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Research Article

Efficiency Score Assessment of Iranian Plastic Industries

Malek Hassanpour*

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

Abstract: Iranian Plastic Industries (IPI) created the main role in generating and producing a variety of plastic commodities and goods for inhabitant's demands. IPI comprised a cluster of 21 industries regarding the initial screening of Iranian evaluator team in Environmental Impact Assessment (EIA) plan. The present research empirically examined a way to find the efficiency score of IPI. Data Envelopment Analysis (DEA) model was integrated with Additive Ratio ASsessment (ARAS) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) to estimate the efficiency score for IPI. The findings were classified IPI into 2 classes pertaining to both TOPSIS and ARAS models supported with both weighing systems of Friedman and Kendall tests. Moreover, the results proved an independent DEA value for the TOPSIS and ARAS models.

Keywords: Iranian plastic industries, DEA, EIA, Efficiency score

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Corresponding author: Malek Hassanpour, Malek.hassanpour@yahoo.com

1 Introduction

The disassembly of plastic containers and disposable bags in nature can not only last for up to four centuries, but the chemicals that it contains can enter the water, plants, and food circles and cause irreparable health and economic damage. Despite all of this, only about 185,000 tons of plastic per year are produced in our country, and from this perspective, we are among the 10 most consuming dishes in the world. The amount of recycled plastic waste is less than 1%, and the minimum time for decomposition in nature is between 200 and 400 years. Disposable vegetable containers have the same shape and appearance as plastic containers, but they are biodegradable. According to research, the time of returning throw-away vegetable dishes - made from modified corn starch - is five to six months in nature without any environmental damage. Estimates suggest that more than 100 million tons of plastic are produced each year due to the development of petrochemicals, petroleum, and changes in human consumption patterns. Iran annually produces large quantities of plastic products, due to its oil resources and petrochemicals. According to estimates, the daily consumption of plastics in the country is 500 tons and more than 185 thousand tons annually. Based on estimates, every inhabitant of Tehran daily average of three pieces of plastics enters the environmental cycle, which today is considered as one of the environmental problems of this metropolis. The high per capita consumption of plastic containers in Iran has also led to the name of our country is among the top 10 consuming throw-away plastic containers[1].

According to our knowledge, around 21 various types of IPI have been confirmed and got the eligibility to develop in Iran. Actually, all industrial projects need to traverse project identification steps in Iran and in parallel with other nations. So, the evaluator teams collect the salutary data about the whole availability of IPI. Therefore, we also tried to find a way to collect data by taking research in this regard and completing the initial screening of IPI availability towards figuring out the efficiency score of IPI via DEA. This method needs to sort out the inventory into 2 groups as input and output materials. There are many matured practices of DEA to find the efficiency score. But here our effort spent on the classification of the IPI in a certain framework of DEA is called DEA based on the additive models[2]. Because of bereavement in access to materials price and also other factors we avoid assigning DEA model based on materials costs. The second difficulty gets back to experiencing problems in identifying the properties of the miscellaneous materials to express them in currency. So present study collected 21 various types of IPI in whole input and output materials in values for the IPI and five main criteria such as the number of staff, land used for each industry, water, power and fuel consumed individually. The TOPSIS and ARAS models were mixed with DEA models to normalize and providing a non-scale matrix of different criteria containing a variety of dimensions to express.

Our attempt to review articles for the DEA based on the additive models failed with the lack of published papers in this regard. However, the literature review got a huge expansion for the other models of DEA. So the difficulty obligated to recede this section and looking forward to hearing more publicity in this field of study.

2 Methods

2.1 Weighting systems of Kendall's W and Friedman tests

The weights were obtained using SPSS software via both Friedman and Kendal tests. By presenting the below equation we are going to show the procedure defined in the software to release the weights. So the equation 1 to 5 and 5 to 9 express the method to calculate weight rates by software in brief[3].

