Vol. XII & Issue No. 3 March - 2019
INDUSTRIAL ENGINEERING JOURNAL

EVALUATION OF IRANIAN MINING AND AGGREGATE INDUSTRIES

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ABSTRACT:

Iranian Mining and Aggregate Industries (IMAI) are underdeveloping day by day and the country is one of the most important mineral producers in the world, ranked among 15 major mineral-rich countries. The current cluster study of IMAI has targeted the weighing and ranking industries empirically based on initial assessment of Iranian organizations once before constructing industries. The Weighted Aggregated Sum-Product Assessment (WASPAS) method was used to rank IMAI along with the Friedman test and Entropy Shannon method to estimate the weights. The existing data were undergone the SPSS and Excel 2013 soft-wares to analyse and design the methodology of computations patterns. The findings based on the Friedman test and Entropy Shannon weighing methods were manifested 2 different classifications for the IMAI. In the following steps, the effect of λ values on the ranking performance of WASPAS method was investigated for 26 IMAI. The input and output materials flow along with an essay upon the existing facilities were sought to find the best and easiest procedure for the economic estimation of IMAI individually.

KEYWORDS: *Evaluation, Assessment, Iranian Mining and Aggregate Industries, WASPAS*

1. INTRODUCTION

According to the current statistics, industries and mines account for about 25 percents of Iran's economy. In this division, the construction sector accounts for 9.8% and the industrial and mining sectors account for 13.6% of the country's gross domestic product. Thus, industries and mines (albeit without taking into account the oil and gas sectors, which are considered to be the country's most important industry) produce a quarter of Iran's economy. The existing connections of various industrial and mining sectors, along with other economic sectors (such as agriculture, oil and energy and construction) have created the scope of industry activity and its impact beyond the industrial and mining sectors. The building sector is also needed as a separate section of the industry and mining sector to meet its needs for construction materials such as cement industries, metal industries etc. In addition to the past and the upstream connections of industry and mining with other sectors of the Iranian economy, this section is also important in terms of technology development and diffusion [1].

IMAI encompassed bitumen blown, building plaster, ceramic dishes, ceramic tiles, floor tiles, glazed tile and ceramic, gypsum, industrial ceramic parts, ceramic brick, firebrick, façade brick, semi-automatic brick, hot asphalt, building lime, orthopaedic bandage, rock wool, glass wool, stone powder and mosaic, precast pressed beam and concrete pile, gypsum prefabricated walls, prefabricated wooden wall by wood powder, cutting granite stone, grindstone, broken stone and debris washed, mineral powders, cement asbestos tube. Globally this cluster has been classified in 3 classes such as (1) stone & pottery products, (2) concrete & glass products, (3) concrete & glass products (cont'd.). The first class included many industries such as vitreous china plumbing fixtures and china vitreous china table and kitchen articles; fine earthenware (white ware) table and kitchen articles; pottery products brick and structural clay tile; ceramic wall and floor tile; structural clay products; lime; cut stone and stone products; minerals and earths, ground or otherwise treated; phosphatic fertilizers; porcelain electrical supplies. the second class also included some industries such as cement, hydraulic; concrete block and brick; ready-mixed concrete; non-clay refractories; glass products, made of purchased glass; radio and television receiving type electron tubes. Third class besets the electric lamps; ophthalmic goods; clay refractories; concrete products, except block and brick; gypsum products [2,3].

As we know, all industries projects should undergo an initial assessment before complete setup. The present study comprised 26 various kinds of IMAI with lots of details in terms of input and outputs materials, facilities, the flow diagram of processes and technologies and 5 main criteria. All existing data were the initial screening of both Iranian industries organization and environmental protection agency as raw information. Therefore, available data came through of the decision making systems to classify and process data. Almost all decision-making methods have several criteria that these criteria are different. In general, decision-making methods seek to evaluate a set of options according to a set of criteria. Today, decision-making models have been widely considered by researchers. So that in recent years a lot of research has been done in various industries such as transportation of healthcare, university and higher education, water and sewage, hotel industry, supply chain management etc. Multi-criteria decision-making methods have diverse techniques. One of the newest multi-factorial decision-making methods is WASPAS method, which was first introduced in 2014. Obviously, based on decision-makers idea all criteria may not be equally important for the indicators, and some of the indicators are more or less important than the other indicators; therefore, after determining indicators, the weight of each criterion should be determined. There are various methods for determining the weight of the indicators, some of which are Friedman test and entropy Shannon etc pertaining to lots of mathematical equations. The present study assigned the WASPAS procedure to achieve the main objective of study as an evaluation of IMAI. Therefore, the following steps were arranged to implement the weighing and ranking calculations [4,5].

2. REVIEW OF RELATED LITERATURE

Busu and Busu[4] have done a study on the linear waste economy conversion to a circular form. By the way, they have developed a ranking and weighing system based on mathematical modelling and Entropy Shannon equations. The values for the weighing system have been obtained between 0-1.Taheriyoun et al.[5] developed an eutrophication index for a basin using Entropy Shannon to figure out the weights for criteria and fuzzy theory to rank the options. Zhao et al.[6], Mkhalet et al.[7], Danaei[8], Ozturk[9], Hashemzadeh et al.[10] used the Entropy Shannon method to determine the weights values for supplier selection, classification of the 13 projects of Kish airport containing 7 criteria, discovering the urban sprawl based on 4 criteria (built-up area (km^2), built up density (%), built-up area growth rate (‰), change in built-up area (km^2)), weighing the 16 criteria in the implementation of an individual dies exchange in 14 plastic industries respectively.

