EGE AKADEMİK BAKIŞ / *EGE ACADEMIC REVIEW*

Cilt 22 • Sayı 2 • Nisan 2022
SS. 155/168
Doi: 10.21121/eab.925772
Başvuru Tarihi: 22 April 2021 • Kabul Tarihi: 04 March 2022

Evaluation of Efficiency Measurement of Selected Technoparks with Data Envelopment Analysis (DEA)

Şakire Nesli DEMİRCİOĞLU[1], Zeynep ÖZGÜNER[2]

ABSTRACT

Technology Development Zones (Technoparks) are units that focuses on working effectively and producing productive works due to their structures. It is known that each technopark differs in terms of its production method and the benefits it provides. This research respond to give information about the general conditions of the Technoparks whose data were shared publicly and they were valuated within the scope of expected and realized benefits. Data Envelopment Analysis (DEA), one of the Multi-Criteria Decision Making (MCDM) Methods is applied in the study. DEA is considered as one of the most frequently preferred analysis methods to measure efficiency, especially in structures with economic decision-making mechanisms. This paper includes 9 Technoparks, which share the data of the determined performance indicators up-to-date, according to the analysis of efficiency measurements performed with 3 inputs and 2 outputs. Collaboration and patent numbers among the variables used in the study are the output variables; infrastructure, offered advantages and proximity to the university refer to the input variables. The efficiency of the technoparks was measured with CCR (Charnes, Cooper and Rhodes) Input and Output Oriented Models, the issues deemed to increase the benefits provided by the technoparks are evaluated, and suggestions are made within the scope of the findings.

Key Words: : Multi-Criteria Decision-Making (MCDM) Methods, Technoparks, Mathematical Models, Efficiency Measurement, Data Envelopment Analysis (DEA).

JEL Classification Codes: C44, C61, M13, O14, O32, Q55

1. INTRODUCTION

Technoparks, which are considered to be an important building block in the commercialization of technological knowledge by turning them into products, also playing a key role in increasing the enterprises with high technology both in terms of quantity and quality, contribute to the country's economy and the development levels of the countries. In the global competitive environment, it has become even more important to carry out all activities effectively in terms of increasing the sustainable competitiveness of institutions and providing competitive advantage. It is necessary to systematically examine all processes and activities carried out in order to achieve the expected benefit from technoparks. In this way, it will be easier to report mature activities within the system and focus on critical activities. With this added value, businesses that provide sustainable competitive advantage will also determine the system they should follow.

It is seen that the competitive environment is getting harder in every sector and concepts such as known information technologies, entrepreneurship and innovation are being redefined. In particular, it is important that their structures and working systems are effective so that technoparks can play an active role in meeting the knowledge and technology with the industry and ensuring the commercialization of ideas. Because of its structure, technoparks are regions where rapid and intense developments are present, at the same time contributing to economic growth and where competition is fierce.

In technoparks where university-industry cooperation is transformed into practice, the main goal is to combine the outputs of the R&D centers with industry and advanced technology. In this way, the production of advanced technology products, determination of market share and sustainable competitive advantage will be provided. For this, it will undoubtedly be possible if the added value provided by technoparks to the market is at a higher level than its competitors, and it is possible to create and implement strategies that cannot be easily imitated.

[1] Hasan Kalyoncu University/Gaziantep, Faculty of Engineering, Department of Industrial Engineering, nesli.demircioglu@hku.edu.tr

[2] Hasan Kalyoncu University/Gaziantep, Faculty of Economics and Administrative Sciences, Department of Business Administration Management, zeynep.ozguner@hku.edu.tr

The rest of the paper is organized as theoretical background, provision of data and method and finally, some concluding remarks.

2. LITERATURE REVIEW

The success of a technopark is determined by the number of R&D projects produced, the number of patents, the personnel, and the economic contributions to the region and the country. It creates the technological infrastructure that enables the employment of qualified labor force and the regions to become attractive for foreign investors who want to make technology-based investments (Kubas and Ozmen, 2020: 105). Technoparks, which contain technological innovation-oriented studies in their ecosystem, include the R&D outputs commercialized by academicians who produce information in the university, and thus contribute to the establishment of university-industry collaboration (Ozdemir, 2020: 75).

Technoparks application areas from research variable to business development variable, they are listed as science park, technology park, technology development center, business incubator. At this point, the basic principle is to prepare a ground that can give weight to industrial cooperation in order to accelerate technology transfer in the light of new inventions and new products at every step and to increase the level of economic prosperity and employment (Guler and Kirbaslar, 2020: 25).

In technoparks that constitute the infrastructure of the knowledge economy in the global arena, productive studies based on a systematic basis are included in order to increase the knowledge of individuals and society, to design the processual systems and applications of this knowledge (Akbulut, 2020: 256).

The main target in establishing technoparks is to increase the development levels of countries, to prevent brain drain, and to rapidly support technological developments in order to ensure economic development (Bayzin and Sengur, 2019: 300). Although the purpose of establishment varies according to countries, the main factors can be listed as competition with the increase of global trade, decrease in employment in traditional manufacturing industry, acceleration of technological developments and technology production (Alkibay et al., 2012: 67). There are a number of objectives that technoparks are expected to contribute to; Attracting new entrepreneurs to the regions, increasing the R&D and innovation capacities of companies, expanding cooperation, providing infrastructure opportunities, etc. (Cansiz, 2017: 155-167; Ozdemir, 2020: 75).

Technology parks undertake a coordination role between various actors in order to cooperate and interact with each other, thanks to the triple spiral model (regional development, contribution to innovation and industry), especially considering the geographical proximity to universities in order to facilitate this process (Baycan and Olcay, 2021: 1).

According to Haliloglu's (2021) study of efficiency evaluation of university-industry cooperation, mutual gains of university-industry cooperation are considered important by both institutions and universities. Therefore, significant efforts are made to achieve successful university-industry collaborations. There are many studies that analyze the cognitive effects of university/industry connections through the way entrepreneurs interact with universities, and this research topic is given great importance (Etzkowitz, 1998: 824).

