Optimization
Iranian Journal of Optimization
Volume 11, Issue 2, 2019, 261-276
Research Paper
Online version is available on: www.ijo.iaurasht.ac.ir
Islamic Azad University
Rasht Branch
ISSN: 2588-5723
E-ISSN:2008-5427

Efficiency Score Assessment of Iranian Mining, Wood and Textile Industries

Malek Hassanpour*

Department of Environmental Science, UCS, Osmania University, Telangana State

Received: 28 January 2019
Accepted: 20 July 2019

Abstract

The Iranian Environment Protection Agency (IEPA) in collaboration with Iranian Industries Organization (IIO) need to design a relevant database for the industries information based on the initial screening of Iranian Evaluator Team (IET) in certain clusters. However, we aware of this fact that all industrial projects should go through the Environmental Impact Assessment (EIA) after and along with screening levels. Therefore, current research concise the three clusters of Iranian industries data to further assessment towards Data Envelopment Analysis (DEA) empirically. To calculate the efficiency score were employed the Additive Ratio ASsessment (ARAS) model in combination with the DEA model along with using Friedman and Kendall tests as weighing systems. Using SPSS software led to estimate the values of weight regarding the inputs and outputs of materials flow. The combination of both mentioned models has expanded the path for determination of DEA score for the Iranian Wood and Cellulose Industries (IWCI), Iranian Mining and Aggregate Industries (IMAI) and Iranian Textile and Leather Industries (ITLI).

Keywords:
Iranian industries
DEA
EIA

* **Correspondence E_mail**: Malek.hassanpour@yahoo.com

INTRODUCTION

It has been more than a century that the study of optimal allocation of limited physical resources has been the focus of applied sciences scientists. Such studies led to the emergence of one of the branches of the applied sciences of mathematics is called "Research in Operations". It was first introduced in 1947 and applied to military matters. Investigating the performance of decision-making units or production units can be a useful tool for evaluating the optimal use of available resources. One way to evaluate industry performance is to estimate the production function. The output function is a function with one or more inputs that produce the maximum output for each combination of inputs. DEA is a method based on mathematical linear programming and its first application refers to 1978. This method is used to evaluate the relative efficiency of decision-making units that are similar. DEA method is widely used in benchmarking; continuous improvement and strategic analysis. When due to the nature of different activities and factors, the usual elements of efficiency (outputs and inputs) are not of the same gender. It is not possible to use a simple set of output to calculate efficiency (Li et al., 2016).

A number of difficulties have experienced in calculating efficiency, such as the fact that multiple outputs or non-identical inputs cannot be combined in a single formula. In other words, multiple outputs cannot be used for multiple inputs, other than the weights of each factor. It may not be known in advance. In addition to monolingual indicators such as labor productivity, there is a need for other types of productivity that can include even the factors that contribute to the optimal use of labor. Many believed that the solution was to provide a production function with respect to outputs and inputs to maximize outputs. This production function can be a column that a fully efficient unit can produce. DEA is a technique that can be applied with the help of linear programming to evaluate relative performance such as production efficiency. DEA creates a performance boundary that offers a good representation of the production function. The following steps are required to perform DEA (Rezaee & Ghanbarpour, 2016).

- Define a set of goals for comparison
- Determine evaluation characteristics and differentiate outputs and inputs variables
- Collect data, showing attribute values for each target
- Analyze and interpret the results

Generally, performance in one or more units is determined by both parametric and nonparametric methods. In parametric techniques, a specific production function is determined using different statistical methods. This function is then used to determine efficiency. Regression techniques can be mentioned in this regard. Nonparametric methods do not require estimating the production function. One of the nonparametric methods is DEA, which evaluates the relative performance of units in comparison with each other. In this method, no need to know the shape of the production function and there is no limit to the number of inputs and outputs variables. The regression method determines the mean of unit observations and performance of each unit against an optimized regression equation. DEA uses all observations collected to measure performance and optimizes each observation against an efficient boundary. The DEA analysis method combines all the units under investigation to make a high-performance virtual unit and compares the inefficient units with it (Bulgurcu, 2013).

In fact, the reason behind the application of DEA was that optimal use of resources has always been of human interest, and one has always tried to make the most of the available resources using the right approach. The constraints factors such as capital, manpower, and energy made managers think of ways to make the most of these factors. In fact, knowing the performance of units under the supervision of the manager is the most important task of management in making appropriate decisions to guide them. In any system where a goal is pursued (such as the education system, office, etc.) two points are important. (1) Performance (2) Effectiveness. Performance means working well as a function of intra-organizational performance indicators and effectiveness means working well as a function of external organizational performance. In

DEA, the goal is to compute performance to compare within-organization indicators. Inputs are the factors that increase it, the efficiency decreases, that is, the inputs and the efficiency are inversely related, and the efficiency increases with decreasing inputs. The output is directly related to efficiency as opposed to input, the more output we increase, the efficiency rises in the decision-making unit. It needs to explain that a decision-making unit is a unit that generates an output vector by receiving an input vector (Sangwan & Digalwar 2008; Salehi & Hamatfar 2012).

The present study used the DEA based on a newly developed additive model (ARAS) to classify three groups of Iranian industries such as IWCI (around 16 various types), ITLI (around 38 various types) and IMAI (around 26 various types). The reason for choosing this kind of DEA model can be mentioned to the presence of various criteria with different dimensions. Data of industries are associated with the activities of IET. IET is in charge of IEPA and IIO to assess the projects once before implementation and in practical scale. At first, the projects go through the initial screening levels for the materials and facilities inventory along with 5 major criteria such as staff number, land area required, fuel, water, and power demands. In the next steps, the EIA keep moving towards discovering the variety of directions of the project such as public applications, decisions in maturation and evolution of projects depend on available data, approval or disapproval of project and all requirements after implementation. Therefore, our research completed the collected data in the direction of the final expansion of the project in connection with IET. By this research, we only tried to classify the above-named industries depend on output and input criteria as the main objective of the study.

