Vol. 9, No. 1, 2022, Pages 1-10

JIEMS

Journal of Industrial Engineering and Management Studies

journal homepage: www.jiems.icms.ac.ir

Providing a DEA and AHP hybrid model to evaluate contractors' performance (Case study: Zarand Iranian Steel Co. (ZISCO))

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Received: Jan 2022-26/Revised: Feb 2022-05/Accepted: Mar 2022-23

Abstract

Regarding contractors are one of the fundamental features of construction and industrial projects, therefore the selection of contractors is one of the major decisions of managers and decision-makers. This paper uses the multi-criteria decision-making method Analytic Hierarchy Process (AHP) to incorporate the weightings of input and output variables into Data Envelopment Analysis (DEA) for evaluation and ranking of contractors (Zarand Iranian Steel Company). At first, according to previous research, the most effective and important evaluation indicators of contractors are selected, then in the proposed model with the AHP approach, seven input indicators and three output indicators are weighted and ranked, and the performance of 20 contractors from one of the company's projects is determined and ranked with the input-oriented CCR model. By applying this approach, decision-makers and practitioners can effectively compare operational efficiency between contractors, and therefore generate more informed and they can provide appropriate solutions to increase the efficiency of other contractors.

Keywords: performance evaluation; contractors; Analytic Hierarchy Process (AHP); Data Envelopment Analysis (DEA).

Paper Type: Original Research

1. Introduction

Nowadays, construction projects are getting bigger day by day, and this will lead to the complexity and multiplicity of different project activities. Managing and deciding on evaluation and choosing of contractors, which is a substantial part of doing industrial and civil projects, are too important and vital since contractors are the main parts of such projects and they are the main factors who turn the sources into the final product. These projects require a high cost, thus in order to perform them, a suitable contractor who has the ability to finish the project under the predicted timetable and predicted resources with the assumed quality is needed (Abbasi et al., 2017). Performance evaluation is one of the best ways to obtain information to identify and rank contractors during implementation. In order to be aware of the desirability and quality of the activities of contractors, there is an urgent need for an evaluation system. The most important concerns of employers and senior managers of project organizations are the evaluation of the organization's projects as well as the ranking of projects and practical indicators during project implementation. Performance appraisal information helps managers implement strategic management. On the other hand, the lack of evaluation and control in a system means that the defects of contractors during execution, which in turn causes time, quality and economic disadvantages. Time, cost and quality of implementation in projects are one of the most important elements in the formation and perform (Mokhtari et al., 2012**).** Proper evaluation of project performance by contractors, in addition to advancing the goals of a project, can help raise the quality level, reduce costs and etc. In general, project performance evaluation methods can be divided into two categories: qualitative methods and quantitative methods (Ghavi panjeh et al., 2018).most of the methods that are considered for evaluating and selecting contractors are done by identifying the effective criteria and weighting each criterion by experts according to the experience and essence of the project, and the criteria that gain the most weight are the key criteria for evaluating and selecting a contractor .regarding the multiplicity of indicators and the fact that many criteria are qualitative, multi-criteria decision-making methods can be used (Qomi et al., 2017).

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DOI: 10.22116/jiems.2022.326598.1473

2. Problem statement

Today, organizations try to make an effort to selection of their contractors to find ways to reduce costs, manage products, increase efficiency, and meet organizational needs. Shortening the transportation cycle and timely delivery of orders have become the main concern of all organizations in the body of contractors in order to gain more market share in this competitive environment. management evaluation and selection of contractors are an essential part of the construction projects and the main factor in converting resources into the final product. Contractor management as an integrated approach to the proper management of material and goods, information and financial features, has the ability to respond to these conditions (Yi-Kai Juan, 2009). Many organizational decisions need to prioritize multiple options based on a set of criteria or indicators. Choosing a contractor is one of these issues, which is one of the most important strategies of the company to gain a competitive advantage. The strategic importance of this selection is such that a large number of researchers in fields such as industrial engineering, production management, automation, etc. have devoted a large amount of their research to the selection of contractors and each has different models for this .companies initially sought to increase their list of contractors in order to increase their bargaining power over prices, now they are trying to reach strategic alliances with fewer contractors who best meet their needs (Hoseinpoor and Alborzi, 2019).

