International Journal of Operations Research and Artificial Intelligence

www.ijorai.reapress.com

Int. J. Oper. Res. Artif. Intell. Vol. 1, No. 2 (2025) 101–109.

Paper Type: Original Article

Efficiency Analysis of Tourism Companies in Fars Province: A DEA and DEA-R Based Approach

Ameneh Taheri*

Department of Computer Science, University of Tehran, Tehran, Iran; Taheri_A@gmail.com.

Citation:

Received: 15 June 2024 *Revised: 22 August 2024* *Accepted: 25 October 2024*	Taheri, A. (2025). Efficiency analysis of tourism companies in Fars province: A DEA and DEA-R based approach. *Intelligence Modeling in Electromechanical Systems, 1*(2), 101-109.

Abstract

The primary objective of this study is to evaluate and compare the efficiency of 40 tourism companies operating in Fars Province using Data Envelopment Analysis (DEA) and its extended model, DEA-R. Two cost-related indicators, personnel expenses and total costs, were considered as inputs, while customer satisfaction and company revenue were selected as output criteria. The classical DEA model and the DEA-R model were applied to calculate the relative efficiency of each company. The results indicate that six companies achieved full efficiency (Score of 1), and the average efficiency scores across both models were very similar. The slight differences between the two models suggest that DEA-R improves the accuracy of evaluations by accounting for more detailed aspects while maintaining the overall structure of DEA results. This study can assist tourism company managers in identifying inefficiencies and optimizing resource allocation.

Keywords: Data envelopment analysis, Data envelopment analysis-R, Performance evaluation, Tourism industry.

1 | Introduction

In recent years, the tourism industry has emerged as a vital driver of economic, cultural, and employment development, particularly in developing countries. Fars province, known for its rich historical, cultural, and natural attractions, holds great potential for attracting both domestic and international tourists. In such a competitive environment, enhancing the productivity and efficiency of tourism companies is essential for improving service quality, reducing costs, and increasing customer satisfaction. One of the key challenges faced by managers in this sector is the optimal allocation of limited resources to achieve maximum output, which requires the use of precise and multi-criteria analytical tools.

Data Envelopment Analysis (DEA), a non-parametric method based on linear programming, offers a practical approach for evaluating the relative efficiency of Decision-Making Units (DMUs) with multiple inputs and

Corresponding Author: Taheri_A@gmail.com

outputs, without assuming any specific functional form. The classical DEA model, introduced by CCR [1], assesses efficiency under the assumption of Constant Returns to Scale (CRS). However, more advanced models have been developed to improve the precision of evaluations. Among them, the DEA-R model is a notable enhancement that incorporates input and output slacks, thereby providing a more comprehensive view of actual efficiency.

This study aims to assess and compare the performance of 40 active tourism companies in Fars province. Two input variables—personnel expenses and total operational costs—and two output variables—customer satisfaction and annual revenue—were defined for each company. Data were collected through field surveys, interviews, and analysis of financial documents. Both the CCR and DEA-R models were applied to calculate efficiency scores, and the Technique for Order of Preference by Similarity to the Ideal Solution (TOPSIS) method was also employed to provide a complementary multi-criteria ranking. The study offers a comprehensive evaluation framework for performance assessment and strategic decision-making in the tourism industry.

The structure of this article is summarized in the following paragraph:

This study begins by introducing the fundamental concepts of efficiency evaluation using DEA and its extended model, DEA-R. Data were collected from 40 active tourism companies in Fars Province, and two input indicators—personnel cost and total operational cost—and two output indicators—customer satisfaction and company revenue—were defined. In the case study section, the CCR and DEA-R models were applied to calculate efficiency scores, and the results were compared and analyzed using the TOPSIS multi-criteria decision-making method. Finally, the findings were interpreted, and their managerial implications for improving the performance of tourism companies and optimizing resource allocation were discussed.

2 | Literature Review

DEA has been widely utilized as a non-parametric method for evaluating the relative efficiency of DMUs when multiple inputs and outputs are involved. The foundational work by Charnes, Cooper, and Rhodes [1] introduced the CCR model, which evaluates efficiency under the assumption of CRS and has become a cornerstone of performance assessment in operations research.

To address the limitation of the DEA model in ranking fully efficient units, Andersen and Petersen [2] proposed a super-efficiency approach that allows for differentiation among efficient DMUs by excluding the evaluated unit from the reference set. This method significantly enhanced the discriminatory power of DEA and has been widely applied in comparative performance analysis.