THEORETICAL BACKGROUND AND LITERATURE

According to our knowledge about using DEA based on additive ratio models to classify the data of the industries before the construction step, there is no research in this regard. However, lots of papers published for other kinds of DEA models. But we notice some recent studies that have approached the objectives followed by current research. The research employed the traditional DEA model to classify seven Indian chemical industries based on efficiency score released from both input and output criteria in currency. The study firstly arranged the criteria in two separate classes of input and output variables and the Friedman test conducted to figure out weight values. The results reported by the author indicated very close relation towards full efficiency border in sorting 7 industries ranged from 0 to 1 (Anthony et al., 2019). Krmac and Djordjevic (2019) assigned non radial DEA model to choose and evaluate the environmental performance of suppliers considering undesirable inputs and outputs such as number of staff, energy exploited (kWh/year), sales (1000 Korean won), return on assets, environmental & investment (100,000 Korean won), CO2 emission (kg). Finally, the proposed model succeeded to offer a sort of supplier allocation in the border of 0 to ≥ 1. An additive DEA model used to assess the performance of industrial productivity and sought a path towards making political decisions to escalate economic growth rate of the country during a period of 1980 to 2000. During mentioned time interval emerged 38% efficient years and 68% inefficient period (Rahmani, 2017). The author also used the current procedure (same with present study) for classifying 6 groups of Iranian industries in certain clusters such as Iranian food manufacturing and processing industries, Iranian chemical industries, Iranian electronic products industries, Iranian automotive industries, Iranian plastic industries, and Iranian household appliance industries.

Also, the author applied the ARAS model in the sensitivity analysis of mentioned researches as well as the classification of industries. By the current study, our effort spent on the classification of three remained groups of Iranian industries (IMAI, IWCI, and ITLI). ARAS model has been employed in lots of papers containing ranking systems for the prioritizing criteria and alternatives such as management of real estate stuffs that comprised both materials quantity and cultural property with regard to rebuilt in terms of archaeological, historical, architectural, economic, social and etc. in Vilnius (Kutut et al., 2014); software testing method to select and use in human demands (Karabasevic et al., 2018); assessing performance of 9 transportation agencies running in 3 various nations including twenty alternatives (Radovic et al., 2018), corporate social responsibility of companies towards sustainability attitudes (Karabasevic et al., 2015) etc. A study combined both procedures of ARAS and Gray systems to select the potential suppliers pertaining on a list of criteria such as delivery price, financial position, production specifications, standards, and proper certificates, commercial strength, and the performance of the supplier, etc. The findings brought a relevant connection of both models to discover supplier's prioritization (Turskis & Zavadskas, 2010). Kersuliene and Turskis (2011) integrated a fuzzy multi-criteria decision-making model with ARAS model to manage the data in both linguistic and numerical dimensions along with a wide range of information sources. So, adaptability was proved via examination of the developed model through an architect's selection difficulty. Our study is the first research to classify the Iranian industries pertaining to 5 main criteria, input and output materials stream. Industrial project identification in the framework of EIA is a promising assessment plan for future expansion and development of one valuable database in this regard.

RESEARCH METHODOLOGY

The author tried to classify ITLI, IMAI, and IWCI via weighing and ranking systems at previous studies according to references (Hassanpour, 2019a, 2019b, 2018). The initial source of employed data gets back to the screening step of project identification in EIA plan by both of IEPA and IIO which has been published at 3 addressed papers. Then the published data were extracted and used in this research. The procedure completed the next steps of project identification in EIA plan. Therefore, the mentioned procedure joined to the project assessment by IET according to Fig.1.

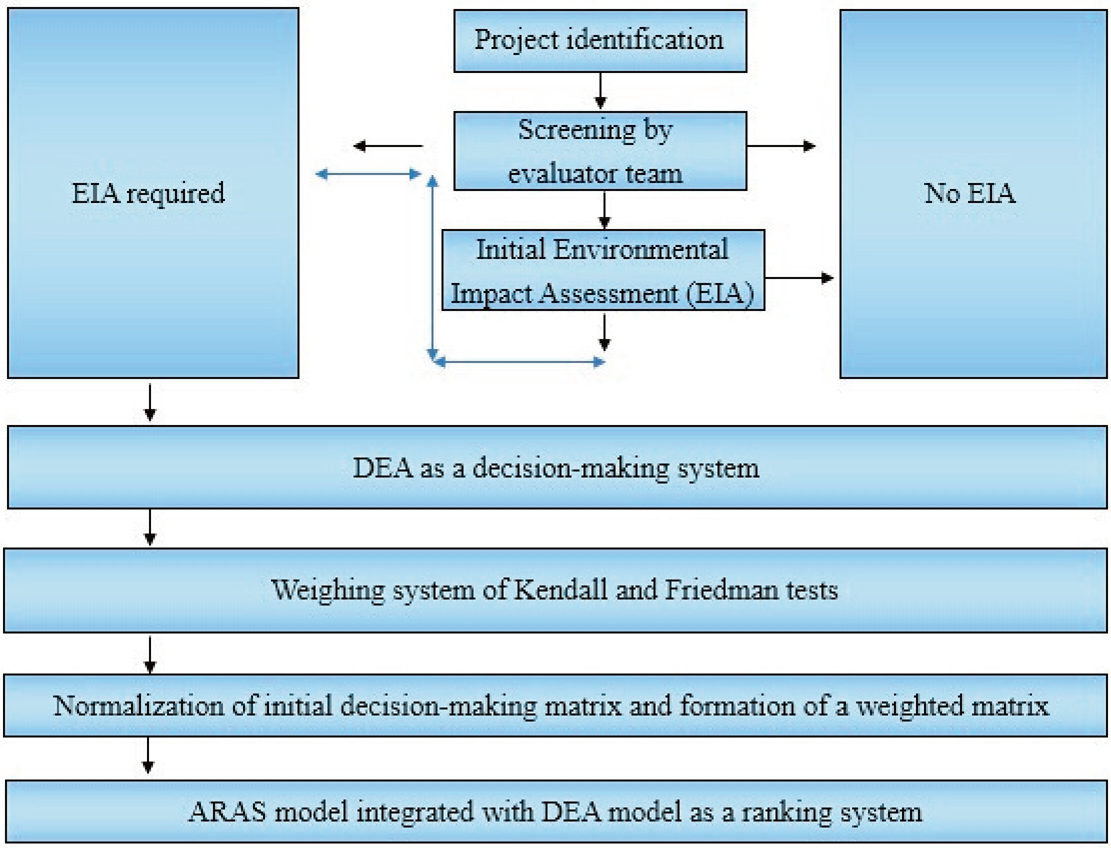

Fig.1. The flow-diagram of followed work [This study]

