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Evaluation and Optimization of Suppliers in Sponge Iron Industries in Chhattisgarh

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ABSTRACT

In the present paper, we have selected the sponge iron industry in Chhattisgarh which uses iron – ore as the main raw material for the purpose of analysis of the iron-ore suppliers, Six important criteria have been considered and four suppliers are taken into account. In this paper MCDM (MultiCriteria decision making) is used for determining order preference with the help of the parameter related to Supplier selection. MCDM refers to making decisions in the presence of multiple, usually conflicting criteria. These criteria are compared using AHP and their weights are found. Using these weights, Topsis is applied to find the ranking of the suppliers and to choose the best among them. Result shows supplier S3 is best alternative supplier.

1. Introduction

Supplier selection is one of the most important decision in today's business because in has a long lasting effect on the future of the business. It becomes difficult when they are in the vicinity of the working area. In the field of sponge iron production, the manufacturers take intuitive decision just to keep the plant operational but a little scientific approach could make their decision more effective. A supply chain (SC) is also a network of facilities and distribution options that functions to procure materials, transform these materials into intermediate and finished products, and distribute these finished products to customers. Supply chains exist in both service and manufacturing organizations, although the complexity of the chain may vary greatly from industry to industry and firm to firm.[1] Realistic supply chains have multiple end products with shared components, facilities and capacities. The flow of materials is not always along an arbores cent network; various modes of transportation may be considered, and the bill of materials for the end items may be both deep and large.. These organizations have their own objectives and they are often conflicting.

Tam, M. C., et al. developed a web-based AHP system to evaluate the casting suppliers with respect to 18 criteria. In the system, suppliers had to register, and then input their casting specifications.[2] Muralidharan et al. proposed a five-step AHP-based model to aid decision makers in rating and selecting suppliers with respect to nine evaluating criteria.[3] Chan developed an interactive selection model with AHP to facilitate decision makers in selecting suppliers.[4] The model was so-called because it incorporated a method called chain of interaction, which was deployed to determine the relative importance of evaluating criteria without subjective human judgment. AHP was only applied to generate the overall score for alternative suppliers based on the relative importance ratings. Chan and Chan applied AHP to evaluate and select suppliers. The AHP hierarchy consists of six evaluating criteria and 20 sub-factors, of which the relative importance ratings were computed based on the customer requirements. Liu and Hai applied AHP to evaluate and select suppliers. Similar to Chan, the authors did not apply the AHP's pairwise comparison to determine the relative importance ratings among the criteria and sub-factors. Instead, the authors used Noguchi's voting and ranking method, which allowed every manager to vote or to determine the order of criteria instead of the weights.[5] Sarkar and Mohapatra suggested that performance and capability were two major measures in the supplier evaluation and selection problem.. Xia and Wu incorporated AHP into the multi-objective mixed integer programming model for supplier selection.[6] Chan et al. developed an AHP-based decision making approach to solve the supplier selection problem. Potential suppliers were evaluated based on 14 criteria. A sensitivity analysis using Expert Choice was performed to examine the response of alternatives when the relative importance rating of each criterion was changed.[8] Florez-Lopez picked up 14 most important evaluating factors from 84 potential added-value attributes, which were based on the questionnaire response from US purchasing managers.[9] In this paper effort has been made to select the best supplier of iron- ore who could meet all the criteria and be beneficial to the sponge iron industries. Topsis method has been applied to get the best alternative among Supplier having different supplier selection parameters, after getting supplier order from Topsis, best alternative is found with respect parameters. Sponge iron industry has been taken for case study. Using Topsis method we found best alternative supplier.

