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Performance Evaluation of Different Districts of the Shiraz City Municipality Using DEA based on financial indicators

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Abstract

Objectives: The purpose of this research is to evaluate and rank the performance of various districts within the Shiraz municipality based on different financial criteria. Therefore, we evaluated the performance of 11 districts of Shiraz municipality in the second half of 2022.

Design/methodology/approach: Efficiency values were obtained for the areas using different technologies, and a suitable model was provided for the ineffective areas. The evaluation of the districts was based on input variables such as the number of employees, the area (in square meters) of the district building, and deferred income, as well as output variables including sold bonds, tax income, service income, and construction income. Input and output values were determined by consulting the informatics department of each district.

Results: Based on the results, optimal performance recommendations can be made to senior managers of the municipality.

Innovation: The current research is focused on evaluating financial aspect of performance in various districts of Shiraz Municipality. The goal is to find a suitable model for ranking these areas. This research can provide researchers and managers with an innovative perspective that can be applied in both theory and practice.

Keywords: Data Envelopment Analysis, Efficiency, Ranking, Municipality.

1. Introduction

In the age of information and competition between organizations, every organization is trying to create a new method for the transformation of its organization to surpass its competitors, maintain and gain a competitive advantage, and examine the important role that efficiency has in the development of societies. All its dimensions, especially in the form of mathematical analysis as a standard for measuring performance, are inevitable. Since the main heart and artery of the country's cities is tied to the municipalities, it is obvious that the correct growth and development of the municipalities will increase their efficiency, which will make the economy flourish and help escape from financial crises. In addition, increasing the efficiency of municipalities can be a big step in the better implementation of the beautiful city plan (Barakpour et. al., 2010).

The current era and the tremendous changes in management knowledge have made the existence of an evaluation system inevitable. In such a way, the lack of evaluation in different dimensions of the organization, including the evaluation of the use of resources and facilities, goals, and strategies, is considered one of the symptoms of the organization's illness.

Evaluating the performance of organizations and economic enterprises with similar activities and examining the results of their performance in a certain period is considered an important and strategic process that, while determining the competitive position of the organization, plays a significant role in continuous improvement and increasing quality and effectiveness.

Performance evaluation and measurement provide the necessary feedback in the following cases:

1. By tracking the amount of progress toward the set goals, it is determined whether the developed policies have been implemented successfully or not.

2. By measuring the expected results of the organization, as well as evaluating and measuring the satisfaction of employees and customers, it is determined whether the policies have been compiled correctly or not.

3. Performance evaluation and measurement make it possible to identify areas to which management should pay more attention and help identify opportunities and limitations.

4. Performance evaluation will provide information for managers in managerial decisions. A large part of the necessary information for managerial decisions is provided by measuring and evaluating the performance system (Razovian et. al., 2014).

Today, the city administration industry has become very competitive. Based on proven experience in competitive conditions, strong institutions that operate efficiently and effectively will survive. Success in a competitive market requires a high level of performance through continuous learning and operational improvement. Managers should know their relative success compared to competitors and how best practices are related to their productivity. In other words, they should be aware of their success compared with other similar institutions and their previous years.

The key to solving this problem is to find out how much of the available capabilities have been used. Banks, as the most important institutions in the money market, are not exempt from this. Since the optimal functioning of municipalities has a significant impact on the country's economic growth and development, creating the necessary conditions and platforms to improve the quality and quantity of banks' performance in the shadow of a healthy competitive environment can play a significant role in achieving these goals (Faraji, 2017).

In the current situation, the need to analyze the financial situation of banks is important for both the government and depositors, and in this way, it facilitates the movement of the wheels of society's economy toward growth and development. In this regard, evaluating the financial performance of banks is an important tool for making investment decisions, and many investors can use it to determine the fate of their money and investments. In addition, the primary goal of the bank, like other for-profit organizations, is to maximize the wealth of its owners. In increasing the wealth of shareholders, the management of the municipality must decide whether to acquire assets with lower quality and more income, assets with higher quality and less risk, or whether the municipality should invest and provide facilities with long maturity and liquidity. Should the municipality reduce it or choose assets with shorter maturities and provide a high degree of liquidity?

The answer to the above questions made it necessary to evaluate financial performance so that banks can examine their performance in terms of profitability, capital adequacy, asset structure, and liquidity compared to rival municipalities so that they can measure their situation and improve their performance (Mousavi, 2016).