Yazdani et al [11] used Step-wise Weight Assessment Ratio Analysis (SWARA) and WASPAS methods to weight and rank criteria in the selection of the best green suppliers respectively. Chakraborty and Zavadskas[12] employed WASPAS method to remove the difficulties experienced in eight manufacturing units, such as selection of cutting fluid, electroplating system, forging condition, arc welding process, industrial robot, milling condition, mach inability of materials, and electro-discharge micro-machining process items. Bausys and Juodagalyiene[13] used WASPAS method to select the position of a garage at the parcel of a single-family residential house. Using WASPAS technique led to rank 4 options and 6 criteria. Azadfallah[14] used the WASPAS method to select the best supplier containing 10 alternative and 5 criteria. Ghorshi Nezhad et al.[15] used WASPAS method to rank the prominent industries in terms of nanotechnology applications in the 11 industries such as agriculture, transportation, construction, oil and gas, textile products, food industry, defence industry, health and medicine, nanoelectronics, nano energy and environment and water based on 29 subcriteria and 5 main criteria. The results have been reported as Nanotechnology in health & medicine > Nanotechnology in oil and gas > Nanotechnology in defence industry>Nano-electronics>Nanotechnology in construction>Nanotechnology in transportation >Nanotechnology in the environment and water>Nanotechnology in the food industry >Nanotechnology in textile products>Nanotechnology in agriculture.

3. METHODOLOGY

3.1. Weighing system based on Friedman test

Using the Friedman test to analysis the matrix of data which is designed in the SPSS software the average weights are estimated for columns individually. Then obtained values can be assumed as weights of criteria to rank the industries values in any ranking system. The procedure to do the first step is fulfilled by equations of 1-5 by software. In the composed matrix rij is the values.

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

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

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

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

$$Q = \frac{SSt}{SSe} \quad (5)$$

3.2. Weighing system based on Entropy Shannon

The weighing system of Entropy Shannon is a well-known procedure to estimate weights within a certain matrix. Using this procedure provides values of weights between 0-1. By the way, the raw data assessed by Iranian industries organization and Iranian Environmental Protection Agency were passed through of weighing system. Equation 6 was used to normalize the existing values. The steps related to the normalization process were done by Excel 2013. In the following steps, it was used the equation of 7 to 10 to calculate and determine the weights for each criterion supported by Excel 2013. The Xij and Wj are existing values and obtained weight values within the decision matrix respectively.

$$Pij = \frac{Xij}{\sum_{i=1}^{m} Xij} \qquad j = 1, \dots, n \qquad (6)$$

$$Ej = -k \sum_{i=1}^{m} Pij \times Ln\, Pij \qquad i = 1,2, \dots, m \qquad (7)$$

$$k = \frac{1}{Ln\, m} \qquad (8)$$

$$dj = 1 - Ej \qquad (9)$$

$$Wj = \frac{dj}{\sum dj} \qquad (10)$$

3.3. Ranking system based on WASPAS

The WASPAS method is one of the recently developed multi-criteria decision-making methods. This method is a combination of both models of the Weighted Sum Model (WSM) and Weighted Product Model (WPM). This method has more accuracy compared to independent methods. To complete the ranking process equation 11 was used to normalize the values. The calculation of the relative importance of the solutions based on the models of WSM and WPM was carried out through of the equations 12 and 13. The accuracy and effect of the WASPASS method are that the significance of the option of i is calculated by λ in the formula.

$$\bar{r}ij = \frac{Xij}{Max\, Xij} \qquad (11)$$

$$Qi(1) = \sum_{j=1}^{n} \bar{r}ij\, Wj \qquad (12)$$

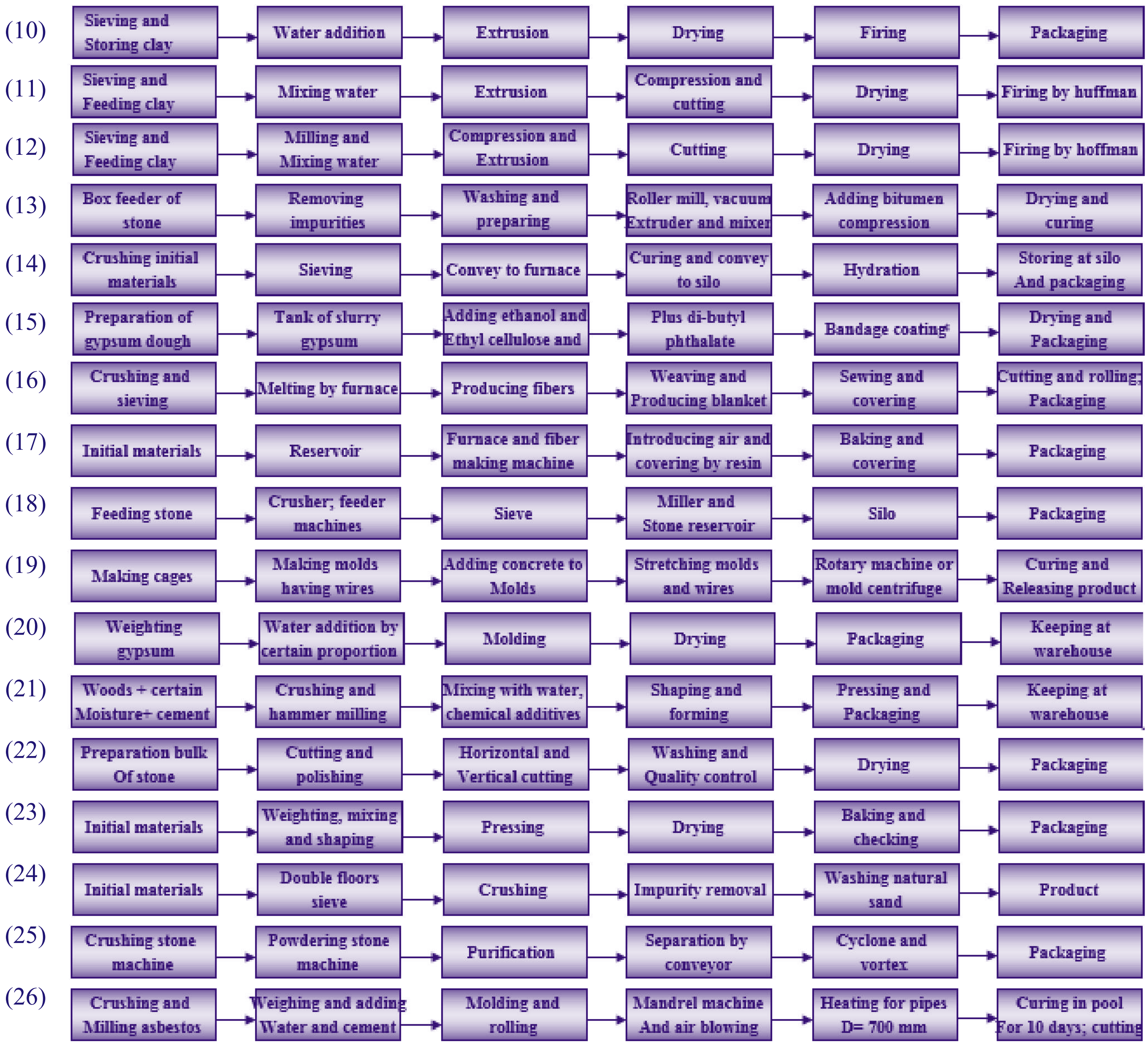
$$Qi(2) = \prod_{j=1}^{n} (\bar{r}ij)^{wj} \qquad (13)$$