2. Methodology

Step 1. Through Literature Review set the supplier selection criteria,

1. Delivery and Transportation(DE&T)
2. Quality(Q)

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3. Management (M)
4. Cost
5. Discipline (D)
6. Minimum order Quantity (MOQ)

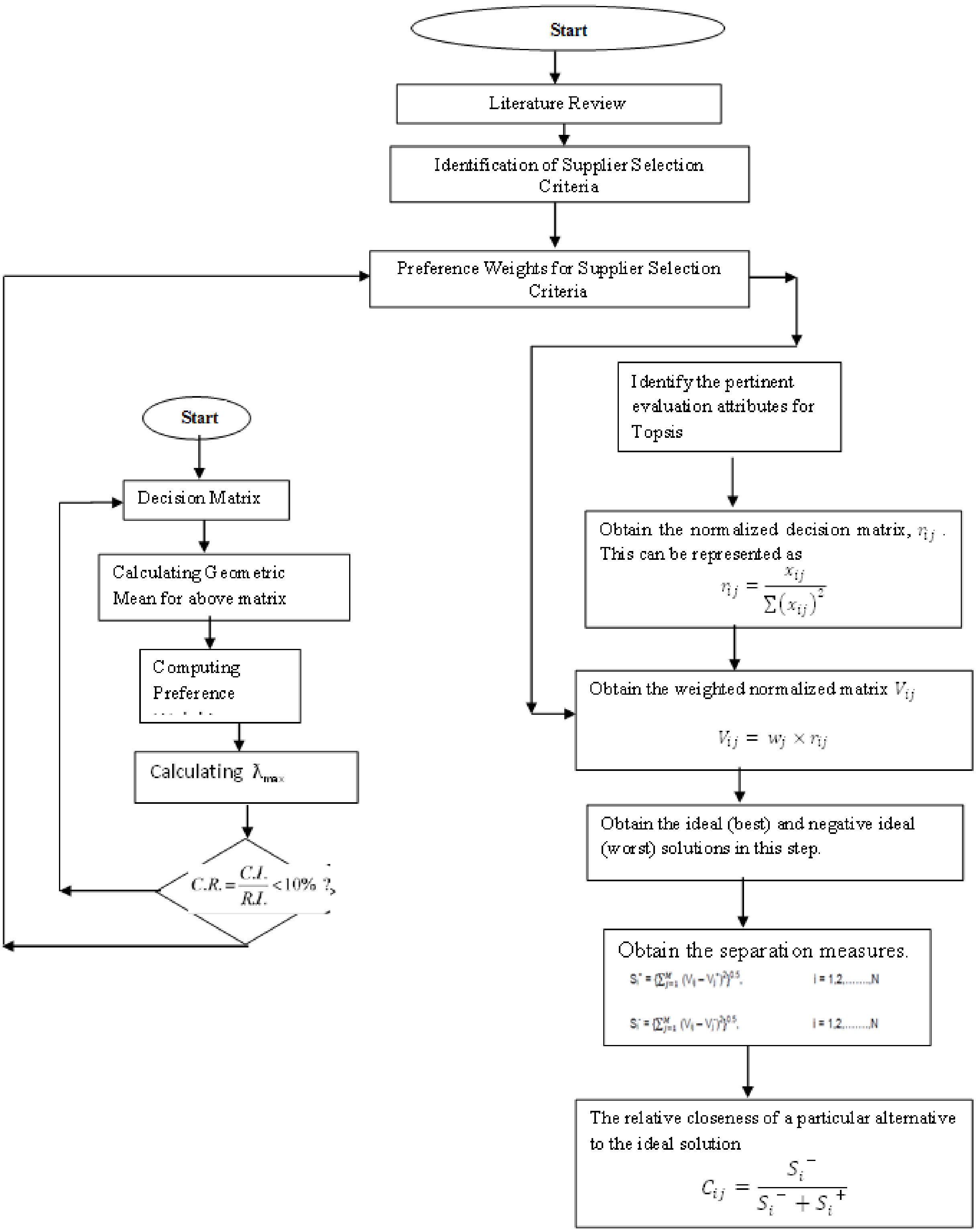

Fig.1. Detailed Methodology

Step 2. AHP Formulation

Calculate the product of every line of the judgment matrix elements M_i :

$$M_i = \prod_{j=1}^{n} x_{ij}, i, j = 1,2,\cdots n \quad (1)$$

$$\overline{W_i} = \sqrt[n]{M_i} \quad (2)$$

$$W_i = \overline{W_i} \Big/ \sum_{j=1}^{n} \overline{W_j} \quad (3)$$

Step 3. Then calculate the consistency ratio CR= CI/RI.