Today, performance appraisal is an integral part of leading organizations in a competitive environment. On the other hand, as organizations become larger, the need for control in them doubles. The fundamental problem in many organizations today is that they are not provided with a rational and accurate performance appraisal method; Because if a suitable indicator is introduced, they can better direct their forces in particular and the departments in the direction of the strategic goals of the organization in general. Today's organizations are competing in a turbulent environment and in order to progress and even survive, they need to determine their strengths and weaknesses to ensure that the basic goals of the organization are achieved. One of the most important tools in modern management theories to meet this need is performance appraisal. In the meantime, project-oriented organizations, which mostly take steps to create specific project goals, achieve a more systematic method of performance appraisal in accordance with the goals and strategies of their organization, to evaluate the performance of projects carried out in the organization .One of the most important concerns of employers and senior managers of project-based organizations is to evaluate the performance of projects entrusted to contractors, as well as to rank and evaluate the performance of contractors during implementation. Therefore, practical indicators are very important during the project implementation. Performance appraisal information helps employers implement strategic management to control contractors' performance during execution.

This research intends to use a new approach to performance appraisal to design a method for evaluating the performance and ranking of contractors by identifying quantitative and qualitative indicators, and then using AHP methods (hierarchical analysis process) And DEA (Data Envelopment Analysis), to achieve an operational result. This research is important in that the combined model of DEA and AHP is used to evaluate the performance of contractors and this leads to individuals and organizations in order to control and reduce costs, product management, increase efficiency and meet organizational needs are difficult and spend countless costs to solve it, to be able to make a better decision in selecting contractors.

3. Literature review

Qomi et al. (2017) The purpose of this study is to evaluate the research performance of a public university through its affiliated faculties and using the network data envelopment analysis method. For this purpose, a set of valid research indicators, from the existing literature and the opinion of experts, is prepared and after identifying the available indicators of the university, is selected and combined and achieving macro indicators, through a hierarchical analysis process. They became balanced. Then, using the network data envelopment analysis model, the data related to macro indicators in the affiliated faculties of the university were evaluated.

Yaser Rahimi et al. (2015) The purpose of this article is to present an agile supply chain model in construction companies and evaluate the performance of suppliers and contractors. In this paper, the combined approach of FDEMATEL / AHP / DEA is used. In the proposed model, first, with the FDEMATEL approach, the most effective and important indicators for evaluating the performance of the company's suppliers and contractors are selected. then evaluated and ranked by the AHP / DEA method and included in the supply chain network. In this network, the concept of agility is also considered. also in this study, for the first time in Iran, the supply chain model in construction companies were studied and designed.

Tahmasebi et al. (2015) In this paper, the solution of the problem of selection and re-evaluation of contractors using non-parametric method of data envelopment analysis (DEA) is presented. Employers' tendency to apply a large number of criteria on the one hand and to face a small number of contractors in executive tenders due to the specialization of work on the other hand will increase the number of contractors at the efficiency limit. Therefore, in order to solve this problem, an integrated model is developed using Analytic Hierarchy Process (AHP) and data envelopment analysis. The hierarchical process is considered by experts due to inaccurate data. The results show this high resolution of the proposed model.

Baghban et al. (2012) In order to evaluate the relative efficiency of contractors, a gray data envelopment analysis model has been performed. Due to the level of tasks and the extent of inputs and outputs of project contractors, key inputs and outputs have been determined. Raw data required for modeling were collected from Mapna Group's 2009 document review method and the model was solved in the form of gray data envelopment analysis model. After determining the answer of the initial model, a number of contractors who had a relative efficiency of one hundred percent were selected. After determining the efficient contractors, it was done using an algorithm to fully rank the performance of efficient contractors. The efficiency of inefficient contractors is presented.
Nikoukar et al. (2011) The aim of this study was to evaluate the performance of managers of hospitals affiliated to Isfahan University of Medical Sciences by data envelopment analysis (DEA). Also, due to the quality of some criteria for evaluating the performance of managers, the AHP method has been used to convert qualitative data into quantitative.
Xinheng et al. (2018) developed a comprehensive evaluation model with a combination of AHP / DEA for performance evaluation that demonstrates the performance of municipal wastewater treatment plants in China. The proposed model fully considers subjective and objective factors with effectiveness and scientific nature.
Ramanathan (2014) used the DEA model to generate local weights of options from pairwise comparisons in the hierarchical analysis process. In this paper, he showed that the DEA method can correctly estimate the weight of the AHP method pairwise comparison matrix. It also showed that the DEA method is more efficient than any other method for adding the local weights of the options in different voting criteria to obtain the final weight.
Ming Liu et al. (2010) modified the DEA model using the AHP method. Whereas the importance of any input or output data may be fuzzy; Therefore, they modified the DEA model using the AHP method and fuzzy series theory. In the second step, they converted the data into a common scale, which by normalizing them and dividing each data into the largest amount of total data. In the third step, by combining the DEA model and the AHP method, they proposed the evaluation model and used that model to select LCD component distributors. As mentioned, this model is very useful for cases where the weights of the criteria are fuzzy, since it introduces them in intervals.