$$Qi = \lambda Qi(1) + (1-\lambda) Qi(2), \qquad \lambda = 0, \dots, 1 \qquad (14)$$

It should be noted that in this research, λ was assumed equal to 0.5. Obviously, the option containing the highest Qi value will be taken with higher priority [11].

4. EMPIRICAL RESULTS AND DISCUSSION

Technology includes important components such as machinery, expert manpower, information and organization. In other words, technology means an activity in which more sophisticated and modern machinery and equipment are used, human resources are employed with a higher level of expertise and modern information systems, and the general organization of the factors of production employed in it. In a modern fashion, it should be considered a high-tech enterprise. From this perspective, the IMAI is sensitive in the country because of its role at a high level of complexity. Many of the country's industries that are considered high-tech industries are contributed to the IMAI sector. Therefore, in this study, all facilities, input materials, output products and energy requirements etc which are related to available technologies used in IMAI are discussed according to Figure 1.



Bitumen blown (1), Building plaster (2), Ceramic dishes (3), Ceramic tiles (4), Floor Tiles (5), Glazed tile and ceramic (6), Gypsum (7), Industrial ceramic parts (8), Ceramic brick (9), Firebrick (10), Façade brick (11), Semi-automatic brick (12), Hot asphalt (13), Building lime (14), Orthopedic bandage (15), Rock wool (16), Glass wool (17), Stone powder and mosaic (18), Precast pressed beam and concrete pile (19), Gypsum prefabricated walls (20), Prefabricated wooden wall by wood powder (21), Cutting granite stone (22), Grindstone (23), Broken stone and debris washed (24) Mineral powders(25), Cement asbestos tube (26).

Figure 1. IMAI and their processes [This study]

Industrial machines are one of the routes of technology transfer and increase productivity. Given the 25 % stake of the industries and mines in the country's economy, the sector is almost 1.5 times more than the stake of a gross domestic product that has been invested in the country. These figures indicate that investing in machinery to develop this sector is more important than other sectors of the Iranian economy, and therefore maintaining the competitiveness of this sector of the Iranian economy, in addition to employing specialized labour, requires access to modern and up-to-date machinery. Table 1 included the number of staff, energy consumption in IMAI.

Table 1.IMAI, their number of staff, energy consumption based on nominal capacity [This study]

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

Conducting a statistical analysis on the existing data in Table 1, Friedman test analysis proved that the mean weights can be about 2.31, 3.96, 1.79, 1.94, and 5 for the number of employees, power, water and fuel utilized and land area applied for IMAI respectively. The test statistics have also revealed the values around 83.260 (N= 26, df =4 and Asymp.sig = 0.000) for the Chi-Square by Friedman test. One-Sample Kolmogorov-Smirnov test had shown the test distribution is normal with the values of mean around 46.5000, 423.5385, 35.5000, 101.2308 and 10492.3077 for employees, power, water, fuel and land respectively. One sample t-test has presented a significant difference (p-value ≤ 0.015 among the criteria of employees, power, water, fuel and land. The Pearson correlation Sig. (2-tailed) had represented the highest correlation between the values of land and employees around 0.797. In the following the correlation among criteria were observed as employee-power (0.665) > power-land (0.663) > water-land (0.445) > employees-water (0.441) by same test respectively. The null hypothesis via one-sample Chi-Square test leads to occur the categories of water with equal probabilities. Therefore, the null hypothesis was retained. The distribution of employees, power, fuel and land were obtained normally with mean and standard deviations of around 46.50 and 28.09, 423.54 and 330.76, 101.23 and 196.56 and 10492.31 and 10763.52 by Null hypothesis and One-Sample Kolmogorov Smirnov Test respectively. Therefore, the null hypothesis was only rejected for the values of fuel. The null hypothesis conducted by related samples Friedman's Two-Way Analysis of Variance by Ranks had manifested that the distributions of employees, power, fuel and land are the same. Thus, the null hypothesis was rejected.

4.1. Findings based on the Friedman test and WASPAS method

Friedman test analysis proved that the mean weights can be about 2.31, 3.96, 1.79, 1.94, and 5 for the number of employees, power, water and fuel utilized and land area applied for IMAI using SPSS software according to equation 1 to 5.These values were used to collect weights in Table 2 as a special vector. The normalization of data was done according to equation 11. Tables 2 and 3 display the values obtained from equations 11 to 14.