Weighting systems of Kendall's W and Friedman tests

The present study used the Eqs. 1 to 9 (1 to 5 for the Friedman test and 6 to 9 for the Kendall test) for calculating the values of weights of the criteria via SPSS software. After obtaining the weights our consideration spent on uniting ARAS model with DEA model. The results of the integration provided a way to normalization (normalization of data is done by the division of values in the columns to sum of the values in the columns) of data via Eqs. 10 to 12, inducing the weights of criteria into the rows of alternatives (industries) or weighing step (according to Eq.13). Finally, the summation of output and input rows and columns (Si calculation via Eq.14) made the framework of the DEA model. The division of Si (output) / Si (input) were illustrated by Eqs. 15 to 19 to issue the DEA score and rank (Hassanpour, 2019; Anthony et al., 2019).

$$\hat{r}.j = \frac{1}{n}\sum_{i=1}^{n} rij \tag{1}$$

$$\hat{r} = \frac{1}{nk}\sum_{i=1}^{n}\sum_{j=1}^{k} rij \tag{2}$$

$$SSt = n\sum_{j=1}^{\cdot}(\hat{r}.j - \hat{r})^2 \tag{3}$$

$$SSe = \frac{1}{n(k-1)}\sum_{i=1}^{n}\sum_{j=1}^{k}(rij - \hat{r})^2 \tag{4}$$

$$Q = \frac{SSt}{SSe} \tag{5}$$

$$Ri = n\sum_{j=1}^{m}(ri,j,..) \tag{6}$$

$$Rave = 1/n\sum_{i=1}^{n} Ri \tag{7}$$

$$S = \sum_{i=1}^{n}(Ri - Rave)^2 \tag{8}$$

$$W = \frac{12\,S}{m^2(n^3 - n)} \tag{9}$$

$$Xoj = max\ Xij \text{ if } max\ Xij \quad \text{is preferable} \tag{10}$$

$$Xoj = min\ Xij \text{ if } min\ Xij \quad \text{is preferable} \tag{11}$$

$$pij = \frac{Xij}{\sum_{i=1}^{m} Xij} \tag{12}$$

$$\tilde{\imath} = pij \times Wj, \quad i = o, m \tag{13}$$

$$Si = \sum_{j=1}^{n} normalized\ values\ of\ Xij, \quad i = o, m \tag{14}$$

$$DEA = \frac{\sum_{r=1}^{S} Ur\ Yrj}{\sum_{i=1}^{m} Vi\ Xij} \tag{15}$$

$$Max\ Z = \frac{\sum_{r=1}^{S} Ur\ Yrj}{\sum_{i=1}^{m} Vi\ Xij} \tag{16}$$

$$= \frac{\sum_{r=1}^{S} Ur\ Yro}{\sum_{i=1}^{m} Vi\ Xio}, \quad j = 1,2,3, \ldots .n \tag{17}$$

$$Ur, Vi \geq 0 \tag{18}$$

$$DEA = \frac{Output\ (1) \times Weight\ (1) + Output\ (2) \times Weight\ (2) + \cdots}{Iutput\ (1) \times Weight\ (1) + Iutput\ (2) \times Weight\ (2) + \cdots} \tag{19}$$

RESEARCH FINDING

IWCI based on nominal capacity (NC)

IWCI included 16 types of industries based on confirmation information in IIO such as (1) Cooler bangs (NC=1400t), (2) Carton (NC=1500t), (3) Industrial drying wood (NC= 7500t), (4) Hydrophilic cotton (NC=400t), (5) Sheet rolls and packing (NC= 1000t), (6) Wax paper (NC= 1000t), (7) Booklet (NC=2600000t), (8) Hasp (NC=120000t), (9) Decal (NC=6250),

(10) Multilayer paper bags (NC= 12000t), (11) Row board (NC=12000t), (12) Wooden and paper disposable products (NC=7565000t), (13) Wooden pencil (NC=324000t), (14) Carbon paper (NC= 450000t), (15) Parquet (NC=150000 m+150000 m2), (16) Sandpaper (NC= 2000000 m2). To calculate the DEA score and rank was tabulated the annual requirements of IWCI according to Table 1.

Table 1: Annual requirements of IWCI [This study]

Industry	NC (t)	NC (pockets)	NC (m^2)	NC (m)	Employees	Power (kw)	Water (m^3)	Fuel (Gj)	Land (m^2)
(1)	1400	0	0	0	8700	37500	3000	900	9500
(2)	1500	0	0	0	6000	30000	1500	900	3500
(3)	7500	0	0	0	7200	52200	3600	8700	5400
(4)	400	0	0	0	8700	56100	5100	10500	4000
(5)	1000	0	0	0	9000	68400	1800	3000	5800
(6)	1000	0	0	0	4800	17400	1200	900	2400
(7)	2600000	0	0	0	9000	52200	3600	8700	2100
(8)	120000	0	0	0	3000	63600	3000	6900	4600
(9)	6250	0	0	0	6900	34800	2100	2100	4000
(10)	12000	0	0	0	10500	46500	2400	2100	5100
(11)	12000	0	0	0	21600	172500	6000	7500	15700
(12)	7565000	0	0	0	9000	45600	3900	1500	3300
(13)	324000	0	0	0	3900	29700	2400	900	2100
(14)	0	450000	0	0	4500	9000	900	900	2100
(15)	0	0	150000	150000	12600	107700	18000	22200	20600
(16)	0	0	2000000	0	6000	62700	3600	9300	7300