Step 4: Construct the normalized decision matrix**.**This step converts the various attribute dimensions into non dimensional attributes. An element rij of the normalized decision matrix R is calculated as follows:

$$r_{ij} = \frac{x_{ij}}{\Sigma(x_{ij})^2} \quad (4)$$

Step 5: Calculate the weighted normalized decision matrix (V).The weighted normalized value vij is calculated as:

Vij=wjrij , i=1,2,….m;j=1,2,….n (5)

Where $V=\left[v_{ij}\right]_{m\times n}$

Step 6: Identify the positive ideal solution and negative ideal solution.

Vij=wjrij , i=1,2,….m;j=1,2,….n (6)

Where $V=\left[v_{ij}\right]_{m\times n}$

Step 7: Calculate the separation measure. In this step the concept of the n-dimensional Euclidean distance is used to measure the separation distances of each alternative to the ideal solution and negative-ideal solution. The corresponding formulas are

The separation from the positive ideal alternative is:

S* = [S (vj*– vij)2] ½ (7)

Similarly, the separation from the negative ideal alternative is:

Si' = [S (vj'– vij)2] ½ (8)

Step 8: Calculate the relative closeness to the ideal solution. The relative closeness of the alternative Ai with respect to A* is defines as:

Ci* = S'i / (Si* +S'i) (9)

Step 9: Rank the preference order. Choose an alternative with maximum Ci* or rank alternatives according to Ci* in descending order.

3. Result

3.1 AHP Method is used to Determine the Weights of the Attributes and Prepared the following Matrix:

	Delivery and Transportation (DE&T)	Quality(Q)	Management (M)	Cost	Discipline (D)	Minimum order Quantity
Delivery and Transportation(DE&T)	1.00	2.00	6.00	0.33	5.00	1.00
Quality(Q)	0.50	1.00	4.50	1.50	4.50	1.00
Management (M)	0.17	0.23	1.00	0.20	2.00	0.50
Cost	3.00	0.67	5.00	1.00	3.00	5.00
Discipline (D)	0.20	0.23	0.50	0.33	1.00	0.50
Minimum order Quantity(MOQ)	1.00	1.00	2.00	0.20	2.00	1.00

So, now calculating the geometric means we get,

$$\overline{W_i} = \begin{pmatrix} 1.6475 \\ 1.5737 \\ 0.4441 \\ 2.3070 \\ 0.3956 \\ 0.9635 \end{pmatrix}$$

Now, let us calculate the weights of the parameters;

$$W=\begin{pmatrix}0.22\\0.21\\0.06\\0.31\\0.05\\0.13\end{pmatrix}$$

Now, λmax= 6.51

CI = (6.51 – 6)/(6 – 1) = 0.10

Now, since CR is less than 0.1, so whatever matrix A1, have been decided, is correct i.e. there is good consistency in the judgements made. Also, there is no contradiction in the judgements.

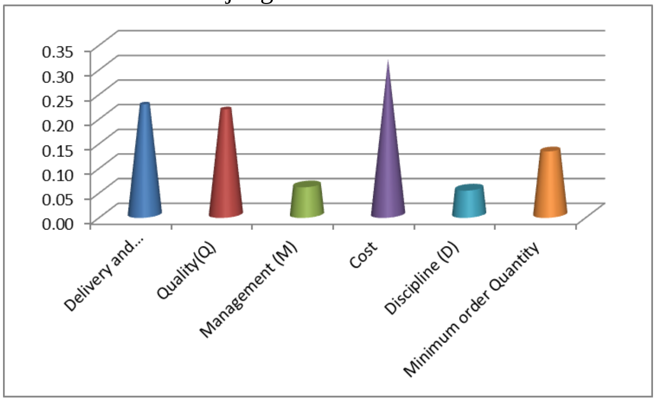

Fig. 2 Aggregate importance weights of the criteria for decision matrix.