Table 2.Normalized matrix [This study]

Industry	Employees	Power	Water	Fuel	Land
(1)	0.162393162	0.291786744	0.091603053	0.012987013	0.059447983
(2)	0.393162393	0.261527378	0.061068702	1	0.04670913
(3)	0.427350427	0.174351585	0.190839695	0.011904762	0.144373673
(4)	0.52991453	0.49351585	0.160305344	0.028138528	0.420382166
(5)	0.256410256	0.248559078	0.198473282	0.015151515	0.420382166

(6)	0.427350427	0.090057637	0.160305344	0.106060606	0.076433121
(7)	0.111111111	0.048270893	0.061068702	0.021645022	0.036093418
(8)	0.564102564	0.144092219	0.122137405	0.008658009	0.112526539
(9)	0.632478632	1	0.160305344	0.37987013	0.367303609
(10)	0.572649573	0.477665706	0.175572519	0.112554113	0.278131635
(11)	0.52991453	0.292507205	0.58778626	0.00974026	0.28343949
(12)	0.52991453	0.292507205	0.58778626	0.00974026	0.28343949
(13)	0.102564103	0.132564841	0.106870229	0.098484848	0.016985138
(14)	0.179487179	0.33573487	0.038167939	0.001082251	0.063694268
(15)	0.188034188	0.100144092	0.06870229	0.002164502	0.038216561
(16)	0.461538462	0.19740634	0.20610687	0.101731602	0.125265393
(17)	0.905982906	0.812680115	1	0.426406926	0.547770701
(18)	0.102564103	0.154178674	0.045801527	0.004329004	0.070063694
(19)	0.572649573	0.146974063	0.190839695	0.04004329	0.535031847
(20)	0.358974359	0.189481268	0.618320611	0.181818182	0.250530786
(21)	0.376068376	0.419308357	0.396946565	0.176406926	0.35881104
(22)	0.145299145	0.369596542	0.152671756	0.007575758	0.082802548
(23)	0.170940171	0.061959654	0.053435115	0.010822511	0.057324841
(24)	0.136752137	0.221181556	0.938931298	0.002164502	0.027600849
(25)	0.495726496	0.208933718	0.091603053	0.006493506	0.089171975
(26)	1	0.768731988	0.580152672	0.072510823	1

Table 3.Ranking matrix [This study]

Industry	Nominal capacity	Q1	Q2	Q
(1)	27000	2.017007895	2.57504E-16	1.008504
(2)	150000	4.226712168	8.52027E-13	2.113356
(3)	250	2.764178421	8.31559E-14	1.382089
(4)	600000	5.621871468	6.84086E-09	2.810936
(5)	600000	4.063173583	3.73022E-11	2.031587
(6)	150000	2.218677475	1.28781E-14	1.109339
(7)	500	0.779590815	9.27777E-21	0.389795
(8)	300	2.671737298	5.1782E-15	1.335869
(9)	30000000	8.281438305	1.33934E-05	4.140726
(10)	10000	5.13766467	1.57952E-08	2.568832
(11)	30000	4.870662055	1.56981E-10	2.435331
(12)	30000000	4.870662055	1.56981E-10	2.435331
(13)	135000	1.229163855	5.00439E-19	0.614582
(14)	75000	2.133016986	1.34308E-18	1.066508
(15)	1300000	1.149188616	1.06168E-20	0.574594
(16)	1500	3.040500522	5.88567E-12	1.52025
(17)	7000	10.66711671	0.003304319	5.335211
(18)	18000	1.2881721	5.55915E-19	0.644086
(19)	15000	4.999284076	6.11223E-10	2.499642
(20)	356400 m^2	4.291751684	1.9753E-09	2.145876
(21)	15000	5.375998034	1.31341E-07	2.687999
(22)	30000 m^2	2.501235482	2.33487E-15	1.250618
(23)	500	1.043500755	1.39876E-19	0.52175
(24)	200000	3.014666802	2.48562E-18	1.507333
(25)	200000	2.594932468	1.78819E-15	1.297466
(26)	500	11.53332295	0.000819579	5.767071
E=10				

According to Table 3 and in comparison with the real values in Table 1 the highest Q obtained from the ranking system is the first priority. Obtained results are in a real compliance with real values of Table 1. Therefore, the classification style developed as following 26> 17> 9> 4 > 21 > 10 > 19 > 11=12 > 20 >2 > 5 > 16 > 24 > 3> 8> 25> 22 > 6 > 14 > 1 > 18 > 13 > 15 > 23 > 7.

4.2. Findings based on Entropy Shannon and WASPAS method

Using equation 6 to 10 resulted in weights for each criterion according to Table 4. Both factors of the number of employees and the land area used can be negative criteria in any expansion purpose in industries. Table 4 shows Weighted values based on Entropy Shannon procedure.

Table 4. Weighted values based on Entropy Shannon procedure [This study]

	Employees	Power	Water	Fuel	Land
E	0.94598861	0.923129378	0.873552221	0.674117915	0.867616665
dj=1-Ej	0.05401139	0.076870622	0.126447779	0.325882085	0.132383335
Wj	0.075477573	0.107421935	0.176702941	0.455400037	0.184997514
$\sum dj$	0.715595211				
K	0.306927676				

With regard to this fact that the normalization process was the same as the previous step so the same and existing values of Table 2 was used. On the other hand, the normalization of data was done according to equation 11. Then equations 11 to 14 were assigned to estimate the ranks values. Table 5 contains the normalized values in Table 2 used to rank options based on Entropy Shannon.

Table 5. Ranking matrix[This study]

Industry	Nominal capacity	Q1	Q2	Q
(1)	27000	0.076699883	0.041079843	0.058889863
(2)	150000	0.532600849	0.279332244	0.405966547
(3)	250	0.116836693	0.053917227	0.08537696
(4)	600000	0.211921458	0.107136246	0.159528852
(5)	600000	0.16579439	0.073807483	0.119800936
(6)	150000	0.132695906	0.117215273	0.12495559
(7)	500	0.040897105	0.035243203	0.038070154
(8)	300	0.104397784	0.04117947	0.072788627
(9)	30000000	0.424429439	0.373759267	0.399094353
(10)	10000	0.228268963	0.190076233	0.209172598
(11)	30000	0.232153229	0.073073003	0.152613116
(12)	30000000	0.232153229	0.073073003	0.152613116
(13)	135000	0.088858157	0.074752478	0.081805317
(14)	75000	0.068633071	0.011758563	0.040195817
(15)	1300000	0.045145616	0.014341606	0.029743611
(16)	1500	0.161963626	0.144163741	0.153063683