Industry	IF (t)	IF (bundle)	IF (m^3)	IF (No)	IF (m)	IF (Rolls)	IF (m^2)	IF (L)	IF (piece)
(1)	1942.96	29120	0	0	0	0	0	0	0
(2)	2446.38	0	0	0	0	0	0	0	0
(3)	0	0	9500	0	0	0	0	0	0
(4)	574.6	0	0	0	0	0	0	0	0
(5)	1064.2	0	0	139000	0	0	0	0	0
(6)	1028.3	0	0	0	0	0	0	0	0
(7)	734.7	0	0	17333	0	0	0	0	0
(8)	40.66	0	400	510000	0	0	0	8800	0
(9)	328.925	0	0	6250000	0	0	0	0	0
(10)	2610	0	0	0	400000	0	0	0	0
(11)	14.52	0	0	0	0	0	1260	0	126000
(12)	267	0	0	210580	10000	0	20457	0	0
(13)	39.046	0	0	386830	0	704158	0	0	0
(14)	62	0	0	454500	0	1285	0	0	0
(15)	1.5	0	4934	25050	5300	0	157000	0	0
(16)	969.4	0	0	0	0	0	0	0	0

IF= Initial feed, No= number, t= ton

Conducting a statistical analysis among 18 criteria via one-sample t-test had shown significant differences among water, fuel and IF (t) (p-value ≤ 0.001, 0.002 and 0.004) respectively. The paired sample test had also presented significant differences (p-value ≤ 0.047 and 0.001) between criteria of water-fuel and land-IF (t). Moreover, the paired sample test revealed the correlation among criteria as NC (t) & NC (pocket), NC (m2) & NC (m), employees & power, water & fuel, land & IF (t), IF (Bundle) & IF (m3), IF (No) & IF (m), IF (Rolls) & IF (m2) and IF (L) & IF (pieces) about -0.091, 0.976, 0.863, 0.886, -0.163, -0.095, -0.89, -0.076 and -0.067 respectively. The distribution of NC (t), NC (pocket), NC (m), employees, power, land, IF (t), IF (bundle), IF (No), IF (Rolls), IF (m), water, IF (pieces), fuel, IF (m2) and NC (m2) were obtained the same via related samples Friedman's two-way analysis of variance by ranks (p-value = 0.00). Therefore, the null hypothesis was rejected.

In Table 1 and also below similar Tables the NC has defined output criteria and all remaining criteria are called output criteria (such as IF (required materials to produce industries products) with various kinds of dimensions along with employees, power, water, fuel, and land criteria) for calculating the DEA score. Therefore, our existing data were divided into two classes of criteria are called outputs and inputs criteria. The criteria of outputs are associated with industries products. Our purpose is dividing normalized and weighted values of outputs criteria to normalized and weighted values of inputs criteria to release the DEA score. To reach the DEA score special vector obtained by both Friedman and Kendall tests was conducted into normalized rows of Table to sum the inputs and outputs values separately for each industry (Si according to Eq. 14), then division of outputs to inputs to emerge the score. The mentioned procedure was observed for all industries in present research (below Tables). As explained above, the values of the weights were estimated via both Friedman and Kendall tests according to Table 2.

Table 2: The weights values for the criteria [This study]

Criteria weights	**Friedman test**	**Kendall test**
NC (t)	12.81	12.81
NC (pocket)	6.06	6.06
NC (m^2)	6.88	6.88
NC (m)	6.13	6.13
Power (kw)	16.94	16.94
Employees	14.66	14.66
Fuel (Gj)	13	13
Water (m^3)	12.75	12.75
Land (m^2)	13.88	13.88
IF (t)	10.94	10.94
IF (m^3)	6.63	6.63
IF (Bundle)	6.03	6.03
IF (No)	11.38	11.38
IF (m)	7.03	7.03
IF (Rolls)	6.63	6.63
IF (m^2)	7.25	7.25
IF (L)	5.97	5.97
IF (pieces)	6.06	6.06

Kendall’s W=0.577

ITLI based on NC

ITLI comprised 38 various kinds of industries such as (1) Bag (NC=120000 No), (2) Carpet thread (NC=600t), (3) Cotton spinning (NC=1400t), (4) Jeans (NC=81000 No), (5) Leather artifacts (NC=90000 No), (6) Leather shoes (NC=135000 pairs), (7) Quilts, mattresses and pillows (NC=85000 No), (8) Raw leather (NC=618300 Ft2), (9) Sewing and embroidery thread (NC=150t), (10) Spinning (NC=2500t), (11) Tannery (NC= 45500 skin covers+214.988t), (12) Underwear (embroidered series) (NC=350000 No), (13) Wicker oil burner (NC=620000 No), (14) Spinning the woolen yarn (NC= 306t), (15) Knitting cotton, synthetic fibers (NC=1000 m2), (16) Band and medical wound texture gas (NC= 1407659 No), (17) Rachel Curtain Fabrics (NC=330000 m), (18) Mink blankets (NC=500000 m2), (19) Woolen blanket (NC=131500 No), (20) Spinning wool (NC=263.5t), (21) Blanket (NC=2250000 m2), (22) Winter clothing (NC=137500 No), (23) Clothing (shirt) (NC=135000 No), (24) Knitted Tricot (NC=130t), (25) Fishing net (NC=270t), (26) Stinger mosquito net (NC=300000 m2), (27) Socks (NC=243000 jeans), (28) Crust leather (NC=2398000 Ft2), (29) Cotton gloves (NC= 62400 pair), (30) Leather gloves (NC=70000 pair), (31) Wipes (Cleansing) (NC=4000 yard), (32) Ribbon Weaving (NC=3000 m), (33) Carpet coverage (NC=54000 No), (34) Spinning silk (NC=102.8t), (35) Zipper (NC=3000 m), (36) Animal skin pickle (NC= 200000 No), (37) Raw silk fabrics (NC= 330000 m), (38) Layer on diapers and sanitary pads (NC=8750 m2). The annual requirements of ITLI were added in Table 3 with a variety of criteria to figure out the DEA rank among 38 industries.