Research universities are leading these collaborations around the world. For example, in Turkey, Middle East Technical University (METU Technopark) and Istanbul Technical University (ITUNOVA Technology Transfer Office) are two of the organizations that aim to produce, commercialize and disseminate the outputs of science and technology projects. It directs academic research and development projects to the industry effectively and on time, and forms an important interface between academics and industry experts to support projects carried out through university-industry collaborations.

The role and activities of the technopark management are found useful by the cooperated institutions to establish a bond with other companies, and their role in increasing innovation is important. With the judgment of science park firms, academics, practitioners and policy makers are provided with valuable information on what benefits firms can seek and what qualifications are required to achieve these perceived benefits. W. K. B. Ng et al. (2021) shows that with the analysis of the data collected from 51 companies in the science parks of the Netherlands, there are economic, innovation and networking benefits of technoparks. In addition, local governments in Sweden support various economies that they expect to contribute to the economy by creating employment through technoparks (Lindelof and Lofsten, 2003: 245).

Collaboration activities in technoparks are of great importance since technoparks are the institution that enables innovation and R&D activities to be delivered to potential customers by proving the product-market compatibility thanks to the cooperation of the public, industry and universities (Etzkowitz et al., 2000: 315). Connection and interaction can be increased through collaboration activities. Also, the aim of increasing the effectiveness of collaboration with local governments in the entrepreneurship ecosystem is considered among the Public Policies and Practices (Cansiz, 2017: 207). In addition, collaborations have been included in this study due to the necessity of supporting the commercialization of information.

The literature on the performance of technoparks gives conflicting results. Some studies can see that technoparks provide positive results for companies and society in terms of the advantages offered. Firms must follow the correct path in management decisions in order to benefit from the advantages offered by technoparks. Therefore, a strategic management system should be established to help technoparks improve their efficiency performance (Ribeiro et al., 2021: 2).

In the studies conducted by Yang and Lee (2021) in China, it was emphasized that the wrong allocation of technoparks in R&D affects the determinants in the selection of the place of establishment, and that the important variables for the establishment of new technoparks are technoparks that are close to universities and have R&D cooperation.

In the light of the literature reviewed, no study has been found in which the input and output factors of this study are handled together and the performance of technoparks is measured at the level of efficiency. In this study, in order to eliminate this deficiency in the literature, some technoparks were analyzed and evaluated based on the results obtained.

Since businesses have limited resources, they should quickly end their decision-making processes regarding their activities or strategic issues; this situation is not only defined as a rapid decision-making process, but also requires intense struggle in the competitive business environment (Uludag and Dogan, 2021: 3).

When there are interrelated but contradictory goals or options, evaluations made using multiple criteria are called Multi Criteria Decision Making (MCDM) methods (Uludag and Dogan, 2021: 3). Data Envelopment Analysis, which is included in the MCDM approach, enables the determination of effective and inactive decision units by using a large number of inputs and outputs (Cooper et al., 2011: 1).

It has been observed that the studies within the scope of the subject were carried out in line with the opinion of the manager and the expert with the reviewed literature and the information in Table 1. It is aimed to fill the gap in the studies on efficiency measurement of technoparks.

3. METHOD AND DATA

Charnes, Cooper, Rhodes (1978) who first used the concept of Data Envelopment Analysis in the literature (Coelli et al., 2005:162). DEA adopts an input-oriented approach (keeping outputs constant and minimizing input amount) or output-oriented approach (keeping inputs constant and maximizing output) in order to obtain an efficient solution (Sozen et al., 2015: 180). Data Envelopment Analysis (DEA) has a methodology that essentially removes the assumptions and limitations of classical efficiency measurement approaches (Bowlin, 1998).

The basic idea of DEA is to determine the decision-making units with the best function among the comparable decision-making units and to develop the methodology that establishes the efficiency limit (Cook and Seiford, 2009: 11-13). DEA is concerned with the system's overall efficiency.

The efficiency of the system is measured by the presence of inputs and outputs that are proven to affect the performance of the systems (Foroutan and Bamdad, 2021: 14). DEA produces a relative measure and uses input and output variables for this (Sirma, 2008: 20).

Data Envelopment Analysis processes are considered under summary stages (Uludag and Dogan, 2021: 431):

1. Selection of decision-making units:

Many studies have explanations about the number of decision units, input and output variables. For example; In Data Envelopment Analysis the number of decision units should be greater than 3 times the number of criteria (Popovic et al., 2020: 6). However Cook et al. (2014) emphasizes that DEA is an individual performance measurement tool and that specifying the sample size is meaningless. The framework of DEA methodology is divided into stages under the titles of objective and subjective efficiency evaluation; Studies that started with the selection of criteria in objective efficiency evaluations also include the process of reducing the number of criteria (Popovic et al., 2020: 6).