The efficiency of municipalities and how to calculate it is an important issue that, in addition to the municipal managers of these financial institutions, is of interest to the supervisory department of the urban system and customers using banking services. Considering the existing challenges, the entry of private service companies, and the increase in the activities of financial and credit institutions, it is important to evaluate the performance of municipalities and examine the efficiency of these organizations. The efficiency of municipalities is not at the desired level. The dissatisfaction of the public with the performance of municipalities is proof of this claim. There are many reasons for the decline in performance, among which we can point out that the municipalities are state-owned, the inefficiency of government management, and the facilities assigned to the municipalities. Since the group of city council officials is trying to improve the efficiency of the municipal system, it is important to conduct research that examines and compares the efficiency of the urban system over a certain period. Despite the importance of the country's municipal system in the domestic and regional economies, few studies have examined the efficiency of municipal organizations in the long term (Mousavi, 2016).

To evaluate the performance, the data envelopment analysis (DEA) method is used as a tool to evaluate the performance of decision-making units. Efficiency measurement has always been considered because of its importance in evaluating the performance of an organization. In the current research, due to the researchers' emphasis on data coverage analysis, special attention has been paid to the selection of inputs and outputs. DEA is a comprehensive approach that is accepted to evaluate performance in the municipal service industry (Charnes et. al.,1978).

Several studies have been conducted in the field of efficiency, both inside and outside the country. Among the research conducted regarding efficiency inside the country, the following can be mentioned:

Amiri (2001) defined and calculated the measure of efficiency in municipal organizations. His goal was to identify the shortcomings of previous planning in the urban system using the efficiency index. Based on this study, there is a relationship between the efficiency of municipal districts and their structure, and it has been determined in this research that there is a negative relationship between improper monitoring and major weaknesses in the service network monitoring system. In addition, in this study, a positive relationship between executive power and the efficiency of the municipal service system has been confirmed.

Hadian (2013) examined the efficiency of 10 banks in the country for the period 1997–1999. According to the results obtained from his research, three service companies in the municipality were technically efficient in the mentioned years, assuming the existence of variable returns to scale. The average technical, specialized, and economic efficiency of these three companies is 84.2%, 86.4%, and 74.3%, respectively.

For example, some shareholders may move their shares from where they fear the uncertainty of future sales. However, other investors take advantage of this chance to acquire shares at a discounted rate due to current inflation and then sell them at a higher price. (Levine et al. 2001).

Secme et al. (2009) evaluated the financial performance of the urban service industry in Turkey using hierarchical analysis and TOPSIS. In this study, the evaluation of the macro-performance of the municipality is investigated in two financial and non-financial sectors. Capital quality index, asset quality, profitability, liquidity, income and cost structure, and stock group are studied to evaluate financial performance, and pricing index, marketing, productivity, and service provision are studied to evaluate non-financial performance.

Worthington and Dollery (2012) developed a model for measuring efficiency in local government that applied an analysis of New South Wales municipalities' domestic waste management.

Rogge and De Jaeger (2001) proposed an adjusted "shared-input" version of the popular efficiency measurement technique DEA, which enables the evaluation of municipal waste collection and processing performances in settings in which one input (waste costs) is shared among treatment efforts of multiple municipal solid waste fractions. The model is a DEA model that not only provides estimates of the overall cost efficiency of municipalities but also provides estimates of the cost efficiency of municipalities for treating various fractions of municipal solid waste (MSW)

Yang et al. (2015) applied the CCR model in the DEA to obtain the green development frontier surface based on 31 regions' annual cross-sectional data from 2008 to 2012. In addition, to classify the regions where assessment values are equal to1 in the CCR model, we chose the Super-Efficiency DEA model for further sorting. Using the five-year panel data, the green development efficiency in 31 regions can be manifested by the Malmquist index.

The organization of this paper is as follows: In the second part, the basic concepts related to performance evaluation models in DEA and the concept of super-efficiency are presented. In the fourth part of this paper, we present a model for evaluating the efficiency of the municipal districts of Shiraz using the DEA models presented in the previous sections. Finally, we present the results of the paper.