Table 3: Annual requirements of ITLI [This study]

Industry	NC (t)	NC (No)	NC (m^2)	NC (m)	NC (ft^2)	NC (skin)	NC (pair)	NC (jeans)	NC (yard)
(1)	0	120000	0	0	0	0	0	0	0
(2)	600	0	0	0	0	0	0	0	0
(3)	1400	0	0	0	0	0	0	0	0
(4)	0	81000	0	0	0	0	0	0	0
(5)	0	90000	0	0	0	0	0	0	0
(6)	0	0	0	0	0	0	135000	0	0
(7)	0	85000	0	0	0	0	0	0	0
(8)	0	0	0	0	618300	0	0	0	0
(9)	150	0	0	0	0	0	0	0	0
(10)	2500	0	0	0	0	0	0	0	0
(11)	214.988	0	0	0	0	45500	0	0	0
(12)	0	350000	0	0	0	0	0	0	0
(13)	0	620000	0	0	0	0	0	0	0
(14)	306	0	0	0	0	0	0	0	0
(15)	0	0	1000	0	0	0	0	0	0
(16)	0	1407659	0	0	0	0	0	0	0
(17)	0	0	0	330000	0	0	0	0	0
(18)	0	0	500000	0	0	0	0	0	0
(19)	0	131500	0	0	0	0	0	0	0
(20)	263.5	0	0	0	0	0	0	0	0
(21)	0	0	2250000	0	0	0	0	0	0
(22)	0	137500	0	0	0	0	0	0	0
(23)	0	135000	0	0	0	0	0	0	0
(24)	130	0	0	0	0	0	0	0	0
(25)	270	0	0	0	0	0	0	0	0
(26)	0	0	300000	0	0	0	0	0	0
(27)	0	0	0	0	0	0	0	243000	0
(28)	0	0	0	0	2398000	0	0	0	0

Industry	NC (t)	NC (No)	NC (m^2)	NC (m)	NC (ft^2)	NC (skin)	NC (pair)	NC (jeans)	NC (yard)
(29)	0	0	0	0	0	0	62400	0	0
(30)	0	0	0	0	0	0	70000	0	0
(31)	0	0	0	0	0	0	0	0	4000
(32)	0	0	0	3000	0	0	0	0	0
(33)	0	54000	0	0	0	0	0	0	0
(34)	102.8	0	0	0	0	0	0	0	0
(35)	0	0	0	3000	0	0	0	0	0
(36)	0	200000	0	0	0	0	0	0	0
(37)	0	0	0	330000	0	0	0	0	0
(38)	0	0	8750	0	0	0	0	0	0

Table 3: Countinue

Industry	Employees	Power (kw)	Water (m^3)	Fuel (Gj)	Land (m^2)	IF (t)	IF (m^2)	IF (No)	F (m)
(1)	15900	35100	3000	2700	3500	134.8	31005.5	1032000	0
(2)	11100	32700	2700	2100	4900	660	0	0	0
(3)	23100	216600	6300	32700	14100	1557.23	0	52875	0
(4)	47100	95100	7800	2100	3900	1.2	0	0	81000
(5)	11700	13200	2100	1200	2300	0.429	164727	3385	0
(6)	28200	29100	5700	3600	9000	79.961	284	680000	0
(7)	21600	14700	4200	1800	4600	73.5	510910	265350	0
(8)	6900	46200	11400	1500	3600	69.3443	0	274163	0
(9)	10500	47400	12600	13500	7600	168.3	0	182000	0
(10)	36000	214500	9600	6900	23600	2903	0	0	0
(11)	13200	45600	24000	20400	7100	1688.605	0	0	0
(12)	8400	7200	2100	3300	1500	36.755	0	0	0
(13)	6000	16200	3000	1500	3200	232.442	0	244000	0
(14)	16800	57000	8100	2400	6800	335	0	0	0
(15)	18600	72000	7800	42000	8400	185.3	0	0	0
(16)	8700	23100	2400	1200	2700	83.94	0	3000	0
(17)	21300	42300	6000	6600	14500	113.565	0	2400	5500
(18)	18900	73200	3900	3000	7400	413.1	0	255700	0
(19)	20100	61500	4800	3600	9300	446.415	0	144700	0
(20)	8400	16200	1800	900	2100	268.8	0	0	0
(21)	21600	152400	13500	63300	14200	1536.9	0	580000	0
(22)	8400	14400	1500	900	1900	59	0	144500	0
(23)	15900	12900	3600	6300	3000	4.05	0	945000	216000
(24)	16500	21300	4200	15600	2700	1435.64	0	720330	0
(25)	8700	18300	2100	900	2900	281.1	0	18000	0
(26)	8400	15600	1800	1500	3700	117.6	0	0	0
(27)	7200	45600	6000	16500	3800	45.428	0	2388	0
(28)	8100	73500	2100	1200	4300	31.75	0	0	0
(29)	3000	24300	1200	1800	3700	1.45	0	1200	0
(30)	9000	9000	2100	1200	2400	0.65	0	1662	0
(31)	4500	68400	1800	3000	6500	2	0	0	0
(32)	9000	12300	2100	1500	3200	8.8	0	137375	0
(33)	5700	14700	1500	1200	3000	114.372	0	55000	0
(34)	24600	126600	23400	39300	15800	131.4	0	4500	0
(35)	14700	58200	2700	1200	2500	27.42	0	10500000	5000
(36)	9000	41100	2700	2882100	6300	210481.16	0	0	0
(37)	7500	30000	2400	3000	6100	2023.7	0	0	0
(38)	5100	71100	1500	1500	3600	481.875	0	7433000	0