Further advancements led to the development of the DEA-R model, which incorporates slack variables directly into the objective function, thereby enabling a more accurate evaluation of inefficiencies. Mozaffari et al. [3], [4] made substantial contributions in this area by formulating DEA-R models for cost and revenue efficiency and analyzing their mathematical relationships with traditional DEA structures. Their subsequent works extended DEA-R to the identification of efficient surfaces [5] and applications in environmentally responsible production systems under uncertainty using fully fuzzy environments [6].

Other researchers have also enhanced DEA methodology by addressing complex operational conditions. For example, Noura et al. [7] proposed a novel approach to measuring congestion in DEA, a phenomenon where excess inputs reduce outputs. In a related study, they examined super-efficiency through the societal contribution of each DMU, offering a broader interpretation of performance [8].

Additionally, Rashidi and Barati [9] explored supply chain evaluation by modeling internal sub-DMUs, revealing interdependencies within complex systems. In a separate study, Rashidi [10] employed a Multi-Attribute Decision-Making (MADM) approach to assess productivity in the oil industry, highlighting the potential for integrating DEA with other decision-support tools.

These studies collectively demonstrate the evolution and flexibility of DEA, particularly with the introduction of DEA-R and its applications across diverse domains. The combination of DEA, DEA-R, and multi-criteria decision-making techniques such as TOPSIS provides a robust foundation for performance evaluation. The current study builds on these developments by applying these models to assess the efficiency of tourism companies, a sector where such analytical approaches are increasingly essential for strategic planning and resource optimization.

3 | Modeling and Methodology

In this study, we employ two primary DEA models to assess the operational efficiency of tourism companies: the classic CCR multiplier model and a modified variant known as the DEA-R model. DEA is a non-parametric method used for evaluating the relative efficiency of DMUs based on multiple inputs and outputs, providing a comprehensive efficiency score without requiring a predefined functional form.

The first model used is the CCR multiplier model, introduced by Charnes et al. [1] in 1978, which assumes CRS. This means that any proportional change in inputs results in the same proportional change in outputs. In this model, the efficiency of each DMU is calculated as the ratio of a weighted sum of outputs to a weighted sum of inputs, where the weights are decision variables optimized individually to maximize each DMU's efficiency score. The efficiency scores range from 0 to 1, where a score of 1 indicates that the DMU is on the efficient frontier, optimally using its inputs to produce outputs. This multiplier formulation is subject to linear constraints that ensure no DMU's efficiency is overestimated, maintaining fairness and comparability among all units.

While the CCR model provides a solid baseline for efficiency evaluation, it does not explicitly consider slack variables—the excess inputs or output shortfalls that represent inefficiencies not captured directly by the efficiency score. To overcome this limitation, the DEA-R model is introduced as a modification of the classic CCR model. DEA-R incorporates slack variables to better capture these slight deviations from the efficient frontier. Slack variables represent input surpluses that could be reduced without affecting output levels and output deficits that could be increased without requiring more inputs. Including these slacks enables DEA-R to provide a more nuanced and realistic assessment of performance, effectively distinguishing between fully efficient units and those that are near-efficient but still have room for improvement.

$$
\begin{aligned}
&\text{Max} \quad U^t Y_o, \\
&\text{s.t.} \\
&U^t Y_j - V^t X_j \leq 0, \ \ j = 1, \dots, n, \\
&V^t X_o = 1, \\
&-U_r \leq -\varepsilon, r = 1, \dots, s, \quad -V_i \leq -\varepsilon, \ \ i = 1, \dots, m.
\end{aligned}
\tag{1}
$$

In this study, two primary DEA models are employed to assess the efficiency of tourism companies. *Model (1)*, known as the classic CCR multiplier model, focuses on maximizing the ratio of weighted outputs to weighted inputs under the assumption of CRS. It optimizes weights to ensure no DMU exceeds an efficiency score of one, with all weights being positive and bounded.

The methodology begins with data collection from 40 tourism companies, focusing on inputs—personnel costs and total operating costs—and outputs—customer satisfaction scores and company revenues. Prior to modeling, the data is normalized and preprocessed to ensure comparability and to meet DEA assumptions, especially given the differing units and scales of the variables.

Following data preparation, the CCR model is applied to calculate baseline efficiency scores, providing an initial evaluation to identify which companies operate efficiently relative to their peers. Subsequently, the DEA-R model is applied to the same dataset, adjusting for input and output slacks to refine efficiency measurements. This step reveals companies that are close to efficiency but possess inefficiencies that require managerial attention.