2. DEA model

Consider the n DMUs as, $DMU_j = (X_j, Y_j)$ $j = 1, \dots, n$, where X_j and, Y_j are the vectors of input and output corresponding, DMU_j $j = 1, \dots, n$, also we have, $X_j \geq 0$, $X_j \neq 0$ and.$Y_j \geq 0, Y_j \neq 0$

In the input-oriented CCR, the goal is to reduce the level of input with a ratio. Theθinput-oriented CCR model is presented as follows:

$$\theta^* = Min \quad \theta$$
$$S.t. \quad \sum_{j=1}^{n} \lambda_j X_j \leq \theta X_o$$
$$\sum_{j=1}^{n} \lambda_j Y_j \geq Y_o \qquad \lambda_j \geq 0\ ,\ j = 1, \dots, n$$
$$\theta \text{ is free in sign.} \tag{1}$$

Definition 1. $DMU_o = (X_o, Y_o)$is called an efficient CCR in the input-oriented sense if and only if,$\theta^* = 1$otherwise, it is inefficient.

If we consider the slacks corresponding to the input and output variables in the model (1.2), we can consider the following model to calculate the Pareto efficiency as follows:

$$Min \quad \theta - \varepsilon\left(\sum_{r=1}^{s} s_r^+ + \sum_{h=1}^{m} s_i^-\right)$$
$$S.t \quad \sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta x_{io}, \qquad i = 1, \dots, m$$
$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{ro}, \qquad r = 1, \dots, m$$
$$\lambda_j \geq 0, \qquad j = 1, \dots, n \qquad s_i^- \geq 0, \qquad i = 1, \dots, m, \tag{2}$$
$$s_r^+ \geq 0\ , \qquad r = 1, \dots, s, \qquad \theta \text{ is free in sign.}$$

Definition 2. $DMU_o = (X_o, Y_o)$ is called Pareto efficient CCR in the input-oriented case if and only if,$\theta^* = 1$and in every optimal solution, all slack variables are equal to zero.

The score θ^* in the input-oriented model is called technical efficiency and $(1 - \theta^*)$ is called technical inefficiency.

The dual of the input-oriented CCR model is as follows:

$$Max\ U^t Y_o$$

$$S.t.\ \ U^tY_j - V^tX_j \le 0,\ j = 1,..n,$$
$$V^tX_o = 1, \qquad (3)$$
$$U \ge 0, V \ge 0.$$

Model (3) is called the input-oriented CCR model in multiple forms. $DMU_o = (X_o, Y_o)$is efficient in evaluating with the multiple models (model (3)), if and only if there is (U^*, V^*) as an optimal solution to model (3) that satisfies the following conditions:
$U^{*t}Y_o = 1, (U^*, V^*) > 0.$
In the output-oriented CCR, the goal is to increase the output level with a ratio. Theφoutput-oriented CCR model is presented as follows:

$$\varphi^* = Max \quad \varphi$$
$$S.t.\quad \sum_{j=1}^{n} \lambda_j X_j \le X_o$$
$$\sum_{j=1}^{n} \lambda_j Y_J \ge \varphi Y_o \qquad (4)$$
$$\lambda_j \ge 0 \qquad , \qquad j = 1, \dots, n.$$

Definition 3. $DMU_o = (X_o, Y_o)$is called efficient CCR in the output-oriented case if and only if,$\varphi^* = 1$else it is inefficient.
The score φ^* in the output-oriented model is called technical efficiency and $\left(1 - \frac{1}{\varphi^*}\right)$ is called technical inefficiency. The input-oriented BCC model is presented as follows:

$$\theta^* = Min \quad \theta$$
$$S.t.\quad \sum_{j=1}^{n} \lambda_j X_j \le \theta X_o$$
$$\sum_{j=1}^{n} \lambda_j Y_j \ge Y_o \qquad (5)$$
$$\sum_{j=1}^{n} \lambda_j = 1,$$
$$\lambda_j \ge 0,\ j = 1, \dots, n,$$
$$\theta\ is\ free\ in\ sign.$$

Definition 4. $DMU_o = (X_o, Y_o)$is called an efficient BCC in the input-oriented case if and only if, $\theta^* = 1$else, it is inefficient.
If we consider the slacks corresponding to the input and output variables in the model (1.8), we can consider the following model to calculate the Pareto efficiency as follows:

$$Min \quad \theta - \varepsilon\left(\sum_{r=1}^{s} s_r^+ + \sum_{h=1}^{m} s_i^-\right)$$
$$S.t \quad \sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta x_{io}, \qquad i = 1, \dots, m,$$
$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{ro}, \qquad r = 1, \dots, s,$$
$$\sum_{j=1}^{n} \lambda_j = 1, \quad \lambda_j \ge 0, \qquad j = 1, \dots, n$$
$$s_i^- \ge 0, \qquad i = 1, \dots, m, \qquad (6)$$
$$s_r^+ \ge 0\ , \qquad r = 1, \dots, s, \quad \theta\ is\ free\ in\ sign.$$