Table 3: Countinue

Industry	IF (L)	IF (duke)	IF (threads)	IF (pair)	IF (yard)	IF (ft^2)	IIF (Sheets)
(1)	0	0	0	0	0	0	0
(2)	0	0	100	0	0	0	0
(3)	0	0	0	0	0	0	0
(4)	0	0	0	0	0	0	0
(5)	1230	380	0	10000	54350	0	0
(6)	0	0	0	6750	0	405000	0
(7)	0	0	0	0	0	0	0
(8)	0	0	0	0	0	0	0
(9)	2000	0	0	0	0	0	0
(10)	0	0	0	0	0	0	0
(11)	0	0	0	0	0	0	0
(12)	0	0	0	0	0	0	0
(13)	0	0	0	0	0	0	0
(14)	0	0	0	0	0	0	0
(15)	1200	0	0	0	0	0	0
(16)	5400	0	0	0	0	0	5800
(17)	0	0	0	0	0	0	0
(18)	0	0	0	0	0	0	0
(19)	0	0	0	0	0	0	0
(20)	0	0	0	0	0	0	0
(21)	0	0	0	0	0	0	0
(22)	0	0	0	0	0	0	0
(23)	0	0	0	0	20250	0	0
(24)	0	0	0	0	0	0	0
(25)	0	0	0	0	0	0	0
(26)	0	0	0	0	0	0	0
(27)	0	0	0	0	0	0	0
(28)	0	0	0	0	00	2530000	0
(29)	0	0	0	0	0	0	0
(30)	0	0	0	0	0	182600	0
(31)	0	0	0	0	0	0	0
(32)	0	0	0	0	0	0	0
(33)	0	0	0	0	0	0	0
(34)	0	0	0	0	0	0	0
(35)	0	0	0	0	0	0	0
(36)	0	0	0	0	0	0	0
(37)	0	0	0	0	0	0	0
(38)	0	0	0	0	0	0	0

The t-test had proved significant differences among NC (t), NC (No) and IF (No) (P-value ≤ 0.045, 0.033 and 0.068) by running the SPSS software for 25 existing criteria in Table 3 respectively. While the paired sample test had revealed significant differences between NC (t) & NC (No) and IF (m2) & IF (No) about (p-value ≤ 0.034 and 0.077) respectively. It was found paired samples correlation between criteria of NC (t) & NC (No), NC (m2) & NC (m), NC (ft2) & NC (skin), NC (pair) & NC (Jean), NC (yard) & employees, power & fuel, land & IF (t), IF (m2) & IF (No), IF (m) & IF (L), IF (duke) & IF (Thread), IF (pair) & IF (yard), IF (ft2) & IF (sheets) about -0.124, -0.052, -0.033, -0.045, -0.176, -0.018, 0.021, -0.042, -0.061, -0.027, 0.766 and -0.033 respectively. The distributions of NC (t), NC (No), NC (m2), NC (m), NC (ft2), NC (skin), NC (Jean), NC (pair), water, power, fuel, IF (t), IF (m) & IF (yard), IF (ft2(, IF (No), IF (m2), land and employees were obtained the same via related samples Friedman's two-way analysis of variance by ranks (p-value = 0.00). Therefore, it resulted to reject the null hypothesis. In the following step, the values of weights were calculated using both Friedman and Kendall tests according to Table 4.

Table 4: The weight values for tabulated criteria [This study]

Criteria weights	Friedman test	Kendall test
NC (t)	11.29	11.29
NC (No)	13.71	13.71
NC (m^2)	10.75	10.75
NC (m)	10.36	10.36
NC (Skin)	9.26	9.26
NC (ft^2)	9.68	9.68
NC (Pair)	10.11	10.11
NC (jean)	9.29	9.29
Employees	22.33	22.33
NC (Yard)	9.20	9.20
Power	23.64	23.64
Water (m^3)	20.29	20.29
Land (m^2)	20.87	20.87
IF (m^2)	10.37	10.37
IF (m)	10.30	10.30
IF (No)	18.38	18.38
IF (duke)	9.07	9.07
IF (L)	10.03	10.03
IF (pair)	9.53	9.53
IF (yard)	9.67	9.67
IF (thread)	9.11	9.11
IF (ft^2)	10.16	10.16
IF (t)	18.16	18.16
Fuel	20.22	20.22
IF (Sheet)	9.24	9.24

Kendall's W=0.662

IMAI based on NC

IMAI encompassed 26 various types of industries as (1) Bitumen blown (NC= 27000t), (2) Building plaster (NC=150000t), (3) Ceramic dishes (NC=250t), (4) Ceramic tiles (NC= 600000t), (5) Floor Tiles (NC=600000t), (6) Glazed tile and ceramic (NC=150000t), (7) Gypsum (NC= 500t), (8) Industrial ceramic parts (NC=300t), (9) Ceramic brick (NC=30000000t), (10) Firebrick (NC=10000t), (11) Façade brick (NC=30000t), (12) Semi-automatic brick (NC=30000000t), (13) Hot asphalt (NC=135000t), (14) Building lime (NC=75000t), (15) Orthopedic bandage (NC=1300000t), (16) Rock wool (NC=1500t), (17) Glass wool (NC= 7000t), (18) Stone powder and mosaic (NC= 18000t), (19) Precast pressed beam and concrete pile (NC=15000t), (20) Gypsum prefabricated walls (NC=356400 m2), (21) Prefabricated wooden wall by wood powder (NC=15000t), (22) Cutting granite stone (NC=30000 m2), (23) Grindstone (NC= 500t), (24) Broken stone and debris washed (NC=200000t) (25) Mineral powders (NC=200000t), (26) Cement asbestos tube (NC=500t). To find the DEA rank has appeared the inventory of availability in Table 5.

