3.2) Ranking**	**MinSum (F3.10) Efficiency**	**MinSum (F3.10) Ranking**	**MiniMax (F3.11) Efficiency**	**MiniMax (F3.11) Ranking**	**Common Weight Model (F3.12-3.13) Efficiency**	**Common Weight Model (F3.12-3.13) Ranking**
1	Afyonkarahisar	1	1	1	1	1	1	0.160848	2
2	Afyonkarahisar-Emirdağ	0.313314	9	0.135991	9	0.093725	10	0.005618	11
3	Aydın- ASTİM	0.430018	7	0.356802	6	0.430019	4	0.092285	4
4	Aydın-Ortaklar	0.251233	10	0.130393	10	0.106392	9	0.017152	9
5	Denizli	1	1	1	1	0.692129	3	0.147266	3

Table 4.25: Efficiency scores and rankings of DMUs in Aegean Region (cont.)

Aegean									
ID	**OIZ**	**Conventional DEA (F3.2) Efficiency**	**Conventional DEA (F3.2) Ranking**	**MinSum (F3.10) Efficiency**	**MinSum (F3.10) Ranking**	**MiniMax (F3.11) Efficiency**	**MiniMax (F3.11) Ranking**	**Common Weight Model (F3.12-3.13) Efficiency**	**Common Weight Model (F3.12-3.13) Ranking**
6	Kütahya	1	1	1	1	1	1	0.229075	1
7	Kütahya-Gediz	0.637160	5	0.302913	7	0.285573	6	0.045076	7
8	Kütahya-Tavşanlı	0.753231	4	0.407115	4	0.253632	8	0.053564	6
9	Manisa-Salihli	0.323198	8	0.282348	8	0.259876	7	0.035370	8
10	Manisa-Akhisar	0.590477	6	0.382116	5	0.381135	5	0.084899	5
11	Uşak-Karahallı	0.143626	11	0.083026	11	0.082432	11	0.007636	10

Table 4.26: Efficiency scores and rankings of DMUs in Marmara Region

Marmara									
ID	**OIZ**	**Conventional DEA (F3.2) Efficiency**	**Conventional DEA (F3.2) Ranking**	**MinSum (F3.10) Efficiency**	**MinSum (F3.10) Ranking**	**MiniMax (F3.11) Efficiency**	**MiniMax (F3.11) Ranking**	**Common Weight Model (F3.12-3.13) Efficiency**	**Common Weight Model (F3.12-3.13) Ranking**
1	Balıkesir	0.659923	17	0.659923	15	0.453512	17	0.031400	20
2	Bilecik-Bozüyük	0.336591	24	0.039663	37	0.187107	30	0.009882	30
3	Bilecik II	0.282481	29	0.276753	26	0.204316	28	0.011945	29
4	Bilecik-Osmaneli	0.255089	32	0.178711	30	0.131315	36	0.008474	31
5	Bilecik-Pazaryeri	0.215656	35	0.114931	34	0.132885	35	0.007455	34
6	Bursa	1	1	1	1	1	1	0.074770	12
7	Bursa-Demirtaş	0.937497	11	0.914154	7	0.921023	6	0.100132	9
8	Bursa-Mustafakemalpaşa	0.286581	28	0.285865	25	0.192885	29	0.015716	27

Table 4.26: Efficiency scores and rankings of DMUs in Marmara Region (cont.)

Marmara									
ID	**OIZ**	**Conventional DEA (F3.2) Efficiency**	**Conventional DEA (F3.2) Ranking**	**MinSum (F3.10) Efficiency**	**MinSum (F3.10) Ranking**	**MiniMax (F3.11) Efficiency**	**MiniMax (F3.11) Ranking**	**Common Weight Model (F3.12-3.13) Efficiency**	**Common Weight Model (F3.12-3.13) Ranking**
9	Bursa-Kestel	0.838130	13	0.835800	10	0.838130	9	0.165226	6
10	Bursa-Nilüfer	1	1	0.937966	6	0.942357	5	0.247046	5
11	Bursa-Hasanağa	0.808202	14	0.767567	13	0.777203	11	0.132812	8
12	Bursa-Leather Specialty	0.297411	27	0.295452	24	0.296542	23	0.080853	11
13	Çanakkale-Biga	0.561285	19	0.557263	17	0.556094	14	0.074015	13
14	Edirne	0.349550	23	0.347371	22	0.346934	21	0.030679	22
15	İstanbul-Tuzla	0.803390	15	0.554027	18	0.552916	15	0.267976	4
16	İstanbul-Birlik	0.978010	10	0.965688	5	0.961706	4	0.270272	3
17	İstanbul-Tuzla Chemical Industrialists	1	1	1	1	1	1	0.378274	1
18	İstanbul-Anadolu Yakası	1	1	0.976629	4	0.974896	3	0.299673	2
19	Kırklareli	0.319533	26	0.044335	36	0.180569	32	0.008463	32
20	Kırklareli-Lüleburgaz Evrensekiz Reclamation	0.165754	37	0.159330	32	0.118733	37	0.006882	35
21	Kocaeli-Gebze	1	1	0.906684	8	0.875519	7	0.048321	14
22	Kocaeli-Asım Kibar	1	1	0.679567	14	0.238050	26	0.004757	37
23	Kocaeli-Gebze Güzeller	0.876253	12	0.876253	9	0.861893	8	0.081542	10
24	Kocaeli-Gebze Plastic Specialty	1	1	0.784848	11	0.780881	10	0.146708	7
25	Kocaeli-Gebze Coal Specialty	1	1	1	1	0.559175	13	0.041551	16
26	Kocaeli-Tosb-Automotive Supply Industry Specialty	1	1	0.061603	35	0.229777	27	0.005496	36
27	Kocaeli-Machine Specialty	0.278307	30	0.145777	33	0.181820	31	0.008401	33
28	Kocaeli-Gebze V Chemistry Specialty	0.268221	31	0.264818	27	0.174669	33	0.012763	28