(17)	7000	0.62790595	0.589047466	0.608476708
(18)	18000	0.047329763	0.020489529	0.033909646
(19)	15000	0.209947651	0.119813121	0.164880386
(20)	356400 m^2	0.285855608	0.253249439	0.269552524
(21)	15000	0.29028414	0.269775952	0.280030046
(22)	30000 m^2	0.096415417	0.038039364	0.06722739
(23)	500	0.044533642	0.029018544	0.036776093
(24)	200000	0.206085195	0.022785305	0.11443525
(25)	200000	0.095500562	0.033893458	0.06469701
(26)	500	0.478589879	0.267284861	0.37293737

With regard to right application of weighing system and considering to real values, a classification was developed for IMAI as following 17> 26> 2> 9 > 21 > 20 > 10 > 19 > 4 > 16 >11=12 > 6 > 5 > 24 > 3> 13> 8> 22> 25 > 1 > 14 > 7 >23> 18> 15.

4.3. Effect of ƛ on the ranking performance of WASPAS method

Figure 2 and 3 display the effect of varying values of ƛ on the ranking performance of WASPAS method for 26 IMAI.

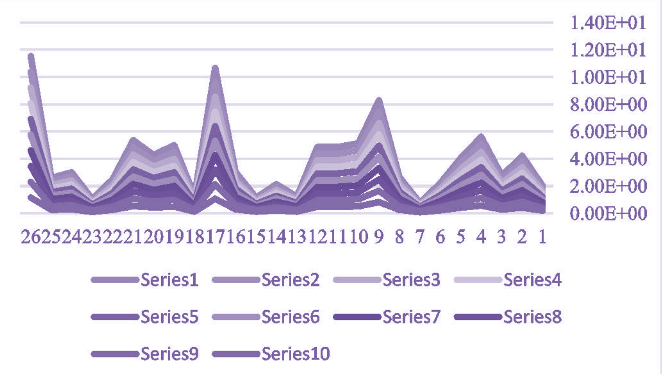


Figure 2. Effect of ƛ (0-1) on the ranking performance of WASPAS method for 26 IMAI [This study]

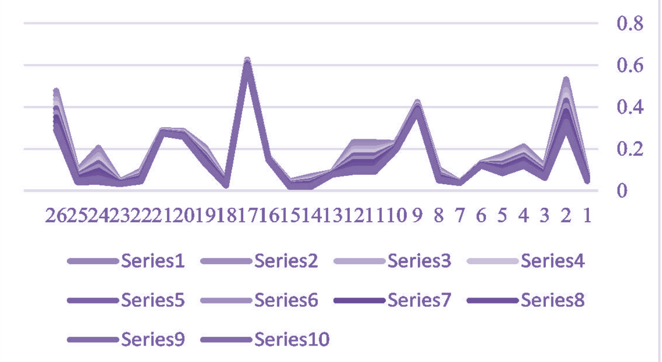


Figure 3. Effect of ƛ (0-1) on the ranking performance of WASPAS method for 26 IMAI [This study]

In the sensitivity analysis, the value of ƛ=0 only plays a role in emerging the starting point. That is why it was ignored to be assumed by the current study. The ƛ containing an interval value of 0-1 means that in the value of 0, WASPAS technique is changed from a weighted product model towards the weighted sum model (at ƛ=1). As we know that WASPAS method is a summation of both WPM and the WSM. The weighing system based on the Entropy Shannon has presented a linear approach in comparison with the weighing system based on the Friedman test. The distribution pattern for both figures (2 and 3) is constant and according to the ranking system developed. Chakraborty and Zavadskas[12] assessed the application of WASPAS practice to remove the difficulties experienced in 8 manufacturing plants. The obtained results proved that WASPAS method as a dominant weighing system with enough precision and accuracy. By the way, the fluctuations in ranking system conducted by ƛ depicted using some flow diagrams. Stojic et al [16]studied the supplier selection circumstances via WASPAS method in a PVC manufacturing plant. Also, it has been investigated the sensitivity and fluctuations in the values of ƛ. According to the results, the values of ƛ have been reported unaffected on the ranking system. A rise in the values of ƛ resulted in a rise in alternatives.The obtained results of figures were proved that better ranking performance of WASPAS technique was achieved by Entropy Shannon weighing system and it was approached to linear format for the data of around 26 IMAI. But according to real data and regardless to negative and positive criteria, the classification based on the Friedman test has appeared in full agreement from the highest value to the lowest one.

4.4. Economic aspect

The economic studies of industries need to figure out the expenses associated to requirements of industries such as required land and landscaping operations, equipment costs, input and output materials flow, energy consumption, number of employees, selling outlay, variable and total manufacturing costs and other costs. The equations 15 to 24 are used to the economic estimation of any industrial project before implementation of industries. According to the equations, the economic estimation needs total facilities inventory, input and output materials streams and all criteria discussed by current research [17]. Tables 6 and 7 present input materials introduced into IMAI and all available facilities of IMAI respectively.

$W = 0.75(\sum e)\times A$	W (electrical energy demand), e (total electrical energy employed in lines), A (area, m^2)	(15)
$C = 0.005\times P$	C (selling outlays), P (selling rate)	(16)
$V = p-((\sum)e + A' + F + Cf)$	V(value-added), A′(initial materials applied), F(maintenance), C_f(unforeseen outlays)	(17)
$\%V = V\times 100/p$	-	(18)
$Qp = V-((\sum)I + L + D + S)$	Q_p(revenue), I (insurance), L (expenditures of interest and fees), D (depreciation), S (salary)	(19)
$Cv = Cvd/Cp$	C_v(variable outlays of commodity unit), C_{vd}(variable project outlays), C_p (production capacity)	(20)
$Ph = Tf/Cv - Cs$	P_h (breakeven point), T_f(fixed manufacturing outlays), C_s (total fixed outlays)	(21)
$Cpi = Cvp + Cfp$	C_{pi} (selling outlay of commodity unit), C_{vp}(manufacturing outlays), C_{fp}(variable manufacturing outlays)	(22)
$Ai = Ts - Cpi$	A_i (annual revenue), T_s (total selling expenses)	(23)
$Vt = If / Ai$	V_t (time of return on investment) and I_f (fixed capital)	(24)