Table 1: Studies Using Data Envelopment Analysis

Application areas	Author name and year	Input variables	Output variables
OECD Countries Environment Performance	Ozkan Aksu and Temel Genger, 2018	Virtually Generated Input	Health Impact, Air Quality, Water Resources, Agriculture, Biodiversity, Habitat, Climate, Energy
Health Efficiency Measurement of OECD Countries	Degirmenci, 2021	Number of doctors, number of hospital beds, health expenditure	Lifetime, surviving infant ratio
Technology Development Zone Executive Firms Management Efficiency Measurement	Baykul, Sungur and Dulupcu, 2016	Number of capacity building activities, total cooperation, key personnel	(Academic) number of spin-offs, domestic-foreign firms, employment
Financial Performance Measurement of Airport Group Companies in Europe	Battal, 2020	Current ratio and financial leverage ratio	Asset Profitability Ratio: Net Profit/ Total Asset
Efficiency Measurement in Borsa Istanbul IT Sector	Ozkan, 2021	Current ratio, cash ratio, receivable turnover, cost of sales growth rate	Market value, asset profitability, equity profitability, net sales growth rate
Performance Measurement of Consumer Arbitration Committees of Provincial Directorates of Commerce	Guner Ertemoglu, Ertemoglu and Peker, 2021	Number of consumer complaint applications, number of expert assignments, number of meetings, number of members, number of reporters	Total number of decisions, number of decisions made in favor, number of decisions taken against, number of decisions taken with lack of duty
Efficiency Measurement in Facilities Providing Oral and Dental Health Services	Esenlik Telatar and Sari, 2020	Dentist, dental unit	Tooth Extraction, root canal treatment, filling treatment, surgical intervention, fixed prosthetic member, removable prosthetic part
Supplier Selection of a Company in On Vehicle Equipment Manufacturing Sector DEA and Global Criteria Method	Umarusman, 2019	Number of personnel, shipping fee, product unit price, lead time	Annual production quantity
Efficiency Measurement of Electricity Distribution Companies	Kara and Uslu, 2020	Line, transformer, subscriber, personnel	Electricity consumption, downtime
Supplier Selection in Plastics Company in Iran	Ozsoy, Orkcu and Orkcu, 2020	Eco design cost, logistics cost, number of raw materials, reliability cost	Hazardous materials, number of sustainable products, fuel cost, occupational health cost
Efficiency Measurement of Social Security Expenditures of OECD Countries	Teles, Konca and Cakmak, 2021	Unemployment payments, retirement expenditures, cash social assistance, disability or occupational injury expenditures, health expenditures	Lifetime, unemployment rate
Efficiency Measurement of Foundation University in Turkey	Ozden, 2008	Total expense, number of faculty members, other academic staff	Undergraduate/postgraduate students, publication
Efficiency Measurement of Health Insurance Companies in Turkey	Naldoken and Kaya, 2020	Operating expenses, number of employees, number of agencies, own resources	Technical revenues, total premium generation, technical profit/loss, investment income
Efficiency Measurement of the Socio-Economic Indicators of Provinces in Turkey	Çakmak and Orkcu, 2016	Number of hospital, bed, intensive care bed, family practice, ambulance, physicians	Inpatient, number of operations, satisfaction in health services
GDP Contribution Analysis for Level2 Regions	Aktas and Kabak, 2020	Employment rate in agriculture, employment rate in industry sector, employment rate in services sector	GDP contribution (%)
Efficiency Measurement of Commercial Banks in Turkey	Demirel and Hazar, 2020	Number of personnel per branch, non-interest income/expense, credit obtained/ total liabilities	Total loans/total assets, net profit/ equity and securities/total assets
Efficiency Measurement of the Turkish Banking Sector	Carikci and Akbulut, 2020	Assets, interest expense, deposits, number of branches	Interest income, term-end profit, loans
Determining the Efficiency Scores of EUROCONTROL Member European Air Navigation Service Provider Organizations	Tasdemir and Aydın, 2020	Institution expenses, number of operational staff, number of support staff	Integrated flight hours, delay values

2. Selecting the inputs and outputs to be used in the model:

In many studies in the literature, it is emphasized that the criteria for input and output variables are obtained as a result of interviews with experts. There are also studies that proceed by comparing the experimental results with the opinions of the experts (Rikalovic et al., 2015: 1). Examples of these studies are Ustundag and Kilinc (2012), who work on Technopark selection for start-up companies, and Chen and Huang (2004), who work on evaluating the criteria for high technology companies to be in technology-based industrial zones.

3. Determination of DEA model and efficiency measurement:

In order to show that a proportional change in input factors causes a change in output factors in the same proportion, a fixed return model should be chosen according to the CCR return-to-scale. Whether a model is input or output oriented is at the initiative of the decision maker, it will be able to make this choice according to the availability of the data or the purpose it wants to achieve (Sozen et al., 2015: 182). In our study, Technoparks that can get output-oriented results and have maximum output by minimizing inputs have been determined.

4. Interpretation of the results:

The Ministry of Industry and Technology does not share the data obtained from the entrepreneurship ecosystem with the relevant actors; since these data are not accessible to the public, the contributions of the funds provided by the state and the ministry to entrepreneurs and the ecosystem are evaluated through Impact Analysis studies (Cansiz, 2017: 16). Studies in this field are blended with data collected from entrepreneurs and/or interviews with experts.

Charnes, Cooper, Rhodes (1978) model is explained below. Decision data of interest are indicated with the index "0".

Notations and Decision Variables;

"S" is the set of weight values of the outputs (s=1, 2,..,s)

"M" is the set of weight values of the inputs (m=1, 2,..,m)

$$u_s = weight\ of\ output\ s$$

$$v_m = weight\ of\ input\ m$$

$$y_{sj} = amount\ of\ unit\ j\ of\ output\ s \quad (j=1, 2, \ldots\ldots, n)$$

$$\max z = u_1 * y_{10} + u_2 * y_{20} + \cdots \ldots \ldots \ldots \ldots + \; u_s * y_{s0}$$

Subject to

$$v_1 * x_{10} + v_2 * x_{20} + v_m * \; x_{m0} = 1$$

$$u_1 * y_{1j} + u_2 * y_{2j} + \cdots \ldots \ldots .. + u_s * y_{sj}$$
$$-(v_1 * x_{1j} + v_2 * x_{2j} + \cdots \ldots \ldots .. + v_m * x_{mj}) \leq 0$$

$$v_1, v_2, \ldots \ldots, v_m \geq 0$$
$$u_1, u_2, \ldots \ldots, u_s \geq 0$$

The objective function equation in (1) aims to find the u and v values that will maximize the decision unit. The constraint number (2) is that the sum of the entries is equal to 1. The constraint equation numbered (3) ensures that the weighted output/input ratio does not exceed 1 for each decision unit. With the equation number (4), it is ensured that decision variables are positive.

In order to measure the efficiency of technoparks the information that can be accessed by compiling from both Cansız (2007) and Ozdemir (2020) studies were included in the study. The most important point in the inputs and outputs considered within the scope of the study was the accessibility and reliability of the data.