Table 5: Annual requirements of IMAI [This study]

Industry	NC (t)	NC (m^2)	Employees	Power (kw)	Water (m^3)	Fuel (Gj)	Land (m^2)
(1)	27000	0	19	405	12	12	2800
(2)	150000	0	46	363	8	924	2200
(3)	250	0	50	242	25	11	6800
(4)	600000	0	62	685	21	26	19800
(5)	600000	0	30	345	26	14	19800
(6)	150000	0	50	125	21	98	3600
(7)	500	0	13	67	8	20	1700
(8)	300	0	66	200	16	8	5300
(9)	30000000	0	74	1388	21	351	17300
(10)	10000	0	67	663	23	104	13100
(11)	30000	0	62	406	77	9	13350
(12)	30000000	0	62	406	77	9	13350
(13)	135000	0	12	184	14	91	800
(14)	75000	0	21	466	5	1	3000
(15)	1300000	0	22	139	9	2	1800
(16)	1500	0	54	274	27	94	5900
(17)	7000	0	106	1128	131	394	25800
(18)	18000	0	12	214	6	4	3300
(19)	15000	0	67	204	25	37	25200
(20)	0	356400	42	263	81	168	11800
(21)	15000	0	44	582	52	163	16900
(22)	0	30000	17	513	20	7	3900
(23)	500	0	20	86	7	10	2700
(24)	200000	0	16	307	123	2	1300
(25)	200000	0	58	290	12	6	4200
(26)	500	0	117	1067	76	67	47100

Table 5: Continue

Industry	IF (t)	IF (No)	IF (L)	IF (m)	IF (m^2)	IF (m^3)
(1)	67000	94300	0	0	0	0
(2)	180000	0	0	0	0	0
337075	15700	0	0	0		0
(4)	13660	0	0	0	0	0
(5)	156676.5	0	0	0	0	0
(6)	1416	28350	0	0	0	0
(7)	446	0	0	0	0	0
(8)	6364.8	0	0	0	0	0
(9)	38350	0	0	0	0	0
(10)	11000	380000	0	0	0	0
(11)	56700	0	0	0	0	0
(12)	56700	0	0	0	0	0
(13)	147750	0	0	0	0	0
(14)	147000	240000	0	0	0	0
(15)	19892	119200	1700	1134000	0	0
(16)	7502100	0	1400	0	784480.5	0
(17)	7217.1	556000	0	0	5781	0
(18)	19800	360000	0	0	0	0
(19)	43350	0	0	0	0	0
(20)	22.5	0	0	445500	0	0
(21)	18016.3	0	0	0	0	0
(22)	1886	0	0	0	0	120
(23)	556	0	0	0	0	0
(24)	250000	0	0	0	0	0
(25)	104200	0	0	0	0	0
(26)	34218.8	0	0	0	0	0

It was found significant differences about (p-value ≤ 0.015 and 0.025) among 13 criteria of Table 5 via t-test analysis. The distribution of NC (t), NC (m2), power, IF (t), IF (m), IF (m2), land, IF (No), employees and fuel were manifested the same via related samples Friedman's two-way analysis of variance by ranks (p-value = 0.00). Therefore, the null hypothesis was rejected. Using both Friedman and Kendall tests were resulted to find the values of the weights for the existing criteria in Table 5 according to Table 6.

DEA score and rank

To figure out the DEA score and rank, the raw data classified into two groups of inputs and outputs criteria after tabulating as mentioned above. Then, using the equations in the methodology section were ended up to the results in Table 7. Table 7 presents the DEA score and rank developed for ITLI, IMAI, and IWCI.

According to Table 7, the values of the weights were obtained after passing through the normalization process, special vector induction on the normalized values and summation of weighted values for each row in two parts of inputs and outputs criteria. Finally, the division of outputs weights to input weights values led to come out scores and ranks outcomes. It needs to explain that the eigenvector was made up via SPSS software and using both Friedman and Kendall tests.

Table 6: The weight values for tabulated criteria [This study]

Criteria weights	Friedman test	Kendall test
NC (t)	10.92	10.92
NC (m^2)	3.94	3.94
Employees	7.77	7.77
Power	9.50	9.50
Water	7.25	7.25
Fuel	7.40	7.40
Land	11.31	11.31
IF (t)	11.77	11.77
IF (No)	6.19	6.19
IF (L)	3.69	3.69
IF (m)	3.98	3.98
IF (m^2)	3.83	3.83
IF (m^3)	3.44	3.44

Kendall's W=0.692

Table 6: The weight values for tabulated criteria [This study]

ITLI	DEA Score	DEA Score	IMAI	DEA score	DEA rank	IWCI	DEA score	DEA rank
(1)	25	25	(1)	0.004119248	14	(1)	0.000145469	16
(2)	26	26	(2)	0.007180373	13	(2)	0.000410793	14
(3)	20	20	(3)	2.81989E-05	25	(3)	0.00101853	10
(4)	29	29	(4)	0.049919779	6	(4)	8.36966E-05	1
(5)	35	35	(5)	0.058763551	5	(5)	0.000235169	15
(6)	15	15	(6)	0.023048188	10	(6)	0.000477476	13
(7)	32	32	(7)	0.000259259	19	(7)	0.62186581	5
(8)	12	12	(8)	5.3007E-05	26	(8)	0.013406465	8
(9)	28	28	(9)	1.435859327	2	(9)	0.000629255	12
(10)	14	14	(10)	0.000513933	22	(10)	0.001134578	9
(11)	5	5	(11)	0.002572055	15	(11)	0.000878858	11
(12)	8	8	(12)	2.572054565	1	(12)	1.852641917	3
(13)	6	6	(13)	0.028178239	9	(13)	0.042662128	7
(14)	23	23	(14)	0.007497175	12	(14)	3.018739877	2
(15)	38	38	(15)	0.03899364	7	(15)	0.29893767	6
(16)	21	21	(16)	1.57697E-05	23	(16)	1.082714995	4
(17)	9	9	(17)	0.00017649	21	-	-	-
(18)	16	16	(18)	0.001793811	17	-	-	-
(19)	24	24	(19)	0.001284495	16	-	-	-
(20)	18	18	(20)	1.129583234	3	-	-	-
(21)	10	10	(21)	0.001085394	18	-	-	-
(22)	17	17	(22)	0.07060289	4	-	-	-
(23)	30	30	(23)	0.000215662	20	-	-	-
(24)	27	27	(24)	0.020073452	11	-	-	-
(25)	19	19	(25)	0.033014605	8	-	-	-