Table 6 Input materials introduced into IMAI [This study]

Industry	Initial materials
(1)	Bitumen 60/70 (61600t); Barrels of 220 l (60000 No); Cartons of 35 kg (34300 No); Raw oil (5400t)
(2)	Gypsum (180000t)
(3)	Powder (290t); Glazed powder (12t): Decal (15000 No); Dye (400 kg); Resin (5 kg); Filler resin (150 kg); Industrial chalk (31t); Pa ckaging carton (3.4t); Varnish; alcohol and rubber (120 kg); Refractory base (700 No)
(4)	Feldspat (144t); Kaolinite (72t); Fe_2O_3 (504t); Gray clay (4320t); Ordinary clay (7200t); Feldspar (1296t); SiO_2 (124t)
(5)	Clay (1365t); Feldspar (450t); Quartz(585t); Kaolin (324t); Glaze (195t); Dye (7.5t); Carton (153750t)
(6)	SiO_2 (666t); Sodium feldspat (99t); $CaCO_3$ (85t); Kaolin (142t); ZnO (99t); Potassium nitrate (71t); Boric acid (127t); Zirconium silicate (127t); boxes of 50 kg (28350 No)
(7)	Package chalk (440t); Dye (6t)
(8)	Kaolin with a grading of 0.1-10 micron (132t); SiO_2 (66t); Feldspat (83t); Dolomite (36.3t); Cartons (6000t); Industrial plaster (6t); Packaging nylon (1t); Balls of ballmill (4t); Glazed powder (36.5t)
(9)	Clay soil containing kaolinite, Monte Moriolonit, illite and chlorite with a grade of 1 -4 µ (38350t)
(10)	Bauxite with a melting point of 2050 °C, the hardness of 9 (8800t); fireclay (1100t); Kaolin with a melting point of 1750 °C (1100t); Cartons with dimensions of 47*23*23 cm^3 (380000 No)

(11)	Eligible clay (56700t)
(12)	Eligible clay (56700t)
(13)	Aggregate (141000t); Bitumens of 60/70 etc (6750t)
(14)	CaO (147000t); Packaging boxes (240000 No)
(15)	Orthopedic plaster, 106 -100 mesh, 88% $CaSO_4$ (110t); Ethyl cellulose, purity of 47 -48% (300 kg); Methyl cellulose (820 kg); Di-butyl phthalate, purity 99.5% (1700 l); Ethanol 80% (84.5t); Bandage fabric (1134000 m); Packaging boxes (110000 No); Plastic packaging (3300 kg); Packaging cartons (9200 No)
(16)	Basalt (2100t); AL foil (780000 m^2); Yarn, grade 10 (7.5 million tons); Vegetable oil (1400 L); Craft paper (4480.5 m^2)
(17)	SiO_2, 94-99% (2309t); $NaCO_3$, 58% Na_2O (877t); Feldspar (739t); Barium carbonate, purity 77% (162t); Dolomite with 20% MgO and 32% CaO (739t); Sodium sulfate containing Na_2O 43%, SO_3 55% (37t); Razorite, B_2O_3 45.5%, Na_2O 20% (457t); Cao 55% (231t); Coal (4.6t); Gasoline (51t); C_6H_5OH, 98% (202t); Parapharmaldehyd (208t); Barite (30t); H_2SO_4 (500 kg); Urea (260t); $AlSO_4$ powder (40t); Resin additives (20t); NH_3 solution (200t); Bitumen (650t); Craft paper, thickness of 0.2 mm (2381 m^2); Cover (3400 m^2); Plastic bags (556000 No)
(18)	Stone (19800t); PE bags (360000 No)
(19)	Portland cement (31500t); Sand (7350000 kg); Hard steel, d= 7 mm (4500000 kg)
(20)	Gypsum, mesh of 200 (22.5t); Plastic straps, W=16 mm (445500 m)
(21)	Wood (4667t); Portland cement (12554t); Chemical materials (790t); Grease (5.3t)
(22)	Stone powder (1875t); Paper sheets (11t); Timbers (120 m^3)
(23)	Magnesite (91t); SiO2 (52t); Corundum (122t); Polyester gum (48t); Pumice (27t); White cement (72t); Foundation cement (72t); Cl2 and Mg (72t)
(24)	Stone and aggregates (250000 t)
(25)	Ore (104200t)
(26)	Portland cement type 1 (29176.2t); Asbestous (5042.6t)

Table 7. All available facilities of IMAI [This study]

Industry	Facilities
(1)	Compressor or centrifuge (capacity of 22 m^3/min) (2 No); Aeration tower (45t, Cs, thickness of 5 mm) (1 No); Bitumen conveyor pump, 17 Atm (2 No); Condenser with capacity of 85 m^3/min (V=3m^3) (1 No); Storage tank (70t) (4 No); Flame (3 Hp) (7 No); Kiln (2*2*3 m^3) (1 No); Fitted lab (1 unit); Repair shop (1 unit)
(2)	The whole machines of the assembly line with a capacity of 75 tons per hour include crusher – furnace- miller - silo - hopper and feeder - spiral - fuel tank –Elevator (1 No)
(3)	Ball mill (2 No); Blancher (6 No); A glazed mixer (1 No); Dryer in the size of 2*2*2 m^3 (1 No); Slurry pumps (2 No); Baking furnace (6 No); Sieving with meshes of 120 and 280 (2 No)
(4)	Ball mill, 500 kg (2 No); Feeding and weighing machine (1 No); Mixer, 1 ton (6 No); Spray dye machine (1 No); Silo (1 No); Diaphragm pump (5 No); Glazed ball mill, 50 kg (12 No); Press (2 No); Dryer machine (2 No); Glazing machine (2 No); Printing machine (4 No); Transportation wagons (25 No); Furnace, L= 90 m (1 No); Inspection and quality control line (1 No); Facilities and equipment unit (1 No)
(5)	Hammer miller, 8 tons, 150 rpm (1 No); Silo, 12 tons (1 No); Initial materials ball mill, 12 tons (1 No); Spray dye machine, 8 tons, 110 ℃ (1 No); Press, 600 tons (2 No); Furnace (dryer), 200 m^3 (1 No); Glazed band (1 No); Glazed ball mill, 2 tons (2 No); Furnace 1130 ℃ (1 No); Sorting and packaging (1 No); Wagon, 8 m^3 (20 No); Transmission lines and conveyor belts (1 No)
(6)	Mixer 1.5 ton/h (1 No); Rotary furnace, 0.5 ton/24h (2 No); Cauldron, 500 kg (4 No); Dryer in size of 2*2*2 m^3 (2 No); Water tank, 2 tons (2 No); Derrick, 2 tons (1 No); Iron rail, 50 m (1 No)