4. Theoretical foundations

4.1. Iron and steel industry

Steel industry is one of the essential industries for the development of any community. the business of processing iron ore into steel, which in its simplest form is an iron-carbon alloy, and in some cases, turning that metal into partially finished products or recycling scrap metal into steel. The steel industry grew out of the need for stronger and more easily produced metals. Technological advances in steelmaking during the last half of the 19th cent. played a key role in creating modern economies dependent on rails, automobiles, girders, bridges, and a variety of other steel products. In fact, it is really the base for numerous industries that could not have been established without steel industry. The European industrial revolution at the beginning of this century was actually founded on this industry. There are three basic routes to obtain finished steel products: (1) integrated steel production, (2) secondary processing, and (3) direct reduction. Integrated steel production involves transforming coal to coke in coke ovens, while iron ore is sintered or bulletized prior to being fed into the blast furnace (BF). The ore is reduced in the blast furnace to obtain hot metal containing some 4% carbon and smaller quantities of other alloying elements. Next the hot metal is converted to steel in the basic oxygen furnace (BOF). Then, it is continuously cast to obtain semi-finished products, such as blooms, bars or slabs. These semi-finished products are rolled to the finished shapes of bars, sheet, rail, H or I beam. (El Haggar, 2005)
Zarand Iranian Steel Company was established on November 19, 2008 with the investment of the Middle East Mines and Mining Industries Development Holding Company (Midco). The main center of the company is located in Tehran and the projects and factories are located in Zarand city, Kerman province. this company includes mines and pellet and concentrate production plants, coke and steel making and the final product of this company is steel.

4.2. Analytic hierarchy process

A hierarchical analysis process is a technique used to rank a set of options or to select the best one from a set of options. This method can be used when the decision-making action is faced with several competing options and several decision-making criteria. The proposed criteria can be quantitative and qualitative. The basis of this technique is decision-making based on pairwise comparisons (Ramanathan, 2014).

4.3. Data envelopment analysis

DEA is a non-parametric linear programming method that often includes negative variables. This method is used to measure the performance of decision units based on different inputs and outputs. Data analysis technique covers all data (figures and Information) and for this reason it is also called data envelopment analysis. Data envelopment analysis is a mathematical programming technique to measure the relative efficiency of organizational units that have similar roles and use multiple inputs to generate multiple outputs (Chin et al., 2009)

CCR Model:

Technical efficiency = (Total weighted output) / (Total weighted input)

The important thing in the above relation is that this performance measuring device requires a set of weights that can be used for all units under study. In this regard, two points should be noted. First, the value of inputs and outputs can be different and difficult to measure, and second, different units may organize their operations to provide outputs with different values. Therefore, they need different weights in measuring performance. Charnas, Cooper, and Rhodes recognized the above problem, and to solve this problem in their model, they assigned different weights to the inputs and outputs, and proposed units that could provide weights that were more suitable and brighter for them. Compare with other units, accept. The model is as follows:

$$Max\ Z_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{ij}}$$

x_{ij}: i is input rate for j unit $i = 1, \dots, m$

y_{ij}: r is output rate for j unit $r = 1, \dots, s$

st:

v_i: Weight given to the input i

u_r: Weight given to the output r

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1 \qquad (1)$$

$$u_r, v_i \ge 0$$

According to the objective function, it is determined that this model is a nonlinear and non-convex model that solves the values of u_r, v_i variables to measure the performance of the unit under study. The mathematical model used in this research is the input-driven CCR model:

$$Max\ Z_0 = \sum_{r=1}^{s} u_r\, y_{r0}$$

x_{ij}: i is input rate for j unit $i = 1, \dots, m$

y_{ij}: r is output rate for j unit $r = 1, \dots, s$

st:

v_i: Weight given to the input i

u_r: Weight given to the output r

$$\sum_{i=1}^{m} v_i\, x_{i0} = 1 \qquad (2)$$

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

$$u_r\, , v_i \ge 0$$

The following chart is a summary of the AHP / DEA combination research process:

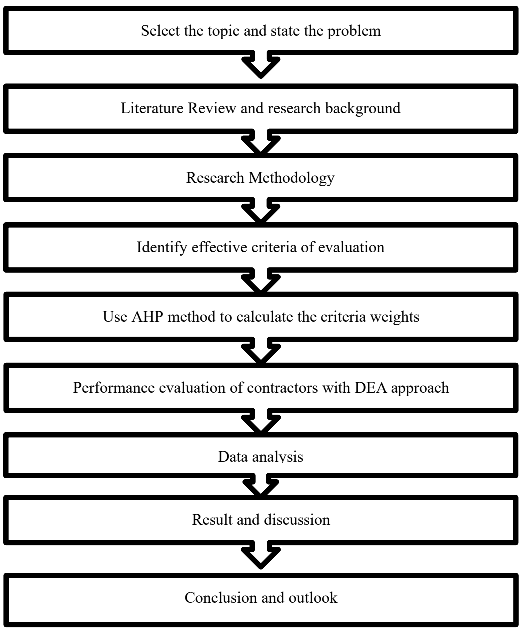

Figure 1: The research process

5. Methodology

Generally, this research consists of three consecutive stages. The first stage includes the identification of indicators affecting the performance of contractors, which are identified by a questionnaire of approximately twenty experts. The second step is to identify the weight of the indicators using AHP, in which five experts are used. In order to evaluate the reliability of the questionnaire questions, the incompatibility rate is used. In the third stage, the CCR data envelopment analysis model is designed. This model has a constant return to scale and by selecting the optimal weights for the input and output variables of the units under study, try to increase the efficiency of this unit (zero unit) in such a way that the efficiency of other units does not exceed the limit of one. Data envelopment analysis divides the studied units into efficient and inefficient groups. Units with a score of one are efficient and points with a score below one is inefficient. In research, the main issue is the ranking of work units.

5.1. Statistical population

The present study aims to obtain a complete ranking of the efficiency of Iranian Zarand steel contractors. Therefore, the statistical population of this research is the contractors of Zarand Iranian Steel Company. The respondents of this research are the experts and managers of the Zarand Iranian Steel Company. Based on the research questions and objectives, the statistical community framework also includes the contractors of Zarand Iranian Steel Company. Also, due to the fact that this study does not include statistical hypotheses, so sampling methods and determining the sample size is not used.

5.2. Research variables

Input variables: 1. Manpower capacity, 2. Equipment and machinery, 3. Work experience, 4. Organizational and managerial formation, 5. Reliability, 6. Financial capacity, 7. Offer price.
Output variables: 1. Compliance of production quality in accordance with the standard of the rating agency approved by the employer, 2. Matching performance and schedule. 3. Match the cost of the project with the estimated cost.
Manpower capacity (first input) indicates the specialized capacity of personnel, which is in fact a function of their level of education and experience. Equipment and machinery criteria (second input) can be calculated from the number of machines related to the project and free contractor. Regarding the work experience criterion (third input), the number of similar projects is used. Scoring is done by two quality criteria of organizational and managerial formation (fourth input) and reliability (fifth input) according to the different opinions of individuals in a periodic manner. The lowest score is considered as the lower limit and the highest score is considered as the upper limit of the interval. Financial capacity (sixth input) indicates the available financial capacity for investments, fulfillment of obligations and guarantee of contracts. For offer price criterion (seventh input), the difference between the bid price ratio and the fair price is used. The criterion of conformity of production quality in accordance with the standard of the rating agency approved by the employer (first output), indicates the work with the least noncompliance with national and international standards considered by the employer, which is announced by the project supervisor and consultant. Matching performance and scheduling (second output) indicate the contractor's track record of delays in recent projects (Tahmasbi et al., 2014).

5.3. Data collection method

Basically, the method of collecting research data is designed based on the type of research. Considering that the data collected in this research were used for modeling, so the main source for collecting this data was documents, reports and information sources in different parts of Zarand Iranian Steel Company. After collecting data related to evaluation indicators, in this stage, all collected data are presented in an integrated manner for the next stages of research.

6. Analysis of research data and findings

Step one, in this section, first, the weights are obtained from the analysis of input and output indices using the analytic hierarchy process through the pairwise comparison questionnaire. Then, the values of the obtained weights are multiplied by the values of the input and output indices, and the final values of the input and output indices are obtained and examined in data envelopment analysis.