Definition 5. $DMU_o = (X_o, Y_o)$ is called Pareto-efficient BCC in the input-oriented sense if only it is,$\theta^* = 1$, and in every optimal solution, all slack variables are equal to zero$s_i^{-*} = 0, i = 1, \dots, m, s_r^{+*} = 0, r = 1, \dots, s$
The dual of the model (6) is as follows:

$$Max \quad \sum_{r=1}^{s} u_r y_{ro} - u_0$$
$$S.t. \quad \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} - u_o \le 0,$$
$$j = 1, \dots, n \quad \sum_{i=1}^{m} v_i x_{io} = 1$$
$$u_r \ge \varepsilon, \qquad r = 1, \dots, s \qquad v_i \ge \varepsilon, \qquad i = 1, \dots, m$$
$$(7)$$

The output-oriented BCC model is presented in envelope form as follows.

$$\varphi^* = Max \quad \varphi$$
$$S.t.\quad \sum_{j=1}^{n} \lambda_j X_j \le X_o$$
$$\sum_{j=1}^{n} \lambda_j Y_j \ge \varphi Y_o$$
$$\sum_{j=1}^{n} \lambda_j = 1 \quad \lambda_j \ge 0, \quad j = 1, \dots, n \qquad (8)$$

Definition 6. $DMU_o = (X_o, Y_o)$is called efficient BCC in the output-oriented case if and only if,$\varphi^* = 1$otherwise, it is inefficient.
If we consider the slacks corresponding to the input and output variables in model (8), we can consider the following model to calculate the Pareto efficiency:

$Min \quad \varphi + \varepsilon(\sum_{r=1}^{s} s_r^+ + \sum_{h=1}^{m} s_i^-)$
$S.t. \quad \sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{io} \;, \qquad i = 1, \ldots, m$
$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = \phi y_{ro}, \qquad r = 1, \ldots, s$
$\sum_{j=1}^{n} \lambda_j = 1 \qquad \lambda_j \geq 0, \qquad j = 1, \ldots, n$
$s_i^- \geq 0, \qquad i = 1, \ldots, m$
$s_r^+ \geq 0, \qquad r = 1, \ldots, s \qquad (9)$

Definition 7. $DMU_o = (X_o, Y_o)$is called Pareto efficient BCC in the output-oriented if only if$\varphi^* = 1$, and in every optimal solution, all slack variables are equal to zero.$s_i^{-*} = 0, i = 1, \ldots, m, s_r^{+*} = 0, r = 1, \ldots, s$

The dual of model (9) is as follows:

$Max \quad \sum_{i=1}^{n} v_i x_{ip} + v_0 \qquad S.t. \quad \sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r y_{rj} + v_0 \geq 0 \;, \qquad j = 1, \ldots, n$
$\sum_{r=1}^{s} u_r y_{rp} = 1$
$u_r \geq \varepsilon, \quad r = 1, \ldots, s \; v_i \geq \varepsilon \;, \quad i = 1, \ldots, m \qquad (10)$

Anderson and Peterson (1993) proposed the super-efficiency model. The super efficiency model for ranking efficient decision-making units was such that the first decision-making unit was removed from the production possibility set and the DEA model was implemented for the remaining decision-making units. and evaluated its efficiency in DMU compared to other decision-making units. By removing DMU_o from the production possibility set, the feasible space of the linear programming problem becomes larger, in which case the value of the optimal solution for DMU_o becomes larger. When this is done for all effective decision-making units, arrange them in descending order. The decision-making unit whose optimal value of the objective function is greater than the others has the first rank, and in the same way, all the efficient decision-making units are ranked.