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

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

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

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

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

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

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

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

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

2.2 Additive models based on TOPSIS and ARAS models to calculate DEA

2.2.1 TOPSIS and ARAS models mixed with DEA

Mixing ARAS and TOPSIS methods with DEA equations is the one way to calculate the DEA quantity considering the multiple output and input options. By the present study first we set up a matrix of input and outputs, estimation of weights (via Friedman and Kendall tests), compose the non-scale matrix, calculation of Euclidian distances and relative proximity and then ranking alternatives to figure out the DEA values via TOPSIS using equations 10 to 16 and 26. aij is the numerical value of each criterion i, according to the index j. The procedure followed the next steps of the normalization and weighting methods for the ARAS model according to equations 17 to 26. By the equations Xij offers the performance of option i on the basis of j and Xjo, the optimal value of the j criterion[4].

$$Nd = \frac{aij}{\sqrt{\sum_{i=1}^{m} (aij)^2}} \tag{10}$$

$$V = Nd \times Wn.n \tag{11}$$

$$A+ = \{(\max Vij | j \in J), (\min Vij | j \in j') | i = 1,2,\ldots, m\} = \{V_1^+, V_2^+,..V_j^+, V_n^+\} \tag{12}$$

$$A- = \{(\min i\, Vij | j \in J), (\max Vij | j \in j') | i = 1,2,\ldots, m\} = \{V_1^-, V_2^-,..V_j^-, V_n^-\} \tag{13}$$

$$di+ = \left\{\sum_{j=1}^{n} (Vij - Vj+\right)^2 \}^{0.5} ; i, = 1,2,3,\ldots m \tag{14}$$

$$di- = \left\{\sum_{j=1}^{n} (Vij - Vj-\right)^2 \}^{0.5} ; i, = 1,2,3,\ldots m \tag{15}$$

$$cli+ = \frac{di-}{di(+) + (di-)} \quad i = 1,2,3,4,5,6 \tag{16}$$

$$Xoj = max\,Xij \;if\; max\,Xij \quad is\; preferable \tag{17}$$

$$Xoj = min\,Xij \;if\; min\,Xij \quad is\; preferable \tag{18}$$

$$pij = \frac{Xij}{\sum_{i=1}^{m} Xij} \tag{19}$$

$$\tilde{f} = pij \times Wj, \quad i = o,m \tag{20}$$

$$Si = \sum_{j=1}^{n} normalized\ values\ of\ Xij, \quad i = o,m \tag{21}$$

$$DEA = \frac{\sum_{r=1}^{S} Ur\, Yrj}{\sum_{i=1}^{m} Vi\, Xij} \tag{22}$$

$$Max\ Z = \frac{\sum_{r=1}^{S} Ur\, Yrj}{\sum_{i=1}^{m} Vi\, Xij} \tag{23}$$

$$= \frac{\sum_{r=1}^{S} Ur\, Yro}{\sum_{i=1}^{m} Vi\, Xio}, \quad j = 1,2,3,\ldots.n \tag{24}$$

$$Ur, Vi \geq 0 \tag{25}$$

$$DEA = \frac{Output\,(1) \times Weight\,(1) + Output\,(2) \times Weight\,(2) + \ldots}{Iutput\,(1) \times Weight\,(1) + Iutput\,(2) \times Weight\,(2) + \ldots} \tag{26}$$

3 Results and discussion

Types of IPI based on nominal capacity comprised 21 industries such as congressional sheets of PP (Polypropylene) and PS (Polystyrene) (2000 T (Ton)), (1), Flat sheets of PP and PS (1200t), (2), Plastic waste recycling (630t), (3), Plastic buttons (100t), (4), PVC (Polyvinylchloride) hose (500t), (5), Plastic rope (1000t), (6), PVC flooring (1700t), (7), PP bags (900t), (8), Plastic bags (1052.67t), (9), PE (Polyethylene) pipes and fittings (1500t), (10), PVC pipes and joints (1400t), (11), Plastic welding artifacts (1000000 No = Number), (12), Plastic bottle (18000 No), (13), PVC shoe bed (2160000 No), (14), Plastic Box (Fruit, Chilli) (246140 No), (15), Plastic flashlight (600000 No), (16), PVC gum (4854109 No), (17), Plastic shaver (75000000 No), (18), Cellular Plastic Sheets (385000 m2), (19), PVC film for agricultural use (21600 m2), (20), Plastic products (175.26t+13580 rolls), (21). Table 1 displays the annual requirements of IPI according to initial screening of Iranian evaluator team in the EIA program.