Dalmarco et al. (2018), it is stated in their studies that universities with Science and Technology Parks are evaluated according to the five performance metrics; Having an entrepreneurial perspective, Development of external links, Providing access to the infrastructures/resources of the university, Providing innovation infrastructures to support entrepreneurship and Application of scientific research. Performance metrics of Science and Technology Parks were prepared within the scope of the study carried out by El Ghazala Technopark serving in Tunisia and supported by the European Investment Bank in 2015.

The similar performance metrics are taken as a basis in the Technology Development Zones Performance Index results by the T.R. Ministry of Industry and Technology. The results of the Technology Development Zones Performance Index for 2020, shared with the public by the Ministry, show only the rankings; however, in the Index results published in 2012, the performance indicators are also expressed. Those indicators are as follows; State Aids and Executive Company Expenditures, R&D Competence, Export and Company Composition, Intellectual Property Rights and Incubation and services.

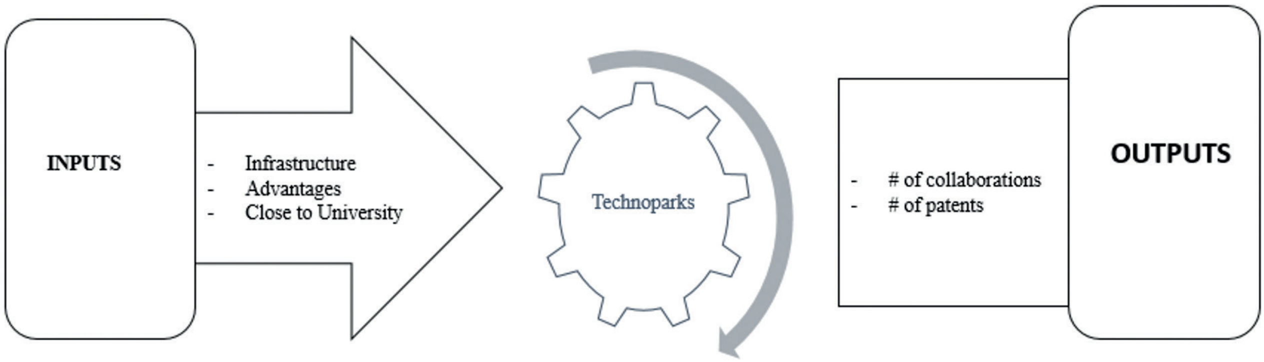

Figure 1: 9 Technopark's Activity Model for DEA

Unlike the documents taken as reference above, the metric "Government Support and Executive Company Expenditures" is not included in our study. Because the same/similar government supports are provided to every entrepreneur/company, submits a project and whose project is approved in order to be included in the Technology Development Zone, so this metric does not differentiate the TDZ Manager Company from each other.

The average distance (km) between the technopark and the university is taken as a basis for access to the resources/infrastructures of the university. If the Technopark or the University is located in more than one campus, the distance between the Rectorate building and the Technopark Executive Building is given, as in Dokuz Eylul University. However, the desired situation here is that two institutions are close to each other. For this reason, distance (km) data cannot be directly included in the analysis. As in Ant Colony Optimization, which is one of the meta-heuristic methods, the inverse of the distance (by measuring 1/Distance) was determined to be close (Dag, 2012: 92).

Under the headings of "Our Policies" on the web pages of TDZ Manager Company (Technology Development Zone Manager companies), they state that "we undertake to create appropriate physical and electronic environments for the security of information assets, to ensure the confidentiality, integrity and accessibility, continuity and control of information assets…". Because, according to the Technology Development Zones Implementation Regulation, was published by the Ministry of Industry and Technology of the Republic of Turkey, they are obliged to keep up-to-date information about some important information for example, the number of personnel, R&D collaborations, industrial property rights, geographical location with institutional/cooperatives etc. which are mentioned in the Technology Development Zone Feasibility Report Preparation Principles. The data verified by these firms and shared with the public on their websites were compiled. Input and output factors are included in the scope of the study with the values stated below.

1. Number of Patents: The greatest power supporting economic growth is technology, so indicators such as high technology exports and patents are known as factors that show and support the progress of technological developments in the economy (Dereli, 2019: 173). Technology management has a close effect on companies' strategies and competitive success (Lindelof ve Lofsten, 2003; 247). Therefore, a conceptual framework has been developed that demonstrates the use of patent data in key areas of technology management (Ernst, 2003: 233).

2. Collaboration: Economic development strategies require a strong university-industry-government cooperation and partnership (Moeliodihardjo, 2012: 308). Nieto et al. (2021) emphasize the importance of university-industry-government cooperation in the entrepreneurship ecosystem, which they define as the Triple Helix. Academicians can serve as consultants, entrepreneurs or R&D personnel with the university-industry cooperation, in this way it actively contributes to the production and dissemination of information and the commercialization of information, and also the infrastructure of the laboratories and R&D Centers used for information generation are enabled to be more active (Keles and Tunca, 2009: 315). In this study, the reason why 5 is written in the input title of "collaboration" for Technopark Istanbul; the number of institutions that Technopark Istanbul cooperates with is 5. These institutions are the Presidency of the Republic of Turkey, Presidency of Defense Industries, Istanbul Chamber of Commerce, Istanbul Airport Operation and Aerospace Industries Inc., Defense Technologies Engineering and Trade Inc. and Istanbul Ticaret University. It is stated that the number of institutions that Yıldız Technopark cooperates with is 2; Yıldız Technical University and EBN Innovation Network. It is stated that the number of institutions that ADU Technopark cooperates with is 5; Aydın Chamber of Commerce, South Aegean Development Agency, Small and Medium Enterprises Development Organization of Turkey, Aydın Adnan Menderes University. It is stated that the number of institutions that ITU Ari Technopark cooperates with is 45; Elginkan Foundation, Istanbul Chamber of Commerce, EnerjiSA, ING Bank, Microsoft etc. It is stated that the number of institutions that Kocaeli University Technopark cooperates with is 5; Kocaeli University, Kocaeli Chamber of Commerce, Kocaeli Chamber of Industry, Gebze Chamber of Commerce, Gebze Organized Industrial Zone Technopark. It is stated that the number of institutions that METU Technopark cooperates with is 2; ASO Technopark and Middle East Technical University. Depark and Ankara Technopark carry out one cooperation each, this cooperation is between their own universities.