Table 4.26: Efficiency scores and rankings of DMUs in Marmara Region (cont.)

Marmara									
ID	**OIZ**	**Conventional DEA (F3.2) Efficiency**	**Conventional DEA (F3.2) Ranking**	**MinSum (F3.10) Efficiency**	**MinSum (F3.10) Ranking**	**MiniMax (F3.11) Efficiency**	**MiniMax (F3.11) Ranking**	**Common Weight Model (F3.12-3.13) Efficiency**	**Common Weight Model (F3.12-3.13) Ranking**
29	Kocaeli-Gebze VI (İMES) Machine Specialty	0.244535	34	0.244111	29	0.242540	25	0.048185	15
30	Sakarya I	0.571219	18	0.557405	16	0.571219	12	0.036727	17
31	Sakarya II	0.769608	16	0.768170	12	0.546114	16	0.034059	18
32	Tekirdağ-Hayrabolu	0.250363	33	0.249389	28	0.247699	24	0.027540	23
33	Tekirdağ-Malkara	0.166413	36	0.165640	31	0.166413	34	0.015846	26
34	Tekirdağ-Velimeşe	0.432877	22	0.429131	21	0.432878	19	0.030746	21
35	Tekirdağ-Veliköy	0.434961	21	0.434961	20	0.434701	18	0.033084	19
36	Tekirdağ-Ergene 2	0.479008	20	0.476874	19	0.378152	20	0.024482	24
37	Tekirdağ-Türkgücü	0.336267	25	0.332511	23	0.336268	22	0.023290	25

Table 4.27: Efficiency scores and rankings of DMUs in Black Sea Region

Black Sea									
ID	**OIZ**	**Conventional DEA (F3.2) Efficiency**	**Conventional DEA (F3.2) Ranking**	**MinSum (F3.10) Efficiency**	**MinSum (F3.10) Ranking**	**MiniMax (F3.11) Efficiency**	**MiniMax (F3.11) Ranking**	**Common Weight Model (F3.12-3.13) Efficiency**	**Common Weight Model (F3.12-3.13) Ranking**
1	Amasya	0.737754	8	0.734068	6	0.718749	6	0.044935	13
2	Amasya-Merzifon	1	1	1	1	0.896682	5	0.159446	7
3	Amasya-Suluova	0.216519	18	0.144272	19	0.138462	18	0.015363	18
4	Bartın-Merkez I	1	1	0.405239	13	0.408821	13	0.203059	3
5	Bayburt	0.047859	21	0.024508	21	0.047244	21	0.000712	21

Table 4.27: Efficiency scores and rankings of DMUs in Black Sea Region (cont.)