The super efficiency model of CCR in the input-oriented model is as follows:

$Min \quad \theta \;\; S.t. \quad \sum_{\substack{j=1 \\ j\neq o}}^{n} \lambda_j X_j \leq \theta X_o \qquad \sum_{\substack{j=1 \\ j\neq o}}^{n} \lambda_j Y_j \geq Y_o$
(11),
$\lambda_j \geq 0 \quad , \quad j = 1, \ldots, n\theta \; is \; free \; in \; sign$

The super efficiency model of BCC in the input-oriented model is as follows:

$Min \quad \theta$
$S.t. \quad \sum_{\substack{j=1 \\ j\neq o}}^{n} \lambda_j X_j \leq \theta X_o \qquad \sum_{\substack{j=1 \\ j\neq o}}^{n} \lambda_j Y_j \geq Y_o$

$\sum_{\substack{j=1 \\ j\neq o}}^{n} \lambda_j = 1 \qquad (12)$
$,\lambda_j \geq 0 \quad , \quad j = 1, \ldots, n\theta \; is \; free \; in \; sign$

Performance evaluation and ranking of different districts in Shiraz municipality

Today, municipalities play an essential role in creating a successful city in a way that is of great importance to the political, social, and cultural structure of society. Therefore, evaluating their performance can help managers in city administration. One of the most important tools for examining the performance of organizations, such as municipalities, is data coverage analysis. Considering the geographical location and strategy of Shiraz City in terms of population and the scientific and medical situation in the country, the administration of mayors is important from various economic and cultural aspects. In this article, we evaluated the performance of different municipal districts in Shiraz City in 2022. The number of these districts is 11 in different parts of Shiraz. First, according to the opinion of municipal experts and using a questionnaire, we determined the inputs and outputs. In this study, three inputs and four outputs were considered. The inputs and outputs are as follows:

Input variable included

Number of employees (by person), area (square meters) of the district building, and delayed income (billion Rials).

Output variables included

Sold securities, tax revenues, service revenues, and construction revenues (The unit of all outputs is a billion Rials).

The input and output data are shown in Table 1.
Now, we evaluate the efficiency of different areas based on the different models. The results are shown in Table 2.

As can be seen, areas 1, 2, 3, 5, 6, 7, and 8 are efficient based on all models. Areas 9 and 9 are inefficient based on all models. Areas 10 and 11 are efficient for variable returns to scale and inefficient for constant returns to scale.

To rank the efficient areas, we apply models (11) and (12) to the constant and variable returns to scale, respectively.
The rank corresponding to the efficient units is given in the form of numbers in parentheses next to the super efficiency score of the areas. As can be seen, the ranks of the areas in the two technologies are different. Based on the super-efficiency CCR model, namely model (11), area 6 has the best performance. We expected this because this area also has the best financial performance. Based on the super efficiency BCC model, namely model (12), area 6 has the best performance, because this area has the highest income due to the area being covered by a smaller number of employees due to its location.

Figure 1 shows a comparison of efficiency values for constant and variable technologies.

Table 3 shows targets corresponding to inputs and outputs of different areas of the CCR and BCC models in the input orientation, respectively.

Table 1. Inputs and Outputs.

Areas	Input1	Input2	Input3	Output1	Output2	Output3	Output4
1	10	230	2220	4228	6850	41200	645
2	17	550	9850	8450	96500	59550	1180
3	12	350	4210	6430	77250	38550	720
4	8	220	850	2450	35235	19550	230
5	8	210	780	3550	45254	16200	243
6	9	265	1135	6884	55450	28350	387
7	8	220	645	3720	42210	30580	264
8	9	260	336	2420	23285	19200	175
9	8	250	765	3820	25554	24350	248
10	7	300	955	3350	28550	26520	225
11	7	250	448	2750	27540	19250	187

Table 2. The results of different models.

Areas	Model (2)	Model (4)	Model (6)	Model (9)	Model (11)	Model (12)
1	1	1	1	1	1.528 (2)	1.9136 (3)
2	1	1	1	1	1.1356 (6)	Infeasible
3	1	1	1	1	1.1454 (5)	1.3689 (4)
4	0.7818	0.7818	0.9853	0.8629	0.7818 (11)	0.9853 (9)
5	1	1	1	1	1.0672 (7)	1.0969 (7)
6	1	1	1	1	1.5908 (1)	4.8261 (1)
7	1	1	1	1	1.4824 (3)	2.046 (2)
8	1	1	1	1	1.2608 (4)	1.3333 (5)
9	0.854	0.854	0.9646	0.885	0.854 (10)	0.9646 (10)
10	0.9882	0.9882	1	1	0.9882 (8)	1.0917 (8)
11	0.9802	0.9802	1	1	0.9802 (9)	1.1938 (6)