3. Infrastructure: It is known that technoparks can count various topics from affordable and low-cost office areas, energy and transportation facilities to prototyping centers offered to entrepreneurs within the infrastructures of technoparks can be counted. The data taken as infrastructure output in the analysis in this study are explained as follows; Yıldız Technopark uses the infrastructures provided by the Prototyping Center, The numerical value of all the facilities provided by this center is taken as 1, which means 1 infrastructure is provided. Considering the example of Technopark Istanbul, the reason for specifying this number as 4; Biocube Lab, Clean Room, Post Incubation Area, Prototyping Center is owned and made available to entrepreneurs. Considering the example of Ankara Technopark, the reason for specifying this number as 6; owning a Biochemistry Lab, Mechanics Lab, Electronics Lab, Food, Agriculture and Animal Center, Gen Research Center and Ear Nose and Throat Research Center and making them available to entrepreneurs. Considering the example of Kocaeli University Technopark, the reason for specifying this number as 4; Prototype Development and Test Center, Laser App. Res., Advanced Materials and Alternative Fuel Research Center is owned and made available to entrepreneurs. The number of infrastructure and laboratory facilities offered to entrepreneurs by the remaining 6 institutions is presented as one; this institution is the centers owned by Technopark and offered to entrepreneurs free of charge, namely Prototyping Center / Workshop / Production Centers.

4. Advantage Offered: The most important point in monitoring the performance of technoparks is attributed to the development of international and inter-regional relations (Bigliardi et al., 2006: 489). Contribution to technology development in the national/international market, which is advocated as one of the most important functions of technoparks, is also included in the study (Chan et al., 2010: 138). The opportunities offered by technoparks to entrepreneurs, such as free mentoring, memberships in valuable organizations, opening offices in international incubation centers for a certain period of time or for an unlimited period, are emphasized in this title. In this way, entrepreneurs will be able to come together with startups working in the same field as them, receive consultancy services from valuable mentors and have the opportunity to meet investors related to their sectors. Looking at Technopark Istanbul, it is possible to cluster in 4 different areas; SAHA Istanbul (Istanbul Defense, Aviation and Space Cluster Association), ARGEMIP (R&D Centers Communication and Cooperation platform), İSEK (Istanbul Health Industry Cluster) and Turkish Maritime Cluster. Looking at METU Technopark, there are opportunities to participate in international acceleration programs and clustering in 5 different fields; It includes clustering opportunities in some areas; Growth Circuit Program, Defense Industry, Informatics, Advanced Health and EEN Anatolia project. ADU Technopark, YTU Technopark, Gaziantep Technopark and ITU Ari Technopark gather the opportunities they offer under one title; It is known as Tralles Academy membership, Starcamp International Acceleration Program, TIM TEB Venture House and Innogate International Acceleration Program, respectively.

5. Proximity to the university: Technoparks are known to be an important channel for them to easily spread the information formed in universities, considering their geographical proximity to the university (Baycan and Olcay, 2021: 102). What is meant to be explained with this title is the extent to which physical distance is supported to access the Technopark. In terms of accessing the resources/infrastructures of the university (if the Technopark's Administration Building is located in more than one campus, the closest distance from the Rectorate Building within the university is given, as in Dokuz Eylul University) the average distance between the Technopark and the university.

Four models related to Data Envelopment Analysis method were applied and results were obtained; the results of the analysis performed according to CCR input-oriented and CCR output-oriented models are stated. For

Table 2: Variables used in the study and their values

#	Institutions	Collaboration	Number of patents	Infrastructure	Advantage	Proximity to the university
1	Technopark Istanbul	5	228	4	4	0.09
2	ADU Technopark	5	6	1	1	0.50
3	YTU Technopark	2	263	1	1	0.50
4	Depark	1	27	1	0	0.08
5	Gaziantep Technopark	1	10	1	1	1
6	Ankara Technopark	1	200	6	0	0.05
7	ITU Arı Technopark	45	245	1	1	0.50
8	Kocaeli University Technopark	5	37	4	0	0.04
9	METU Technopark	2	200	1	5	0.50

each model, interpretations are made based on input and output weights according to the reference clusters and residual values.

$$\max z = 5*u_1 + 228*u_2$$

Subject to

$$5*u_1 + 228*u_2 - 4*v_1 - 4*v_2 - 0,09*v_3 \leq 0$$

$$5*u_1 + 6*u_2 - v_1 - v_2 - 0,50*v_3 \leq 0$$

$$2*u_1 + 263*u_2 - v_1 - v_2 - 0,50*v_3 \leq 0$$

$$u_1 + 27*u_2 - v_1 - 0,08*v_3 \leq 0$$

$$u_1 + 10*u_2 - v_1 - v_2 - v_3 \leq 0$$

$$u_1 + 200*u_2 - 6*v_1 - 0,05*v_3 \leq 0$$

$$45*u_1 + 245*u_2 - v_1 - v_2 - 0,50*v_3 \leq 0$$

$$5*u_1 + 37*u_2 - 4*v_1 - 0,04*v_3 \leq 0$$

$$2*u_1 + 200*u_2 - v_1 - 5*v_2 - 0,50*v_3 \leq 0$$

$$4*v_1 + 4*v_2 + 0,09*v_3 = 1$$

$$u_1, u_2, v_1, v_2, v_3 \geq 0$$

Data Envelopment Analysis method with the Solver add-on of the Microsoft Excel package program was applied for each institution and efficiency scores were obtained. The findings provided by the analysis for Technopark Istanbul are listed in Table 3.