Table 6: Continue

ITLI	DEA Score	DEA Score	IMAI	DEA score	DEA rank	IWCI	DEA score	DEA rank
(26)	11	11	(26)	1.92934E-05	24	-	-	-
(27)	2	2	-	-	-	-	-	-
(28)	13	13	-	-	-	-	-	-
(29)	4	4	-	-	-	-	-	-
(30)	7	7	-	-	-	-	-	-
(31)	1	1	-	-	-	-	-	-
(32)	31	31	-	-	-	-	-	-
(33)	22	22	-	-	-	-	-	-
(34)	33	33	-	-	-	-	-	-
(35)	36	36	-	-	-	-	-	-
(36)	34	34	-	-	-	-	-	-
(37)	3	3	-	-	-	-	-	-
(38)	37	37	-	-	-	-	-	-

CONCLUSIONS AND PROPOSAL FOR FUTURE RESEARCH

Actually, industries stakeholders pay a huge budget to energy consumption, staff salary and input materials conducted into industries as well as other outlays. Therefore, awareness of collected data by this research encourages them to move towards green materials, products and technologies, use the renewable resource to compensate the energy consumption outlay. Moreover, efficiency score awareness leads to pave the path for more competition among them. Classification of industries considering the initial screening information and based on DEA score with regard to select one certain way can be noticed as a relevant database deployment in this regard as a benchmarking. Then, industrial projects can pass through the annual growth rates reports after complete establishment with regard to any progress and rise in the values of inputs and outputs materials stream and other variables. Also, the designed database will provide lots of information to compare Iranian industries with other nations and creates a way towards industry 4 aims and executes the materials stream, energy cycles, and industrial ecology promotions. With regard to the presence of various criteria with miscellaneous scales, both Friedman and Kendall tests can be employed to estimate the values of weights effectively. According to our experience, we got a point for the effective weight value estimation using both tests, worth to declare here. The point is allocating the values of weights based on the highest to lowest amounts by them. As a result, the highest values in the columns offer high weight amount in comparison with the lowest values of criteria. The database developed in this regard can expand rely on the change in NC of industries that is proposed for the future researches. With regard to this fact that Iranian industries followed the same technologies in products manufacturing operation and the difference is attributed to NC. Additionally, the present study facilitated the path for DEA calculation based on currency. By the way, IET attempted to opening gates towards underpinning the economic estimation of industries in the EIA and following in industries sustainable development assessments.

ACKNOWLEDGEMENT

This research was conducted as part of the corresponding author Ph.D. research work.

REFERENCES

Anthony, P., Behnoee, B., Hassanpour, M., Pamucar, D. (2019). Financial Performance Evaluation of Seven Indian Chemical Companies. Decision Making: Applications in Management and Engineering, 2(1), 19-37.

Bulgurcu, B. (2013). Financial Performance Ranking of the Automotive Industry Firms in Turkey: Evidence from an Entropy-Weighted Technique. International Journal of Economics and Financial Issues, 3(4), 844-851.

Hassanpour, M. (2018). Evaluation of Iranian Wood and Cellulose Industries. Decision Making: Applications in Management and Engineering, 2(1), 13-34.

Hassanpour, M. (2019). Evaluation of Iranian Electronic Products Manufacturing Industries Using an Unsupervised Model, ARAS, SAW, and DEA Models, 6(2), 1-10.

Hassanpour, M. (2019a). Evaluation of Iranian Textile and Leather Industries. J. Appl. Ind. Eng, 6(1), 33-51.

Hassanpour, M. (2019b). Evaluation of Iranian Mining and Aggregate Industries. Industrial Engineering Journal, 12(3), 1-15.

Karabasevic D. M., Maksimovic M. V., Stanujkic D. M., Goran B. J., Dusan P. D. (2018). Selection of Software Testing Method by Using ARAS Method. Tehnika, 73(5), 724-729.

Karabasevic D., Paunkovic J., Stanujkic, D. (2015). Ranking of Companies According to the Indicators of Corporate Social Responsibility Based on SWARA and ARAS Methods. Serbian Journal of Management, 11(1), 43 – 53.

Kersuliene, V, Turskis, Z. (2011). Integrated Fuzzy Multiple Criteria Decision Making Model for Architect Selection. Technological and economic development of economy, 17(4): 645–666.

Krmac, E., Djordjevic, B. (2019). A New DEA Model for Evaluation of Supply Chains: A Case of Selection and Evaluation of Environmental Efficiency of Suppliers. Symmetry, 11, 565.

Kutut, V., Zavadskas, E. K., Lazauskas, M. (2014). Assessment of Priority Alternatives for Preservation of Historic Buildings Using Model Based on ARAS and AHP Methods. Archives of civil and mechanical engineering, 14, 287-294.

Li, X., Liu, Y., Wang, Y., Gao, Z. (2016). Evaluating Transit Operator Efficiency: An Enhanced DEA Model with Constrained Fuzzy-AHP Cones. Journal of traffic and transportation engineering (English edition), 3(3), 215-225.

Radovic D., Stevic Z., Pamucar D., Zavadskas EK., Badi, I., Antucheviciene J., Turskis, Z. (2018). Measuring Performance in Transportation Companies in Developing Countries: A Novel Rough ARAS Model. Symmetry, 10, 434, 1-25.

Rahmani, M. (2017). A productivity analysis of Iranian Industries Using an Additive Data Envelopment Analysis. Management Science Letters, 7, 197–204.

Rezaee, M.J., Ghanbarpour, T. (2016). Energy Resources Consumption Performance in Iranian Manufacturing Industries Using Cost/Revenue Efficiency Model. IJE transactions C: Aspects, 29(9), 1282-1291.

Salehi, M., Hematfar, M. (2012). Comparing Linear and Non-linear Relationships between Accounting Variables and Dividend: Evidence of Iranian chemical industries. African Journal of Business Management, 6(6), 2143-2151.

Sangwan, K.S., Digalwar, A.K. (2008). Evaluation of World-class Manufacturing Systems: A Case of Indian Automotive Industries. Int. J. Services and Operations Management, 4(6), 687-708.

Turskis, Z., Zavadskas, E. K. (2010). A Novel Method for Multiple Criteria Analysis: Grey Additive Ratio Assessment (ARAS-G) Method, INFORMATICA, 21(4), 597–610.