(7)	Mixer 1500 (1 No); Heater, in size of 250*150*200 cm ^{3} (3 No); Conveyor, 10 m (1 No); Frame in size of 145*50*8 cm^3 (5 No); Tray in size of 60*50*2 cm^3 (600 No); Wagon (4 No)
(8)	Glazed ball mill, 500 L, 4 kW (2 No); Mixer, 4 tons, 20 kW (1 No); Blancher, 4 tons, 4 kw (1 No); Vibration sieve, 0.5 kw (1 No); Dye spray, 1000 kg, 4 kW (1 No); Miller, 5 tons, 35 kW (1 No); Press and frame machines, 16 kW (1 No); Dryer, 10 kW (1 No); Glaze furnace, 1 ton (1 No); Biscuit furnace, 1.5 tons (1 No); Caldron, 500 tons (1 No); Wagon with drill (44 No); Conveyor, in size of 6*0.5 cm^2, 2 kW (2 No); Elevator, in sizes of 2*2 m^2 and 4 kW (1 No).
(9)	Silo, 4 m^3/h, L= 6 m (2 No); Crushing machine, roller withd and W =0.8 m, 65 m^3/h (1 No); Two-axis mixer, 30-40 m^3/h, Medium silo, 3.2 -33 m^3/h (1 No); Extruder, 30 bar (1 No); Automatic cutting, 8000 frame/h (1 No); Tunnel dryer, 15500000 kj/h (1 No); Tunnel furnace, L=1500000 m, 54 rooms (1 No); Rubber conveyor, 2.2 kW (4 No); Steel conveyor, 3 kw (4 No); Grinding machine, 0.17 kW (1 No); Roller machine, 220/170 rpm, 28 m^3/h.
(10)	Silo, 50 m^3 (1 No); Elevator, 3 tons/h, L= 5 m (1 No); Mixer, 30-40 m^3/h (2 No); Air hammer (2 No); Hydraulic press, 2000 tons (2 No); Furnace, 1400 ℃ (1 No); Vibration sieve (1 No); Compressor, 4-1000 L/h (1 No); Conveyor, 2.5 tons/h (5 No); Material silo, 10 m^3 (2 No); Elevator, 600 kg/h (2 No); Fitted lab (1 unit)
(11)	Box feeder, 3 m^3, 30 m^3/h (1 No); Conveyor, L and W= 15 m and 60 cm, 1.3 m/s (1 series); Initial mixer, 25 tons/h (1 No); Two -axis mixer, 25 tons/h (1 No); Roller mill, d and L=900 and 650 mm (1 No); Two-axis extruder (1 No); Cutter, 20 units (1 No); Wetted clay carrying pallet (1 series); Furnace ventilator, 30 kw (2 No); Power panels (1 series); Trans and dryer (1 and 1 No)
(12)	Feeder box, 3 m^3 (1 No); Rubber conveyor, W= 60 cm (1 series); Initial mixer, 25 tons/h (1 No); Two-axis mixer, 25 tons/h (1 No); Roller mill, D and L= 900 and 650 mm (1 No); Two-axis extruder (1 No); Cutter, 20 units (1 No); Wetted clay carriage pallet (1 series); Furnace ventilator, 30 kw (2 No); Power panels (1 series)
(13)	A complete set up to 80 tons capacity per hour, including cold storage silos, conveyors, dryers, drippers, vertical elevators, silos, and aggregates (1 unit);Crusher mill, 80 tons/h, 75 hp, 640 rpm (1 No); Bitumen tanks, 50000 L (1 No); Plumbing facilities (1 series); Weighbridge (1 No)
(14)	Hopper Crusher, 40 m^3 (1 No); Shatonic feeder, 80 tons/h (1 No); Jaw crusher, 77 tons/h (1 No); Conveyor (1 No); Sieve, A= 6 m ^{2} (1 No); Feeder, 20 tons/h (2 No); Rotary vertical furnace, 250 tons/h (1 No); Steel silos, 250 tons (2 No); Elevator, 30 tons/h (1 No); Hammer crusher, 40 tons/h (1 No); Elevator, 30 tons/h (2 No); Hydrator, 40 tons/h (1 No); Separator, 40 tons/h (1 No); Lime silo, 250 tons (2 No); Packaging machine, 10 tons/h (1 No); Boiler (1 No)
(15)	Various plastic frames (1 series); Mixer, 50 L (4 No); Automatic spray device (4 No); Semi-automatic cutting machine (2 No); Hot air tunnel (1 No); Plastic injection machine, 220, 510 and 280 g, 17 and 18 kW (1, 1 and 1 No); Conveyor system (2 No); Assembling table (4 No)
(16)	Stone crusher, 2 tons/h, 1.5 kW (1 No); Conveyor, L= 10 m, 3 tons/h, 1.25 kW (4 No); Sieve, 6 kW (1 No); Furnace, 152 kW, 15 m ^{3}/d (1 No); Blanket producer machine, 9 kW (1 No); Panel (1 No); Suction equipment (1 No); Fitted lab and repair workshop (1 and 1 unit)
(17)	Silo, V= 20 and 8 m^3 (1 and 9 No); Rubber conveyor, L= 15 m and W= 50 cm (4 No); Feed tunnel, in size of 3*3 m^2 (1 No); Weighbridge, 5 tons (1 No); Mixer, 10 m ^{3}, 3 kW (1 No); Glass melting furnace, 25 tons/d (1 No); Fiber maker machine, 20 tons/d (1 No); Thermal tunnel, 30 m (1 No); Automatic Guillotine, W= 1.5 m (1 No); Rolling machine, W= 1.5 m, 3 kW (1 No); Compressor, 4 and 6 bar, 3000 and 1920 m ^{3}/h, 55 and 3 kW (1 and 1 No); Compressor, 0.6 bar, 1400 m^3/h, 55 kW (2 No); Feeding silo, 10 m^3 (1 No); Reactor, 18 m^3 (1 No); Tank of 25 m^3, steel (1 No); Storage tank of 3, 0.5 and 25 m^3 (individually 1 No)