Table 3 and Table 4 are included in a single page on the Microsoft Excel spreadsheet. Output and input values explained in Table 3 are respectively c1 cooperation, c2 number of patents, g1 infrastructure, g2 offered advantages, g3 proximity to university. Table 3 contains the output maximization results. In order to obtain these results, the institutions were numbered and the input variables belonging to the institutions were processed on the Microsoft Excel spreadsheet. It is obtained by multiplying the input and output variables included in the weighted calculations and the weight coefficients to these variables. Decision variables are named by c1, c2, g1, g2 and g3, the weighting coefficients and efficiency score of these variables are entered in Table 3.

In the Microsoft Excel table, two equations are entered in the Solver add-on as constraints. The model, which has output maximized objective function and two constraint equations, is solved separately for each institution as a simple linear programming model. The value specified in the output row in Table 4 is the efficiency score.

In Table 3, analysis results are given based on CCR input direction model data. As a result of the analysis, efficiency score of technoparks, reference clusters and how often an effective technopark is taken as reference by inactive technoparks can be seen in the table given by the method. Effective decision-making units according to Table 3 are Teknopark Istanbul, Yildiz Technical University (YTU) Technopark, Dokuz Eylul University Technology Development Inc. (Depark), Ankara Technopark, Istanbul Technical University (ITU) Ari Technopark and Kocaeli University Technopark.

As we have obtained with Excel Solver and the results can be obtained with the CCR Input and Output oriented

Table 3: Efficiency Score for METU Technopark with Solver add-on

		Output		Input			Weighted Calculations	
#	**Institutions**	**c1**	**c2**	**g1**	**g2**	**g3**	**Output**	**Input**
1	Technopark İstanbul	5	228	4	4	0.09	0.87	0.87
2	ADU Technopark	5	6	1	1	0.50	0.03	1
3	YTU Technopark	2	263	1	1	0.50	1	1
4	Depark	1	27	1	0	0.08	0.10	0.31
5	Gaziantep Technopark	1	10	1	1	1	0.03	1.81
6	Ankara Technopark	1	200	6	0	0.05	0.75	1.15
7	ITU Arı Technopark	45	245	1	1	0.50	1	1
8	Kocaeli University Technopark	5	37	4	0	0.04	0.14	0.79
9	METU Technopark	2	200	1	5	0.50	0.76	1

Table 4: Technopark weighting coefficients and efficiency score of the variables of METU Technopark

	c1	c2	g1	g2	g3
Weighting coefficient	0,0015	0,0037	0,1808	0	1,6384
Technopark	9				
Output	0,7612				
Input	1				

efficiency score measurement made in the OSDEA GUI package program. The institutions or DMU Names (Decision Making Units) and Peer Group information, these means that shows the technoparks with which they are compared. In Table 5 DMU Names in which their efficiencies are identified as "Yes" are benchmarking with themselves, so their peer groups are themselves.

4. CONCLUSION AND DISCUSSION

Data Envelopment Analysis enables efficiency measurement. This shows why this method is preferred for analyzing and performance measurement of Technology Development Zone operating in Turkey. 9 Technoparks who shared their data with the public were included in the analysis. The main result is to compare the performances of Technoparks according to input and output variables, which Technopark is more effective and which is taken as a reference. CCR Input and Output oriented efficiency score calculations were made in Microsoft Excel package program. The results are similar to works of literature and interpreted as follows;

Technoparks that are ineffective according to the determined variables: Adnan Menderes University) ADU Technopark (0,11), Gaziantep Technopark (0,04). Since METU Technopark has a high efficiency score (0,76), it is not considered in this category.

Technoparks, whose efficiency were measured within the scope of DEA findings, were evaluated in terms of input and output dimensions. The results of the study

Table 5: CCR Input Oriented Activity Score

#	DMU Names	Objective Value	Efficient
1	**Technopark Istanbul**	1	Yes
2	**ADU Technopark**	0,111	
3	**YTU Technopark**	1	Yes
4	**Depark**	1	Yes
5	**Gaziantep Technopark**	0,038	
6	**Ankara Technopark**	1	Yes
7	**ITU Arı Technopark**	1	Yes
8	**Kocaeli University Technopark**	1	Yes
9	**METU Technopark**	0,761	

are based on the literature (Cansız, 2017; W.K.B. Ng et al., 2021; Lindelof and Lofsten, 2003; Baykul, Sungur and Dulupcu, 2016; Yang and Lee, 2021); and it is thought that the efficiency of inputs and outputs with DEA method provides an important perspective in terms of measuring. In addition, the study can be considered as a first step for similar studies. For the future studies that are planned to be carried out, it will be possible for more Technoparks to share data transparently, so that it will be possible to reach more data at the point of efficiency measurement.

The present study had limitations in data collection and validation. Technology Development Zone Management Enterprises, which share limited data, are stated as the limitations of the study. Geographical differences, demographic features and other technological variables can be added to the scope of future studies, as the east-west synthesis is tried to be achieved within the scope of the study. In this direction, the subject of another study can be formed by considering DEA methods more comprehensively or by using integrated MCDM methods. Future studies are encouraged to take qualitative or other indicators as output/input variables, which can be effective in efficiency measurement according to literature.

In addition to measuring efficiency with the analysis made in the study, it is also emphasized that technoparks should be more transparent in terms of visibility. It is considered important that performance indicators, which are one of the motivation-enhancing tools, should be prompted to think in more detail about data sharing in terms of technology development regions. The proposed methodology, when evaluated against relevant criteria, can be considered representative of the overall paradigm for measuring efficiency.

REFERENCES

AKBULUT, K. (2020). Extension of Technopark Boundaries to Include Free Zone, *Financial Solution*, 30(162), 255-260.

AKTAS, A. and KABAK, M. (2020). Analysis of GDP Contribution of NUTS – 2 Regions via Data Envelopment Analysis, *Ankara Hacı Bayram Veli University Journal of Faculty of Economics and Administrative Sciences,* Special Volume, 191-206.