Black Sea									
ID	**OIZ**	**Conventional DEA (F3.2) Efficiency**	**Conventional DEA (F3.2) Ranking**	**MinSum (F3.10) Efficiency**	**MinSum (F3.10) Ranking**	**MiniMax (F3.11) Efficiency**	**MiniMax (F3.11) Ranking**	**Common Weight Model (F3.12-3.13) Efficiency**	**Common Weight Model (F3.12-3.13) Ranking**
6	Bolu-Mixed and Textile Specialty	0.725091	9	0.679657	7	0.654860	7	0.176160	6
7	Çorum	0.349893	16	0.257825	15	0.349895	15	0.044783	14
8	Düzce	1	1	0.971004	4	1	1	0.179489	5
9	Düzce II	0.818190	7	0.160012	17	0.159708	17	0.047649	12
10	Giresun	0.589724	13	0.586410	9	0.567567	9	0.075832	10
11	Kastamonu-Seydiler	0.181871	20	0.180797	16	0.177778	16	0.009609	19
12	Ordu-Fatsa	1	1	1	1	0.966667	2	0.414562	1
13	Samsun-Center	1	1	1	1	0.953537	3	0.187721	4
14	Samsun-Bafra	0.306135	17	0.147438	18	0.138286	19	0.006895	20
15	Samsun-Kavak	0.398791	15	0.397658	14	0.391308	14	0.027992	16
16	Samsun-Food Specialty	0.642148	12	0.527128	10	0.499998	10	0.022765	17
17	Sinop	0.446622	14	0.445892	12	0.432835	12	0.082153	9
18	Tokat-Erbaa	0.204173	19	0.119614	20	0.115385	20	0.073987	11
19	Trabzon-Arsin	1	1	0.955650	5	0.902100	4	0.216106	2
20	Trabzon-Beşikdüzü	0.642781	11	0.475573	11	0.457143	11	0.043612	15
21	Zonguldak-Çaycuma	0.645658	10	0.641279	8	0.630769	8	0.105632	8

Table 4.28: Efficiency scores and rankings of DMUs in Central Anatolia Region

Central Anatolia									
ID	**OIZ**	**Conventional DEA (F3.2) Efficiency**	**Conventional DEA (F3.2) Ranking**	**MinSum (F3.10) Efficiency**	**MinSum (F3.10) Ranking**	**MiniMax (F3.11) Efficiency**	**MiniMax (F3.11) Ranking**	**Common Weight Model (F3.12-3.13) Efficiency**	**Common Weight Model (F3.12-3.13) Ranking**
1	Aksaray	0.850591	7	0.810591	5	0.637017	6	0.005424	10
2	Ankara Başkent	0.264801	12	0.226607	12	0.263231	10	0.009319	8
3	Ankara Chamber of Industry 2.-3.	0.179787	13	0.171790	13	0.174718	11	0.006068	9
4	Ankara-Anadolu	0.095664	14	0.089452	14	0.066556	14	0.000954	14
5	Ankara-Polatlı	1	1	1	1	1	1	0.022602	3
6	Ankara OSTİM	1	1	1	1	0.891544	3	0.189495	1
7	Çankırı-Korgun	0.664715	9	0.630957	8	0.474231	8	0.018505	4
8	Çankırı-Şabanözü	1	1	1.000000	1	1	1	0.040704	2
9	Eskişehir Chamber of Industry	1	1	0.725986	6	0.702377	5	0.013071	5
10	Kayseri-İncesu	0.998531	6	0.335983	9	0.310774	9	0.003348	12
11	Kayseri-Mimarsinan	0.283906	11	0.228825	11	0.145827	13	0.001318	13
12	Kırıkkale I	0.690494	8	0.669064	7	0.570734	7	0.012472	7
13	Kırıkkale-Keskin	0.059692	15	0.056295	15	0.034173	15	0.000571	15
14	Konya-Ereğli	0.432119	10	0.317733	10	0.158953	12	0.004167	11
15	Niğde	1	1	1	1	0.743250	4	0.012558	6

Table 4.29: Efficiency scores and rankings of DMUs in Eastern Anatolia Region

Eastern Anatolia									
ID	**OIZ**	**Conventional DEA (F3.2) Efficiency**	**Conventional DEA (F3.2) Ranking**	**MinSum (F3.10) Efficiency**	**MinSum (F3.10) Ranking**	**MiniMax (F3.11) Efficiency**	**MiniMax (F3.11) Ranking**	**Common Weight Model (F3.12-3.13) Efficiency**	**Common Weight Model (F3.12-3.13) Ranking**
1	Bingöl	0.586420	6	0.516264	6	0.026316	8	0.142856	6
2	Elazığ	0.621468	5	0.585227	5	0.128328	5	0.159350	5
3	Erzincan	0.353118	8	0.333891	8	0.196626	4	0.090543	7
4	Erzurum-Center I	1	1	1	1	1	1	0.256410	1
5	Iğdır	0.189697	9	0.159246	9	0.018563	9	0.043731	9
6	Kars	0.667542	4	0.617585	4	0.095619	6	0.171164	4
7	Malatya Center I	0.452887	7	0.380353	7	0.452888	3	0.088235	8
8	Malatya II	1	1	1	1	1	1	0.237440	2
9	Van	1	1	0.697687	3	0.083608	7	0.192163	3

Table 4.30: Efficiency scores and rankings of DMUs in Southeastern Anatolia Region