Table 1. Annual requirements of IPI [This study]

Land (m^2)	Fuel (GJ)	Water (m^3)	Power (kW)	Nominal capacity (pair)	Nominal capacity (m^2)	Nominal capacity (t)	Nominal capacity (No)	Industry
10300	2880	9360	155520	0	0	2000	0	(1)
8300	2880	9360	160200	0	0	1200	0	(2)
7600	3240	2160	122040	0	0	630	0	(3)
2700	1440	2160	72360	0	0	100	0	(4)
2900	1440	2160	30600	0	0	500	0	(5)
3900	1800	5400	82800	0	0	1000	0	(6)
10000	11160	10440	79920	0	0	1700	0	(7)
7000	21960	6120	161640	0	0	900	0	(8)
3200	1440	4680	91440	0	0	1052.67	0	(9)
5800	2160	4680	120240	0	0	1500	0	(10)
3200	1800	2520	104040	0	0	1400	0	(11)
1800	29520	1440	1080	0	0	0	1000000	(12)
3500	2160	3240	241920	0	0	0	18000	(13)
5900	4320	4320	38160	0	0	0	2160000	(14)
3100	1080	2520	105120	0	0	0	246140	(15)
2600	1440	2160	88200	0	0	0	600000	(16)
2500	1080	1440	46440	0	0	0	4854109	(17)
6600	1800	5400	60840	0	0	0	75000000	(18)
3200	1800	1440	116640	0	385000	0	0	(19)
4900	36360	3600	74160	0	21600	0	0	(20)
2100	1080	2880	30960	13580	0	175.26	0	(21)
Initial feed (pair)			**Initial feed (m^2)**	**Initial feed (m)**	**Initial feed (No)**	**Initial feed (t)**	**Employees**	**Industry**
0			0	0	0	20225	18360	(1)
0			0	0	0	1225.2	22320	(2)
0			0	0	0	1000	3240	(3)

0	0	125000	0	107.846	8640	(4)
0	0	0	0	505.4	9000	(5)
0	0	0	0	1060	18000	(6)
0	0	0	10000	1769	25920	(7)
0	0	0	0	937	17280	(8)
0	0	0	1310958	1039.618	22680	(9)
0	0	75000	0	1485	20160	(10)
0	0	0	0	1404	10440	(11)
3969000	409710	476280	716276	0	6120	(12)
0	0	0	0	561	15560	(13)
0	0	0	0	1080505	10440	(14)
0	0	0	0	659.67	6120	(15)
0	0	0	1270100	40.245	10800	(16)
0	0	0	9865608	0	4320	(17)
24000	0	0	100000	778.5	25200	(18)
0	0	0	0	800.16	4320	(19)
0	0	0	220000	3837	6560	(20)
0	0	0	1312200	339.36	10440	(21)

By Table 1 the nominal capacity is defined output criteria and the power, water, fuel, land, employees and initial feeds criteria as input items. It needs to explain that by the present study the DEA was calculated for the time interval of one year and before establishing the industries in the EIA program. So after distinguishing the efficiency score and passing through of decision making systems projects are conducted to the final steps of EIA and towards approving the project. The study by author classified the IPI in a class as 1>2>7>8>13>10>3>20>18>9>6>14>19>11>16=4>15>5>12>17>21 via decision making systems.

To assess the raw data SPSS software was chosen to investigate the statistical aspects of raw data in Table 1. It was observed significant differences around (p-value ≤ 0.001 and 0.009) for the values of Nominal capacity (t) and fuel among parameters of nominal capacity (No), nominal capacity (m^2), nominal capacity (pair), power, water, fuel, land, employees, initial feed (t), initial feed (No), initial feed (m), initial feed (m^2) and initial feed (pair). While the pair test for the same parameters proved no significance. It was found the values of the weights for the same criteria as nominal capacity (No; 6.98), nominal capacity (t; 5.93), nominal capacity (m^2; 4.52), nominal capacity (pair; 4.12), power (12.90), water (9.74), fuel (9.57), land (10.45), employees (11.69), initial feed (No; 7.4), initial feed (t; 8.02), initial feed (m; 5.05), initial feed (pair; 4.57) and initial feed (m^2; 4.05) using both Friedman and Kendall tests respectively. Tables 2 and 3 display the DEA score in both TOPSIS and ARAS models.