ALKIBAY, S., ORHANER, E., KORKMAZ, S. and SERTOGLU, A. E. (2012). Technoparks within the Framework of University-Industry Cooperation, Managerial Problems and Suggested Solutions, *Ataturk University Journal of Economics and Administrative Sciences,* 26(2), 65-90.

BATTAL, U. (2020). Measurement of Financial Performance of Airport Groups Companies in Europe: Data Envelopment Analysis Method, *Academic Review of Economics and Administrative Sciences,* 13(1), 171-184.

BAYCAN, T. and ARKALI OLCAY, G. (2021). Linking the Performance of Entrepreneurial Universities to Technoparks and University Characteristics in Turkey, *Region*, 8(1), 97-117. Doi: 10.18335/region.v8i1.300.

BAYKUL, A., SUNGUR, O. and DULUPCU, M.A. (2016). Evaluation of Management Efficiencies of Technology Development Zones Managing Company Using Data Envelopment Analysis, *Suleyman Demirel University The Journal of Visionary,* 7 (15), 70-82.

BAYZIN, S. and SENGUR, M. (2019). Role of Technoparks In University-Industry Cooperation, *The International Journal of Economic and Social Research,* 15(3), 299-314.

BIGLIARDI, B., DORMIO, AI., NOSELLA, A. and PETRONI, G. (2006). Assessing science parks' performances: Directions from selected Italian case studies, *Technovation,* 26(4), 489-505.

BOWLIN, W. F. (1998). Measuring Performance: An Introduction to Data Envelopment Analysis (DEA), *The Journal of Cost Analysis,* 15(2), 3-27.

CAKMAK, E. and ORKCU, H. (2016). The Evaluation of Efficiency of Provinces in Turkey by Socio-Economic Main Indicators Using Data Envelopment Analysis, *Karabuk University Journal of Social Sciences Institutes,* 6(1), 30-48.

CANSIZ, M. (2017). Turkey Technoparks to 2023, Republic of Turkey Ministry of Development of Social Sectors and Coordination General Directorate, Publication No: 2972, December.

CARIKCI, O. and AKBULUT, F. (2020). Measurement of the Efficiency of the Turkish Banking Sector with Data Envelopment Analysis, *Journal of Business Research-Turk,* 12(1), 215-226.

CHAN, K., OERLEMANS, L. and PRETORIUS, M. (2010). Knowledge flows and innovative performances of NTBFs in Gauteng, South Africa: An attempt to explain mixed findings in science park research, *International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering.* 4(6), 1440-1454.

CHEN, C. J. and HUANG, C. C. (2004). A Multiple Criteria Evaluation of High-Tech Industries for The Science-Based Industrial Park in Taiwan*, Information & Management,* 41, 839–851.

COELLI, T.J., PRASADA RAO, D.S., O'Donnell, C.J. and Battase, G.E. (2005). *An Introduction to Efficiency and Productivity Analysis,* 2nd Edition, Springer Science + Business Media Inc.

COOK, D., TONE, K. and ZHU, J. (2014). Data envelopment analysis: Prior to choosing a model, *Omega*, 44, 1-4.

COOK, W. D., and SEIFORD, L. M. (2009). Data envelopment analysis (DEA)-Thirty years on, *European Journal of Operational Research, 192(1), 1-17.*

COOPER, W., SEIFORD, L. and ZHU, J. (2011). *Data Envelopment Analysis: History, Models and Interpretations,* 2nd Edition, Springer Science + Business Media Inc.

DAG, S. (2012). *Optimization of Flow shop Scheduling Problems Using Heuristic Techniques. (Unpublished doctoral thesis). İstanbul University/Social Sciences Institute, Istanbul.*

DEGIRMENCI, N. (2021). Evaluation of Health Efficiency of OECD Countries with Data Envelopment and Inverse Data Envelopment Analyses, *UIIID-IJEAS,* (30), 171-182.

DEMIREL, A.C. and HAZAR, A. (2020). An Application for Efficiency Measurement of Commercial Banks via Data Envelopment Analysis, *Journal of Commercial Sciences,* 4(1), 43-58.

DERELI, D. (2019). The Relationship Between High-Technology Exports, Patent and Economic Growth in Turkey (1990-2015), *Journal of Business, Economics and Finance*, 8(3), 173-180.

ERNST, H. (2003). Patent Information for Strategic Technology Management, *World Patent Information,* 25, 233-242.

ESENLIK TELATAR, D. and SARI, K. (2020). A Data Envelopment Analysis Model for the Efficiency Measurement of Facilities Providing Oral and Dental Health Services: The Case of Istanbul, *Pamukkale University Journal of Engineering Sciences,* 26(4), 768-778.

ETZKOWITZ, H. (1998). The Norms of Entrepreneurial Science: Cognitive Effects of the New University–Industry Linkages, *Research Policy,* 27(8), 823–833. Doi: 10.1016/S0048-7333(98)00093-6.

ETZKOWITZ, H., WEBSTER, A., GEBHARDT, C. and TERRA, B. (2000). The future of the university and the University of the Future: evolution of ivory tower to entrepreneurial paradigm, *Research Policy,* 29, 313-330.

FOROUTAN, S.L.F. and BAMDAD, S. (2021). Efficiency measurement of railway passenger stations through network data envelopment analysis, *Research in Transportation Business and Management,* Available Online, 1-15. Doi: 10.1016/j.rtbm.2021.100767

GULER, M. and KIRBASLAR, S. I. (2020). *The Role of Technology Transfer Offices in University-Industry Collaboration,* Iksad Publishing House, Adiyaman

GUNER ERTEMOGLU, H., ERTEMOGLU, S. and PEKER, I., (2021). Performance Evaluation of Provincial Directorates of Commerce by Data Envelopment Analysis, *Ataturk University Journal of Economics and Administrative Sciences,* 35(1), 291-317.