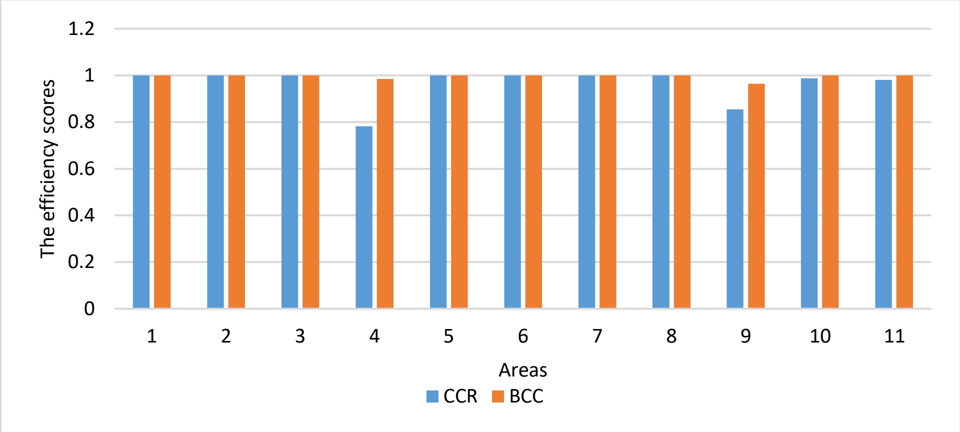

Figure 1. Comparison of efficiency values between the two technologies used.

Table 3. Targets the corresponding inputs and outputs of different areas of the CCR model.

Areas	Input1	Input2	Input3	Output1	Output2	Output3	Output4
1	10	230	2220	4228	6850	41200	645
2	17	550	9850	8450	96500	59550	1180
3	12	350	4210	6430	77250	38550	720
4	6.0096	171.9888	664.5023	3915.939	35235	19550	234.7713
5	8	210	780	3550	45254	16200	243
6	9	265	1135	6884	55450	28350	387
7	8	220	645	3720	42210	30580	264
8	9	260	336	2420	23285	19200	175
9	6.832	191.9088	653.3101	3820	37795.82	24679.91	248
10	6.9171	183.1948	853.88	3350	28550	26520	294.1634
11	6.8613	195.11	439.1217	2750	27540	19788.18	187.2578

Table 4. Targets the corresponding inputs and outputs of different areas of the BCC model.

Areas	Input1	Input2	Input3	Output1	Output2	Output3	Output4
1	10	230	2220	4228	6850	41200	645
2	17	550	9850	8450	96500	59550	1180
3	12	350	4210	6430	77250	38550	720
4	7.8827	216.7737	712.9586	3491.516	42542.37	19550	240.7996
5	8	210	780	3550	45254	16200	243
6	9	265	1135	6884	55450	28350	387
7	8	220	645	3720	42210	30580	264
8	9	260	336	2420	23285	19200	175
9	7.7164	241.1385	646.3698	3820	37938.48	24350	249.2389
10	7	300	955	3350	28550	26520	225
11	7	250	448	2750	27540	19250	187

4. Conclusion

Municipalities play a crucial role in the progress and economic development of every city. Currently, due to the growth of the population of megacities, evaluating their performance is particularly important. This organization operates in various fields, including economic, cultural, and health, in a city and deals directly with people’s lives. A municipality with a good performance can be the basis for improving the lives of the people under its coverage. Due to its geographical location and high population, Shiraz is one of the most important cities in Iran. This organization has different subgroups. Evaluating the performance of different covered areas can help managers choose appropriate strategies. In addition, many economic works are done in Shiraz City through the municipality. Therefore, due to the importance of this organization in the economic system of the country, it prompted us to assess and evaluate the efficiency of different districts of Shiraz municipality using a suitable method. The performance of the districts was evaluated in one year related to 2022. We evaluated and ranked different areas of the municipality using the DEA model as a suitable technique. In the following, considering that several areas became efficient in each of the technologies used, we used supper-efficiency models to rank the efficient branches to determine the areas with the best performance. Finally, we presented the effective targets corresponding to the ineffective areas. According to the results, the optimal performance policy of the municipal districts for city council managers was determined. In future work, we will develop the models presented in this paper for evaluation during consecutive periods. We can also develop an evaluation to consider the cost and revenue factors simultaneously.

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