Table 2. DEA score in TOPSIS model [This study]

DEA Score	DEA	cli (output)	cli (input)	Industry
8	0.097158924	1.13059E-05	0.000116365	(1)
14	0.03497744	4.07014E-06	0.000116365	(2)
18	0.009640935	1.12183E-06	0.000116362	(3)
21	0.000242905	2.8265E-08	0.000116362	(4)
19	0.006072913	7.06623E-07	0.000116357	(5)
16	0.02429111	2.82649E-06	0.000116359	(6)
11	0.070200952	8.16851E-06	0.000116359	(7)
17	0.019674801	2.28946E-06	0.000116365	(8)
15	0.026696849	3.13207E-06	0.00011732	(9)
12	0.054652929	6.35957E-06	0.000116363	(10)
13	0.047609884	5.5399E-06	0.00011636	(11)
5	1.499783216	0.000177777	0.000118535	(12)
20	0.000494977	5.75997E-08	0.000116368	(13)
4	7.103721294	0.000829435	0.000116761	(14)
9	0.092562351	1.07706E-05	0.00011636	(15)
7	0.545792696	6.39996E-05	0.00011726	(16)
3	18.90241689	0.004188843	0.000221604	(17)
1	8565.24959	0.996681624	0.000116363	(18)
2	28.50300161	0.003316644	0.000116361	(19)
10	0.089995773	1.04742E-05	0.000116385	(20)
6	0.913284282	0.000107145	0.000117319	(21)

Table 3. DEA score in TOPSIS model [This study]

Ranks	DEA	Si (input)	Si (output)	Industry
5	0.229625383	4.24820197	0.975495006	(1)
11	0.142636607	4.103413682	0.585297004	(2)
12	0.139845581	2.197287356	0.307280927	(3)
17	0.020374034	2.393966323	0.04877475	(4)
8	0.198619045	1.227846763	0.243873752	(5)
7	0.199690313	2.442519598	0.487747503	(6)
9	0.178877744	4.635404817	0.829170755	(7)
13	0.091900347	4.776616919	0.438972753	(8)
10	0.161782879	3.173618666	0.513437164	(9)
6	0.210073822	3.482686449	0.731621255	(10)
4	0.365205919	1.869757497	0.682846504	(11)
20	0.005458051	15.24643984	0.083215853	(12)
21	0.000481002	3.114094453	0.001497885	(13)
18	0.018264044	9.841535905	0.179746241	(14)
19	0.012595412	1.626207221	0.02048275	(15)
16	0.021908053	2.279048301	0.049929512	(16)
14	0.068318719	5.912564292	0.403938819	(17)
3	2.108997647	2.959315269	6.24118894	(18)
1	2.729857788	1.567803996	4.279881948	(19)
15	0.054273116	4.424254005	0.240118052	(20)
2	2.193306586	1.917416678	4.205482627	(21)

DEA has defined the division of weighted average of outputs to the weighted average of inputs as a dominant assessment model to distinguish the efficiency of projects. Actually, DEA does the best ranking based on criteria in outlays. The DEA methods are expressed into a few classes such as (1) The Charnes-Cooper-Rhodes (CCR) ratio model (a) Estimating net technical efficiency by a determined measure of operations, (b) Identification of rising, falling, or fixed return on the scale. (2) Coefficient models (3) Additive model and additive developed model[5]. The present study examined the last option in this choice.

Conducting a t-test between weighs values of both TOPSIS and ARAS models were revealed a significant difference around (p-value≤0.023). Therefore, the classification of industries based on the DEA model can be done via one certain model because the released results are not the same or close together.

4 Conclusion

By the present study, the DEA model based on the additive models was applied to classify the IPI. The initial screening of Iranian evaluator team employed to classify the industries. Further studies can use the raw data in currency to find the DEA score. The nominal capacity of IPI indicates the energy consumed, employees' number and land area used. However, we know with a rise in the nominal capacity a rise in criteria values will happen. But here we were used the current values to estimate the DEA.

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