Model (2), the DEA-R model, extends the classic approach by incorporating slack variables to capture inefficiencies due to input excesses and output shortfalls. This modified model provides a more detailed and realistic evaluation of efficiency, distinguishing units with minor performance differences more effectively.

$$\begin{aligned} &\text{Min} \quad W^t \frac{X_o}{Y_o}, \\ &\text{s.t.} \\ &W^t \frac{X_j}{Y_j} \geq 1,\ j = 1, \dots, n, \quad W^t \geq 0,\ r = 1, \dots, s. \end{aligned} \tag{2}$$

Finally, the efficiency results from both models are compared and analyzed. This comparison identifies not only efficient and inefficient companies but also near-efficient ones, offering insights into potential operational improvements. Based on these findings, practical recommendations are proposed to enhance the performance and competitiveness of tourism companies in the region.

4 | Case Study

In this section, a practical case study is conducted to evaluate the efficiency of tourism companies operating in Fars province, Iran. The target population includes 40 active tourism companies, whose data were collected and analyzed. The main objective is to assess the relative efficiency of each company in utilizing resources to achieve desirable outcomes.

4.1 | Input and Output Definition

To implement both the classical DEA and the extended DEA-R models, two input and two output variables were defined for each DMU:

Inputs: i1: Personnel expenses (In million IRR) and i2: Total operational cost including salaries, rent, advertising, and other expenditures (In million IRR)

Outputs: o1: Customer satisfaction (Score out of 10 based on surveys) and o2: Annual revenue (In million IRR)

Inputs represent the consumed resources, while outputs reflect the results or performance of each company. The goal is to identify companies that use their inputs most efficiently to maximize their outputs.

Table 1. Input and output data of tourism companies in Fars province.

Company	Personnel Cost (i1)	Total Cost (i2)	Customer Satisfaction (o1)	Company Revenue (o2)
1	350	1100	8.5	1500
2	400	1250	9.0	1650
3	280	970	7.8	1350
4	300	1000	8.0	1400
5	370	1150	8.6	1550
6	320	1040	8.2	1450
7	250	900	7.5	1280
8	450	1350	9.2	1700
9	390	1200	8.7	1580
10	310	980	8.0	1380
11	420	1300	9.1	1680
12	330	1050	8.1	1440
13	360	1120	8.4	1500

Table 1. Continued.

14	295	950	7.6	1300
15	340	1080	8.3	1480
16	410	1280	9.0	1650
17	375	1170	8.5	1540
18	265	880	7.4	1250
19	290	920	7.7	1320
20	315	1010	8.0	1390
21	270	940	7.6	1310
22	300	990	8.0	1370
23	280	960	7.9	1350
24	360	1140	8.4	1520
25	290	930	7.8	1330
26	335	1070	8.2	1460
27	310	1005	8.0	1395
28	250	870	7.3	1230
29	430	1320	9.1	1690
30	390	1210	8.6	1570
31	285	960	7.9	1340
32	305	995	8.1	1400
33	320	1030	8.2	1430
34	295	945	7.7	1290
35	365	1130	8.5	1510
36	275	915	7.5	1270
37	355	1105	8.4	1490
38	345	1090	8.3	1470
39	385	1190	8.8	1600
40	265	890	7.4	1240

The data were obtained through field surveys, interviews with company managers, and reviews of the financial documents of tourism companies in Fars Province. All data refer to a one-year period during which the companies maintained active operations. For the analysis, both the CCR model—assuming CRS—and the DEA-R model were applied. The DEA-R model is an enhanced version that considers input and output slacks to improve evaluation accuracy. All computations were performed using Python and relevant scientific libraries. The mean and standard deviation of the input and output variables are summarized below:

Table 2. Summary statistics of input and output variables used in the DEA analysis of tourism companies in Fars Province.

Indicator Mean	Standard Deviation
i1 (Personnel cost)	≈ 327≈ 55
i2 (Total cost)	≈ 1068≈ 140
o1 (Customer satisfaction)	≈ 8.16≈ 0.52
o2 (Annual revenue)	≈ 1440≈ 134

By applying both the DEA and DEA-R models, the efficiency scores of all 40 companies were calculated. Several companies (e.g., DMUs 7, 18, 19, 25, 28) achieved full efficiency (Score=1.000). A comparison of the two models revealed minimal differences in efficiency scores, often in the range of 0.0001 to 0.0003, indicating a high level of consistency and robustness in the DEA framework. This confirms the validity of the chosen variables and modeling approach.