6.1. Data normalization

Data normalization increases the accuracy of the answers and makes the final results more reliable. Therefore, the values of input and output indices of each contractor were normalized using the following equation. To normalize the data, each of the input (output) indicators was divided by the sum of the indicators of the same name in the input (output) of each decision unit (contractors).

$$A_i = \frac{a_i}{\sum_{i=1}^{n} a_i} \tag{3}$$

In the above relation, A_i is the normalized value of the index, a_i is the numerical value of the index and $\sum_{i=1}^{n} a_i$, $\sum_{i=1}^{n} a_i$ is the numerical sum of the indexes of the same name at the input (output) of each decision unit (contractors).

In the following tables, the input and output indicators of the contractors are normalized:

Table 1: Normalized input indicators of contractors

DMUs	Offer price	Financial capacity	Manpower capacity	Reliability	Organizational formation	Work experience	Equipment and Machinery
1	0.0087196628	0.109090909	0.05	0.0516129	0.06164384	0.04310345	0.03389831
2	0.123528557	0.1818181818	0.05625	0.05806452	0.06849315	0.09195402	0.19774011
3	0.012352856	0.007272727	0.0375	0.05806452	0.05479452	0.0316092	0.0960452
4	0.012716175	0.009090909	0.05	0.04516129	0.03424658	0.0316092	0.04519774
5	0.005813109	0.003636364	0.05625	0.03225806	0.04109589	0.02586207	0.01129944
6	0.047231507	0.003636364	0.0625	0.06451613	0.06164384	0.08908046	0.02259887
7	0.653974713	0.003636364	0.04375	0.0516129	0.05479452	0.02586207	0.01129944
8	0.00508647	0.005454545	0.0375	0.03870968	0.03424658	0.05172414	0.02259887
9	0.002906554	0.007272727	0.05625	0.05806452	0.04794521	0.00574713	0.03389831
10	0.007266386	0.050909091	0.04375	0.05806452	0.02739726	0.04310345	0.06214689
11	0.000653975	0.036363636	0.05	0.03870968	0.05479452	0.02873563	0.05084746
12	0.00094463	0.036363636	0.05	0.04516129	0.04109589	0.03735632	0.03954802
13	0.007993024	0.054545455	0.0625	0.06451613	0.06849315	0.05172414	0.05084746
14	0.013079494	0.036363636	0.05	0.0516129	0.06164384	0.04310345	0.10169492
15	0.000799302	0.003636364	0.05625	0.0516129	0.05479452	0.01724138	0.02259887
16	0.079930243	0.03636364	0.04375	0.04516129	0.04109589	0.07183908	0.03389831
17	0.000326987	0.036363636	0.05625	0.06451613	0.06164384	0.07758621	0.02259887
18	0.000690307	0.058181818	0.05	0.0516129	0.06164384	0.01724138	0.04519774
19	0.0008719663	0.007272727	0.04375	0.0516129	0.04794521	0.11781609	0.06779661
20	0.007266386	0.018181818	0.0375	0.0516129	0.04794521	0.04310345	0.02824859

Table 2: Normalized output indicators of contractors

DMUs (Contractor)	Match the cost of the project with the estimated cost	Matching performance and schedule	Compliance of production quality with standard
1	0.0610687	0.05384615	0.05405405
2	0.05343511	0.06153846	0.06081081
3	0.03816794	0.04615385	0.0472973
4	0.04580153	0.01538462	0.0472973
5	0.03053435	0.03846154	0.0472973
6	0.05343511	0.03076923	0.05405405
7	0.0610687	0.06923077	0.05405405
8	0.05343511	0.04615385	0.03378378
9	0.0610687	0.06923077	0.05405405
10	0.03816794	0.04615385	0.02027027
11	0.0610687	0.05384615	0.05405405
12	0.04580153	0.03076923	0.0472973
13	0.03816794	0.03076923	0.06081081
14	0.03053435	0.05384615	0.04054054
15	0.05343511	0.06153846	0.05405405
16	0.0610687	0.05384615	0.05405405
17	0.0610687	0.07692308	0.06081081
18	0.05343511	0.06153846	0.06081081
19	0.05343511	0.04615385	0.04054054
20	0.0610687	0.05384615	0.05405405