Southeastern Anatolia									
ID	**OIZ**	**Conventional DEA (F3.2) Efficiency**	**Conventional DEA (F3.2) Ranking**	**MinSum (F3.10) Efficiency**	**MinSum (F3.10) Ranking**	**MiniMax (F3.11) Efficiency**	**MiniMax (F3.11) Ranking**	**Common Weight Model (F3.12-3.13) Efficiency**	**Common Weight Model (F3.12-3.13) Ranking**
1	Adıyaman-Kahta	0.362292	5	0.357689	4	0.357689	5	0.212069	5
2	Adıyaman-Gölbaşı	0.255173	6	0.196130	6	0.196127	6	0.126392	6
3	Batman-İli	1	1	1	1	1	1	0.460784	3
4	Gaziantep-Nizip	0.996764	3	0.747246	3	0.747246	3	0.481556	2
5	Kilis	1	1	1	1	1	1	0.644443	1
6	Şanlıurfa-Viranşehir	0.468963	4	0.316567	5	0.468964	4	0.302220	4

5. DISCUSSION AND CONCLUSION

As it is seen on the efficiency scores and rankings tables, according to conventional DEA model and mimsum and minimax efficiency models' results there are more than one efficient OIZs in the related region. Although the minsum and minimax efficiency models usually reduce the number of efficient OIZs that are obtained from the conventional DEA-CCR model, they are not successful to reduce this number to one in general. And their discriminating power is low because all of the efficient OIZs are first in rank. On the other hand according to the results of common weight DEA based decision model (Formulation 3.12 and 3.13) there is only one "most efficient OIZ" for all regions. Because of the high discriminating power and usage of common weights for variables, common weight DEA based model's results are taken as references.

According to these results the most efficient and the least efficient 3 OIZs on the basis of regions are as follows:

- Mediterranean Region:
    - The most efficient 3 OIZs: Burdur, Kahramanmaraş and Osmaniye
    - The least efficient 3 OIZs: Adana-Kozan, Hatay-Antakya and Mersin-Silifke
- Aegean Region:
    - The most efficient 3 OIZs: Kütahya, Afyonkarahisar, Denizli
    - The least efficient 3 OIZs: Afyonkarahisar-Emirdağ, Uşak-Karahallı, Aydın-Ortaklar
- Marmara Region:
    - The most efficient 3 OIZs: İstanbul-Tuzla Chemical Industrialists, İstanbul-Anadolu Yakası, İstanbul-Birlik

    - The least efficient 3 OIZs: Kocaeli-Asım Kibar, Kocaeli-TOSB Automotive Supply Industry Specialty, Kırklareli-Lüleburgaz Evrensekiz Reclamation
- Black Sea Region:
    - The most efficient 3 OIZs: Ordu-Fatsa, Trabzon-Arsin, Bartın-Center I
    - The least efficient 3 OIZs: Bayburt, Samsun-Bafra, Kastamonu-Seydiler
- Central Anatolia Region:
    - The most efficient 3 OIZs: Ankara-OSTİM, Çankırı-Şabanözü, Ankara-Polatlı
    - The least efficient 3 OIZs: Kırıkkale-Keskin, Ankara-Anadolu, Kayseri-Mimarsinan
- Eastern Anatolia Region:
    - The most efficient 3 OIZs: Erzurum-Center I, Malatya II, Van
    - The least efficient 3 OIZs: Iğdır, Malatya-Center I, Erzincan
- Southeastern Anatolia Region:
    - The most efficient 3 OIZs: Kilis, Gaziantep-Nizip, Batman
    - The least efficient 3 OIZs: Adıyaman-Gölbaşı, Adıyaman-Kahta, Şanlıurfa-Viranşehir

As a conclusion, it is seen in the study that Turkey's organized industrial zones' relative efficiencies (on geographical regions based) were determined with the conventional DEA – CCR model, a minsum efficiency model, a minimax efficiency model and a common weight DEA based decision model.

As it is mentioned on the literature review section, there is no study which measures the relative efficiencies of OIZs in Turkey by DEA model and with this study this gap in the literature was filled.

One of the reasons for this study was the idea of "if the efficiencies of OIZs are measured, the OIZs which have potential development areas can be identified." Efficiency scores of OIZs were determined in the study and they were ranked according to these scores. Thus the OIZs which their efficiencies can be improved are identified.

To access to relevant data for each OIZ was one of the biggest limitations in the study. For this reason some OIZs were not included to the study. If the data are kept in a healthier way by the related institutions and organizations, then OIZ efficiency evaluations to be performed can be more inclusive.

In this study, geographical regions were used to classify OIZs to ensure homogeneity. The same study can be performed using different classification regions in future studies.

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