4.2 | Analysis of Technique for Order of Preference by Similarity to the Ideal Solution Results

In this section, the performance of 40 tourism companies in Fars province was evaluated using the TOPSIS method, considering two input criteria (Personnel cost and total cost) and two output criteria (Customer satisfaction and company revenue). First, the data were normalized using the Min-Max method, and equal weights were assigned to all criteria.

The results showed that companies with higher scores achieved a better balance between minimizing costs and maximizing benefits. Specifically, company 6, with moderate costs (320 for personnel cost and 1040 for total cost) and relatively high customer satisfaction and revenue (8.2 and 1450), obtained the highest score (0.557570) and ranked first. Additionally, companies 0 and 31, with very close scores, ranked second and third, respectively. These results indicate that some companies, by managing their costs and maintaining customer satisfaction, performed better compared to others.

On the other hand, companies with higher costs and lower satisfaction received lower scores and were ranked at the bottom; for example, company 13, with a score of 0.485 and rank 40, showed weaker performance. Overall, the TOPSIS analysis provided a comprehensive and practical overview of the relative status of the companies, serving as a basis for managerial decision-making and improving company performance.

4.3 | Analysis Using Data Envelopment Analysis and Data Envelopment Analysis -R Models

Following the initial analysis with the TOPSIS method, more precise efficiency evaluation of the companies was conducted using DEA and its enhanced version, DEA-R. These models calculate the relative efficiency of each company based on inputs (Costs) and outputs (Benefits) through an efficiency score.

The DEA-R model, by considering slack values in inputs and outputs, provides a more comprehensive assessment and better reflects minor differences in efficiency. The results of this section accurately identified efficient and inefficient companies and helped to pinpoint opportunities for improvement. The efficiency scores obtained from the DEA model mainly ranged between 0.87 and 1.00, with several companies achieving a perfect efficiency score of 1.0000, indicating full efficiency. Similarly, the DEA-R model produced very close results, with slight adjustments reflecting the inclusion of slacks.

Table 3. Efficiency scores of tourism companies based on DEA and DEA-R models.

Company	DEA Efficiency Score	DEA-R Efficiency Score
1	0.9504	0.9504
2	0.9199	0.9200
3	0.9761	0.9761
4	0.9792	0.9792
5	0.9393	0.9394
6	0.9734	0.9734
7	1.0000	1.0000
8	0.8774	0.8777
9	0.9176	0.9177
10	0.9814	0.9814
11	0.9006	0.9007
12	0.9560	0.9561
13	0.9334	0.9334
14	0.9556	0.9556

Table 3. Continued.

Company	DEA Efficiency Score	DEA-R Efficiency Score
15	0.9552	0.9552
16	0.8984	0.8984
17	0.9173	0.9174
18	1.0000	1.0000
19	1.0000	1.0000
20	0.9599	0.9599
21	0.9777	0.9777
22	0.9672	0.9672
23	0.9857	0.9857
24	0.9293	0.9293
25	1.0000	1.0000
26	0.9515	0.9515
27	0.9690	0.9690
28	1.0000	1.0000
29	0.8922	0.8923
30	0.9042	0.9043
31	0.9813	0.9813
32	0.9827	0.9827
33	0.9687	0.9687
34	0.9688	0.9690
35	0.9313	0.9313
36	0.9760	0.9760
37	0.9397	0.9398
38	0.9399	0.9399
39	0.9370	0.9371
40	0.9892	0.9893

Table 2 presents the efficiency scores of 40 tourism companies based on two DEA models: The classical DEA and its enhanced version, DEA-R. These scores represent the relative efficiency of each company in converting inputs (Costs) into outputs (Benefits), where a score of 1 indicates full efficiency.

Full efficiency (Score=1)

Several companies, such as companies 7, 18, 19, 25, and 28, achieved a perfect efficiency score of 1 in both models, indicating their optimal management of resources and costs.

Scores close to 1

Most companies have efficiency scores above 0.9, demonstrating good performance and effective use of resources.

Differences between models

The efficiency scores from DEA and DEA-R are very close, reflecting consistency and robustness in the results. However, DEA-R, by considering Slack values in inputs and outputs, captures subtle but essential differences. For example, company 34's efficiency score slightly increases from 0.9688 DEA to 0.9690 DEA-R.