Step two, Expert choice software is a powerful software to solve multi-criteria decision-making problems, prioritize goals and evaluate options in the organization. AHP, which is a simple technique, but with almost long and large computing and it is simply solved by this software and also this software can help the researcher in everyday issues with complex and important decisions with extensive criteria. The weight of all the indicators was determined by Expert choice software.
According to the calculations performed with the software, the incompatibility rate is 0.05, considering that this number is less than 0.1, the incompatibility rate is acceptable
Therefore, the input and output indicators in order of priority as follows:

Table 3: Prioritization of input indicators

Rank	Weight	Indicator
1	0.242	Financial capacity
2	0.208	Work experience
3	0.138	Equipment and machinery
4	0.136	Reliability
5	0.124	Offer price
6	0.082	Organizational and managerial formation
7	0.070	Manpower capacity

Table 4: Prioritization of output indicators

Rank	Weight	Indicator
1	0.495	Compliance of production quality with standard
2	0.276	Matching performance and schedule
3	0.230	Match the cost of the project with the estimated cost

Step three. By multiplying the weights by the existing values of the inputs and outputs, the final data obtained by using the AHP method are shown in Table 5 and 6.

Table 5: Final values of contractors' input indicators

DMUs	Equipment and machinery	Work experience	Organizational formation	Reliability	Manpower capacity	Financial capacity	Offer price
1	0.0013254238	0.008965518	0.0050548	0.007019354	0.0035	0.0264	0.001081238
2	0.027288135	0.019126436	0.00561644	0.007896775	0.0039375	0.044	0.015317541
3	0.013254238	0.006574714	0.00449315	0.007896775	0.002625	0.00176	0.00153175
4	0.006237288	0.006574714	0.00280822	0.006141935	0.0035	0.0022	0.012716175
5	0.001559323	0.005379311	0.00336986	0.004387096	0.0039375	0.00088	0.000720825
6	0.003118644	0.018528736	0.00505479	0.008774194	0.004375	0.00088	0.005856707
7	0.001559323	0.005379311	0.00449315	0.007019354	0.0030625	0.00088	0.081092864
8	0.003118644	0.010758621	0.00280822	0.005264516	0.002625	0.00132	0.000630722
9	0.019044	0.001195403	0.00393151	0.007896775	0.0039375	0.00176	0.000360413
10	0.008576271	0.008965518	0.00224658	0.007896775	0.0030625	0.01232	0.000901032
11	0.007016949	0.005977011	0.00449315	0.005264516	0.0035	0.0088	0.0000810922
12	0.005457627	0.007770115	0.00336986	0.006141935	0.0035	0.0088	0.000117134
13	0.007016949	0.010758621	0.00505479	0.008774194	0.004375	0.0132	0.000991135
14	0.014033899	0.008965518	0.06164384	0.007019354	0.0035	0.0088	0.001621857
15	0.003118644	0.003586207	0.00449315	0.007019354	0.0039375	0.00088	0.0000991134
16	0.004677967	0.014942529	0.00336986	0.006141935	0.0030625	0.0088	0.00991135
17	0.003118644	0.016137932	0.00505479	0.008774194	0.0039375	0.0088	0.0000405464
18	0.006237288	0.003586207	0.00168493	0.005264516	0.002625	0.00176	0.000085598
19	0.009355932	0.024505747	0.00505479	0.007019354	0.0039375	0.01408	0.001081238
20	0.003898305	0.008965518	0.00393150	0.007019354	0.002625	0.0044	0.000901032

Table 6: Final values of contractors' output indicators

DMUs (Contractor)	Compliance of production quality with standard	Matching performance and schedule	Match the cost of the project with the estimated cost
1	0.026756755	0.014861537	0.0140458
2	0.030101351	0.016984615	0.01229008
3	0.023412164	0.012738463	0.00877863
4	0.016722971	0.004246155	0.008778626
5	0.016722971	0.010615385	0.0070229
6	0.026756755	0.008492307	0.01229008
7	0.026756755	0.019107693	0.0140458
8	0.016722971	0.012738463	0.01229008
9	0.026756755	0.019107693	0.0140458
10	0.010033784	0.008492307	0.00877863
11	0.020067567	0.012738463	0.0140458
12	0.023412164	0.008492307	0.01053435
13	0.030101351	0.008492307	0.00877863

DMUs (Contractor)	Compliance of production quality with standard	Matching performance and schedule	Match the cost of the project with the estimated cost
14	0.020067567	0.014861537	0.0070229
15	0.026756755	0.016984615	0.01229008
16	0.026756755	0.014861537	0.0140458
17	0.030101351	0.02123077	0.0140458
18	0.020067567	0.012738463	0.01229008
19	0.030101351	0.016984615	0.01229008
20	0.026756755	0.014861537	0.0140458

Step Four. At this stage, the final data is reviewed by DEA-Solver software. The DEA-CCR model was used to evaluate the performance of contractors and based on the scores obtained, the contractors were ranked. In this ranking, the contractors who had the highest efficiency score were ranked higher. It should be noted that the numerical performance score is between zero and one, a score of one indicates perfect performance. Table 7 shows the rank of each contractor in this ranking.