HALILOGLU, E. Y. (2021). *Efficiency Assessment of University-Industry Collaboration, University-Industry Collaboration Strategies in the Digital Era*, Doi: 10.4018/ 978-1-7998-3901-9.ch008

KARA, O. and USLU, M. (2020). Efficiency of Electricity Distribution Companies: Bootstrap Estimated Two-Stage DEA Analysis, *Nigde Omer Halisdemir University Journal of Social Sciences Institutes,* 2(2), 189-206.

KELES, M. and TUNCA, M. (2009). University-Industry Cooperation and the Role of Technopark in Turkey. University Industry Collaboration Centers Platform (UICCP) Proceedings of the National Congress of University-Industry Cooperation, Eskisehir, 7-8 May, 311-322.

KUBAS, A. and OZMEN, N. B. (2020). Entrepreneurship and Technopark, *Balkan and Near Eastern Journal of Social Sciences,* 6(4), 104-109.

LINDELOF, P. and LOFSTEN, H. (2003). Science Park Location and New Technology-Based Firms in Sweden-Implications for Strategy and Performance, *Small Business Economics*, 20, 245-258.

MOELIODIHARDJO, B., SOEMARDI, B., BRODJONEGORO, S. and HATAKENAKA, S. (2012). University, Industry and Government partnership: its present and future challenges in Indonesia, *Procedia-Social and Behavioral Sciences,* 52, 307-316.

NALDOKEN, U. and KAYA, M. V. (2020). In Turkey Health Insurance Companies Efficiencies Measurement with Data Envelopment Analysis, *Dumlupinar University Journal of Social Sciences,* 65, 21-33.

NG, W. K. B., APPEL-MEULENBROEK, R., CLOODT, M. and ARENTZE, T. (2021). Perceptual Measures of Science Parks: Tenant Firms' Associations between Science Park Attributes and Benefits, *Technological Forecasting & Social Change,* (163), 1-15. Doi: 10.1016/j.techfore.2020.120408.

NIETO, J., CRECENTE, F., SARABIA, M. and DEL VAL, M. (2021). The Habitat of University and Non-University Startups, *Entrepreneurship & Regional Development*, 33(3-4), 273-286, Doi: 10.1080/08985626.2021.1872938.

OZDEMIR, Y. (2020). Determination of AHP and Importance Coefficients of Variables Which Effective in the Establishment Choice of Technoparks Supported by Innovation-Focused Initiatives, *International Journal of Management Information Systems and Computer Science,* 4(1), 74-83.

OZDEN, U. H. (2008). Efficiency Evaluation of Foundation Universities in Turkey by Using Data Envelopment Analysis (DEA), *Istanbul University Journal of the School Business Administration,* 37(2), 167-185.

OZKAN AKSU, E. and TEMEL GENCER, C. (2018). Investigating the Environmental Performance of OECD Countries By Data Envelopment Analysis, *UIIID-IJEAS, 18. EAS Special Issue,* 191-206.

OZKAN, T. (2021). Evaluating The Efficiency of Enterprises Traded in Borsa Istanbul IT Sector, *Journal of Finance Letters,* (115), 253-268.

OZSOY, V. S., ORKCU, M. and ORKCU, H. (2020). The Most Efficient Supplier Selection with Mixed-İnteger Two-Stage Data Envelopment Analysis Model, *Pamukkale University Journal of Engineering Sciences,* 26(4), 758-767.

POPOVIC, M., SAVIC, G., KUZMANOVIC, M. and MARTIC, M. (2020). Using Data Envelopment Analysis and Multi-Criteria Decision-Making Methods to Evaluate Teacher Performance in Higher Education, *Symmetry*, 12(563), 1-19.

RIBEIRO, J. A., LADEIRA, M. B., FARIA, A. F. and BARBOSA, M. W. (2021). A Reference Model for Science and Technology Parks Strategic Performance Management: An Emerging Economy Perspective, *Journal of Engineering and Technology Management,* 59, 1-16.

RIKALOVIC, A., COSIC, I., LABATI, R. and PIURI, V. (2015). A Comprehensive Method for Industrial Site Selection: The Macro-Location Analysis, *IEEE*, 11(4), 2971-2980, Doi: 10.1109/JSYST.2015.2444471.

SIRMA, I. (2008). *Parametric and Non-Parametric Approaches to the Financial Efficiency. (Unpublished doctoral thesis). İstanbul University/Social Sciences Institute, Istanbul.*

SOZEN, A., MİRZAPOUR, A., CAKIR, M., ISKENDER, U. and CIPIL, F. (2015). Selecting Best Location of Wind Plants Using DEA and TOPSIS Approach In Turkish Cities, *Gazi Journal of Engineering Sciences,* 1(1), 173-194.

TASDEMIR, M. and AYDIN, E. (2020). Determining the Efficiency Scores of EUROCONTROL Member European Air Navigation Service Provider Organizations by Data Envelopment Analysis Method, *Journal of Business Research,* 12(4), 4305-4322. Doi: 10.20491/isarder.2020.1106.

TELES, M., KONCA, M. and CAKMAK, C. (2021). Evaluating the Health System Performance of OECD Countries with Malmquist Index, *Journal of Health and Social Welfare Research,* 3(1), 67-76.

ULUDAG, A. S and DOGAN, H. (2021). *Multi-Criteria Decision Making Methods, Literature, Theory and Practice in Production Management,* 1st Edition, Nobel Publication, Ankara.

UMARUSMAN, N. (2019). *An Integrated Solution Proposal for Supplier Selection Problems: Data Envelopment Analysis and Global Criteria Method,* 1st Edition, Bilgin Culture and Art Publications, 301-315.

USTUNDAG, A. and KILINC, M. (2012). Fuzzy Multi-Criteria Selection of Science Parks for Start-up Companies, *International Journal of Computational Intelligence Systems,* 4(2), 217-227.

YANG, C. H. and LEE, W. C. (2021). Establishing Science Parks Everywhere? Misallocation in R&D and Its Determinants of Science Parks in China, *China Economic Review*, 67(2), 1-18, Doi: 10.1016/j.chieco.2021.101605.