Identification of improvement opportunities

Companies with efficiency scores below 0.9, such as company 8 (0.8774 in DEA and 0.8777 in DEA-R), are identified as inefficient and may require management attention to improve their performance.

Practical implications

These results assist managers and decision-makers in recognizing top-performing companies, analyzing weaker performers, and developing strategies to improve productivity and reduce costs. Overall, employing both DEA and DEA-R models provides a more comprehensive and accurate evaluation of company efficiency, facilitating better identification of leading companies and opportunities for improvement.

5 | Conclusion

The findings of this study demonstrate that DEA is an effective tool for evaluating the performance of tourism companies based on multiple input and output criteria. By applying both the classical CCR model and the extended DEA-R model, the relative efficiency of each company was calculated with high accuracy. Several companies—such as units 7, 18, 19, 25, and 28—achieved full efficiency (Score of 1.000), indicating optimal resource management. At the same time, other firms exhibited varying degrees of inefficiency, highlighting the need for performance improvement and resource reallocation.

The comparison between the DEA and DEA-R models revealed a high degree of consistency, with only minimal differences in efficiency scores (Typically between 0.0001 and 0.0003). Nevertheless, the DEA-R model, by incorporating slack values in inputs and outputs, provides a more nuanced and accurate assessment, capable of revealing subtle yet meaningful differences in performance. In addition, the TOPSIS method served as a complementary approach for ranking companies by evaluating the balance between minimizing costs and maximizing benefits.

The managerial implications of this research are significant. Company leaders can identify and benchmark high-performing firms, while also analyzing performance gaps in less efficient units to design targeted improvement strategies. Furthermore, this study demonstrates the value of combining advanced analytical tools in tourism management and can serve as a model for evaluating efficiency in other service-oriented sectors. Future research could expand on this framework by incorporating qualitative variables or adopting dynamic DEA models to reflect changes over time.

Conflict of Interest

The authors declare no conflict of interest.

Data Availability

All data are included in the text.

Funding

This research received no specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

[1] Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European journal of operational research*, *2*(6), 429–444. https://doi.org/10.1016/0377-2217(78)90138-8

[2] Andersen, P., & Petersen, N. C. (1993). A procedure for ranking efficient units in data envelopment analysis. *Management science*, *39*(10), 1261–1264. https://doi.org/10.1287/mnsc.39.10.1261

[3] Mozaffari, M. R., Kamyab, P., Jablonsky, J., & Gerami, J. (2014). Cost and revenue efficiency in DEA-R models. *Computers & industrial engineering*, *78*, 188–194. https://doi.org/10.1016/j.cie.2014.10.001

[4] Mozaffari, M. R., Gerami, J., & Jablonsky, J. (2014). Relationship between DEA models without explicit inputs and DEA-R models. *Central european journal of operations research*, *22*, 1–12. https://doi.org/10.1007/s10100-012-0273-4

[5] Mozaffari, M. R., Dadkhah, F., Jablonsky, J., & Wanke, P. F. (2020). Finding efficient surfaces in DEA-R models. *Applied mathematics and computation*, *386*, 125497. https://doi.org/10.1016/j.amc.2020.125497

[6] Mozaffari, M. R., Mohammadi, S., Wanke, P. F., & Correa, H. L. (2021). Towards greener petrochemical production: Two-stage network data envelopment analysis in a fully fuzzy environment in the presence

of undesirable outputs. *Expert systems with applications*, *164*, 113903. https://doi.org/10.1016/j.eswa.2020.113903

[7] Noura, A. A., Lotfi, F. H., Jahanshahloo, G. R., Rashidi, S. F., & Parker, B. R. (2010). A new method for measuring congestion in data envelopment analysis. *Socio-economic planning sciences*, *44*(4), 240–246. https://doi.org/10.1016/j.seps.2010.06.003

[8] Noura, A. A., Lotfi, F. H., Jahanshahloo, G. R., & Rashidi, S. F. (2011). Super-efficiency in DEA by effectiveness of each unit in society. *Applied mathematics letters*, *24*(5), 623–626. https://doi.org/10.1016/j.aml.2010.11.025

[9] Rashidi, S. F., & Barati, R. (2014). On the comparison of supply chain with Sub-DMUs in DEA. *Advances in environmental biology*, 2387–2391. https://B2n.ir/zz1079

[10] Rashidi, S. F. (2015). Evaluation of productivity indicators in the oil industry by using multi-attribute decision making approach (MADM). *International journal of advanced and applied sciences*, *2*(6), 25–31.