(18)	Feeder, 8 tons/h, 6 kW (1 No); Jaw machine, 65 kW (1 No); Crusher, 65 kW (1 No); Mill, 35 kW (1 No); Sieve, L= 9 m, 10 kW (1 No); Powder Machine, 50 kg (1 No); Conveyor, L= 20 m, W= 60 cm (3 No); Weighbridge, 100 kg (2 No); Sewing machine, 15 kW (1 No)
(19)	Universal testing machine (1 No); Concrete testi ng machine (1 No); Concrete sieve, 500 L (1 No); Rotating Machine Abrasion Test (1 No); Balance, 20 g (1 No); Electrical furnace, 1 ton (1 No)
(20)	Silo, 85 tons, H and d =11 and 3 m (1 No); Weighbridge, 750 kg (2 No); Water volumeter, 600 L (2 No); Mixer , 3 kW, 3 kg (2 No); Block manufacturing machine (2 No); Derrick, 4 tons (3 No); Tunnel dryer, 6*50 m^2, 38 wagons containing 150 °C (1 No); Wagons 2.5*2.5 m^2 (48 No); Fitted lab (1 unit)
(21)	Grinder, 2 tons/h (1 No); Hammer mill, 1.5 tons/h (2 No); Two-storeys sieve, 2 tons/h (1 No); Silo, 2 tons/h (1 No); Steel silo, 50 m^3 (1 No); Storage tanks of chemical materials, 250 kg (2 No); Mixer, 8 tons/h (2 No); Press machine, 8 m^3/h (1 No); Tunnel for rising strength of product, 50 m^3/5-6 h (1 No); Air ch annel, 35 m^3 (1 No); Buffing machine, L and W= 1.3 and 4 m (1 No)
(22)	Derrick, 40 tons (1 No); Blade machine containing 32 blades (1 No); Polishing machine (1 No); Various stone cutters (4 No); Conveyors (3 No); Brachial derrick (1 No); Packaging machine (1 No)
(23)	Silo, 20 tons (8 No); Feeder, 2 kW (2 No); Conveyor (1 No); Slurry blancher, 5.5 kW, 2 tons/h (1 No); Humidity machine, 7 kW, 2 tons/h (1 No); Hydraulic press, 5.5 kW (1 No); Press mold (4 No); Dryer, 3 m^3 (1 No); Weighbridge, 350 kg (1 No)
(24)	Silo, 15 m^3 (1 No); Feeder, 7.5 (1 No); Three storeys sieve, 7.5 m^3 (1 No); Spiral sand brush, 5-80 tons/h (1 No); Hammer crusher (1 No); Secondary sieve, three storeys, 60 m^2, 10-60 tons/h (1 No); Conveyor (1 No)
(25)	Jaw crusher, 70 tons/h (1 No); Hammer crusher with 24 hammers (2 No); Cyclone as particle separator (2 No); Conveyor containing gearbox, L= 50 m (7 No); Silo (5 No); Suction machine, 40 kW (1 No); Ballmill as vibrator and 10 tons/h (3 No)
(26)	Steel cement silo, 70 m^3 (1 No); Cement distributer, capacity of 570 kg (1 No); Asbestos discharge chamber, 2900 m^3/h; Ston miller, 500 kg (1 No); Wet asbestos silo, 2.5 t, 7.5 kW (1 No); Asbestos transfer and weighing, capacity of around 1500 kg, 4 kW (1 No) ; Batting system, 350 kg (1 No); Steel mixing tank, 4 m^3, 1.5 kW (1 No); Feeder 14 m^3, 5.5 kW (1 No); Water reuse system, 1000 m^3 (1 No); System control, 600 kg (1 No); Distillation facilities including 2 vacuum pumps of 1550 m^3; Centrifuge pump to supply water for pipe making machine (1 No); Hot and humid air supply unit, 3500 kg (1 No); Water supply pump (1 No); Pipe joints and fittings and cutting machine, 20, 10 and 5.5 tons (1, 1 and 1 No); Hydraulic pump station (1 No); Pipe cutting machine, 1200 kg (1 No); Various frames maker machine (1 No); Compressor (1 No)
L=Length, d=Diameter, H= Height, W=Width	

5. CONCLUSIONS

The major achievements of present research get back to development plans in IMAI such as developing industrial ecology, approaching sustainable development and technology development in parallel with the move towards industry 4.0. According to recent studies, there is no similar research published across all Iranian mining and aggregate industries to cover energy demand and materials streams. Thus, it is concluded that:

1-The flow diagram of industries plays the main role to introduce the existing processes and needs to any change, expansion and evolution in the future.

2- It was indispensable that offer an appropriate database to manage and handle the difficulties raised in the developing industrial ecology. Therefore, this data can be used in this regard.

3-The energy, materials and facilities management in the framework of a valuable database will expand the further achievements in industry 4.0 discussions.

4-The simplicity in depiction the spectrum of growth and economic estimation along with data envelopment analysis can be mentioned as other achievements in this regards.

5-The validity of Friedman test in weighing criteria and its valuable response in the ranking system with WASPAS method as well as the suitable classification developed using Entropy Shannon weighing method for IMAI.

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