Table 7: Performance-based contractor ranking table

Contractors	Performance rating	Performance percentage	Performance score
DMU1	1	100	1
DMU2	2	100	1
DMU3	3	100	1
DMU4	4	100	1
DMU5	5	100	1
DMU6	6	100	1
DMU7	7	100	1
DMU8	8	100	1
DMU9	9	100	1
DMU10	10	100	0.9979
DMU11	11	99	0.9936
DMU12	12	99	0.9944
DMU13	13	95	0.9483
DMU14	14	91	0.9112
DMU15	15	90	0.9003
DMU16	16	89	0.8889
DMU17	17	87	0.8729
DMU18	18	84	0.8359
DMU19	19	67	0.6714
DMU 20	20	60	0.603

Table 8, shows the reference units for contractors. The set of efficient units from which an inefficient unit's inefficiency has been determined. The term used to denote the set of all units in the analysis and the set of efficient units was known as a reference subset.

Table 8: Reference units for contractors

Contractors	Number of references	Reference units
DMU1	0	DMU 7,11,15,17,18,20
DMU2	0	DMU 7, 15,17,18
DMU3	0	DMU 7,9,17,20
DMU4	0	DMU15,17,18
DMU5	1	DMU 5
DMU6	0	DMU 17
DMU7	8	DMU 7
DMU8	2	DMU 8
DMU9	2	DMU 9
DMU10	0	DMU18,20
DMU11	2	DMU 11
DMU12	0	DMU 15,17,118
DMU13	0	DMU 7,15,17,18,20
DMU14	0	DMU 7,15,17,18
DMU15	8	DMU 15
DMU16	0	DMU 7, 8,15,17,18,20
DMU17	11	DMU 17
DMU18	9	DMU 18
DMU19	0	DMU 7,17
DMU 20	6	DMU 20

7. Discussion

In expressing the results of this research, the first step, as raised, effective indicators in selecting contractors of similar previous researches were used and to determine the importance of the indicators, a questionnaire was designed with a hierarchical analysis process. Then, by analyzing these questionnaires using Expert Choice software, the final weight of each indicator as well as their prioritization was obtained.
In this study, criteria and weighting have been identified by experts and the combined AHP / DEA model was used to rank and evaluate the performance of contractors. However, it should be noted that this ranking is based only on the indicators have been studied and by changing the indicators, it is possible to change this ranking If the performance of contractors has not the required quality, the execution of activities will be longer and more costly in terms of time and will ultimately cause losses to the company, eventually it will cause losses to the company.
Evaluation and determination of contractors' position by data envelopment analysis technique, with input-oriented CCR model, the efficiency of contractors as well as reference units were determined. The more efficient contractor means that these units have made better use of the available resources and inputs to achieve performance results. In other word, efficient contractors have been able to make better use of manpower, time, capital and other available facilities and equipment and achieve higher results with these inputs compared to other units.
Hierarchical analysis also determines the best weight values for inputs and outputs; These values indicate with which priority of the indicators the maximum efficiency can be achieved and maintained. According to the values obtained from this model, in Table 4, the prioritization of input indicators and in Table 5, the prioritization of output indicators, according to which contractors should pay attention to their inputs and outputs, are specified. In the inputs section, the contractor should focus primarily on the amount of financial capacity. In the output indicators section, the contractor must first pay attention to the compliance of production quality in accordance with the standards, and in the second and third priority, respectively, compliance of performance and schedule and compliance of the cost with the estimated cost.

8. conclusion and future directions

The results show that 50% of the contractors have been fully efficient and the rest of the contractors need to work harder to improve their indicators and achieve better performance.
Contractors (DMUs) 20,18,17,15,11,9,8,8,7,5,2 have the best rankings. In the meantime, the condition of the contractor 17 is significant because it has been able to achieve full efficiency and the maximum number of reference units, and this indicates the need for other contractors to pay attention to the performance indicators of this contractor. Contractors (DMUs) 4, 10 had lowest performance, which are 67% and 60%, respectively. The employer should consider criteria such as experience, technical ability, financial ability, managerial ability, after-sales service when selecting contractors. They can also encourage the superior contractor to motivate the work and perform a periodic evaluation process for all contractors. Try to improve the status of middle contractors, try to replace better contractors with better qualified contractors to help improve the quality of contractor work.
The issue of identifying reference contractors is one of the advanced cases specific to the DEA approach. this approach can maximize its efficiency if it brings its performance in various indicators closer to the reference contractor. In order for contractor programs to be effective, the interaction between the contractor and the employer in various fields is essential. Since it may be well identified and not discussed in the pre-project stages, Therefore, in order to fully and effectively implement the project, it is necessary to communicate in the form of meetings, explain the rules, and compile instructions in order to work progress.

Acknowledgement

This research was conducted as part of corresponding author master research work.

References

Abbasi, O., Abbasianjahromi, H., & Norouzian, F. (2016). Identify subcontractors' selection criteria in construction companies with new approach using Kano model. Journal of structural and construction engineering, 3(2), 19-29.

Mokhtari, A., Nasiri, M., (2012). Analysis of strengths and weaknesses of project contractors' evaluation and ranking methodologies in the last decade 9th international conference on industrial engineering, Tehran, Iran Industrial Engineering Association", Khajeh Nasir al-Din Tusi University of Technology.

Ghavi panjeh, M., (2018). Performance appraisal of Sepehr Andishan Payab Contractors with Hierarchical analysis approach, Payam noor university of shahin shahr.

Qomi, H., Rahmani, M., & Khakzar, M., (2017). Evaluating the research performance of a public university using the process of hierarchical analysis and envelopment analysis of network data, Military management quarterly.

Rahimi, Y., Tavakkoli-Moghaddam, R., Shojaie, S., & Cheraghi, I. (2017). Design of an innovative construction model for supply chain management by measuring agility and cost of quality: An empirical study. Scientia IRANICA, 24(5), 2515-2526.

Tahmasbi, H.,Tavakoli moghadam, & R.,Najafi, S., (2015). Presentation of AHP / DEA integrated model to evaluate construction industry contractors despite inaccurate data. Research article of Isfahan University

Baghban, A., Amiri, M., Olfat, L., & Sharafi, A. Z. (2012). Evaluation and ranking contractors and promotion of inefficient contractors with approach grey data envelopment analysis-case study MAPNA group contractors.

Nikoukar, S., Ketabi, S., & Moazam, E. (2011). A combined model of Data Envelopment Analysis (DEA) and Analytical Hierarchy Process (AHP) in ranking of hospitals managers.

Xiaoxin, Z., Jin, H., Ling, L., Yueping, W., & Xinheng, Z. (2018). Research of AHP/DEA evaluation model for operation performance of municipal wastewater treatment plants. In E3S Web of Conferences (Vol. 53, p. 04009). EDP Sciences.

Ramanathan, R. (2006). Data envelopment analysis for weight derivation and aggregation in the analytic hierarchy process. Computers & Operations Research, 33(5), 1289-1307.

Chih-ming Liu, Hen-Shen Hsu, & Hai-Kun Lee, (2010). A performance evaluation model based on AHP and DEA. JCIIE.

Juan, Y. K. (2009). A hybrid approach using data envelopment analysis and case-based reasoning for housing refurbishment contractors' selection and performance improvement. Expert systems with applications, 36(3), 5702-5710.

Hoseinpoor, A., & Alborzi, M. (2019). The combination of DEA and AHP approach in the selection of contractors participating in tenders. HOLOS, 2, 1-15.

Chin, K. S., Wang, Y. M., Poon, G. K. K., & Yang, J. B. (2009). Failure mode and effects analysis by data envelopment analysis. Decision support systems, 48(1), 246-256.

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision-making units. European journal of operational research, 2(6), 429-444.

El Haggar, S. M. (2005). Rural and developing country solutions. In Environmental solutions (pp. 313-400). Academic Press.

This article can be cited: Heidarpour, S., Esfahani, S.H., Khorshidvand, B., (2022). Providing a DEA and AHP hybrid model to evaluate contractors' performance (Case study: Zarand Iranian Steel Co. (ZISCO)), Journal of Industrial Engineering and Management Studies, Vol.9, No. 1, pp. 1-10.