3.2 Ranking of Criteria Using Topsis

1. Identify the pertinent evaluation attributes.

Weight	0.22	0.21	0.06	0.05	0.13	0.31
	Delivery(DE) and Transportation	Quality(Q)	Management (M)	Discipline (D)	Minimum order Quantity	Cost
S1	9	6	8	8	10	6
S2	7	9	7	7	0	9
S3	8	8	9	9	9	8
S4	8	7	8	8	8	8

Step 1(a): calculate $(\Sigma x^2_{ij})^{1/2}$ for each column

S1	81	36	64	64	100	36
S2	49	81	49	49	0	81
S3	64	64	81	81	64	64
S4	64	49	64	64	81	64

$\Sigma x_{ij}^{2}{}_{i}$	258	230	258	258	245	262
$(\Sigma x^2)^{1/2}$	16.06	15.17	16.06	16.06	15.65	16.19

Step 1 (b): divide each column by (Sx2ij)1/2 to get rij

S1	0.560398506	0.395517469	0.498132005	0.498132005	0.63897764	0.3705991
S2	0.435865504	0.593276203	0.435865504	0.435865504	0	0.5558987
S3	0.498132005	0.527356625	0.560398506	0.560398506	0.57507987	0.4941322
S4	0.498132005	0.461437047	0.498132005	0.498132005	0.51118211	0.4941322

Step 2 (a): multiply each column by wj to get vij.

S1	0.123288	0.083058668	0.029888	0.064757	0.198083	0.01853
S2	0.09589	0.124588003	0.026152	0.056663	0	0.027795
S3	0.109589	0.110744891	0.033624	0.072852	0.178275	0.024707
S4	0.109589	0.09690178	0.029888	0.064757	0.158466	0.024707

Step 3 (a): determine ideal solution A*.

A* = {0.123288, 0.124588003, 0.033624, 0.072852, 0.198083, 0.01853}

S1	0.000000	-0.041529	-0.003736	-0.008095	0.000000	-0.009265
S2	-0.027398	0.000000	-0.007472	-0.016189	-0.198083	0.000000
S3	-0.013699	-0.013843	0.000000	0.000000	-0.019808	-0.003088
S4	-0.013699	-0.027686	-0.003736	-0.008095	-0.039617	-0.003088

Step 3 (b): find negative ideal solution A'.

A' = {0.09589, 0.083058668, 0.026152, 0.056663, 0, 0.024707}

S1	0.027398	0.000000	0.003736	0.008094	0.198083	0.00000
S2	0.000000	0.041529	0.000000	0.000000	0.000000	0.00926
S3	0.013699	0.027686	0.007472	0.016189	0.178275	0.00618
S4	0.013699	0.013843	0.003736	0.008094	0.158466	0.00618

Step 4 (a): determine separation from ideal solution A* = {0.059, 0.244, 0.162, 0.080}

Si* = [S (vj*– vij)2] ½ for each row

S1	0.000000	0.001725	0.000014	0.000066	0.000000	0.000086
S2	0.000751	0.000000	0.000056	0.000262	0.039237	0.000000
S3	0.000188	0.000192	0.000000	0.000000	0.000392	0.000010
S4	0.000188	0.000767	0.000014	0.000066	0.001569	0.000010

Step 4 (b): determine separation from ideal solution Si*

	$\Sigma(v_j^*-v_{ij})^2$	$S_i^* = [\Sigma(v_j^*-v_{ij})^2]^{½}$
S1	0.001890	0.04347426
S2	0.040305	0.20076213
S3	0.000781	0.02794991
S4	0.002613	0.05111440

Step 4 (c): find separation from negative ideal solution

A' = {0.040, 0.164, 0.144, 0.118}

Si' = [S (vj'– vij)2] ½ for each row

S1	0.000751	0.000000	0.000014	0.000066	0.039237	0.000000
S2	0.000000	0.001725	0.000000	0.000000	0.000000	0.000086
S3	0.000188	0.000767	0.000056	0.000262	0.031782	0.000038
S4	0.000188	0.000192	0.000014	0.000066	0.025112	0.000038

Step 4 (d): determine separation from negative ideal solution Si'

$\Sigma(v_j'-v_{ij})^2$	$S_i' = [\Sigma(v_j'-v_{ij})^2]^{½}$
0.040067	0.20016745
0.001811	0.04255026
0.033092	0.18191245
0.025609	0.16002667

Step 5: Calculate the relative closeness to the ideal solution Ci* = S'i / (Si* +S'i)

C_i^*
0.821565
0.174879
0.866818
0.757914

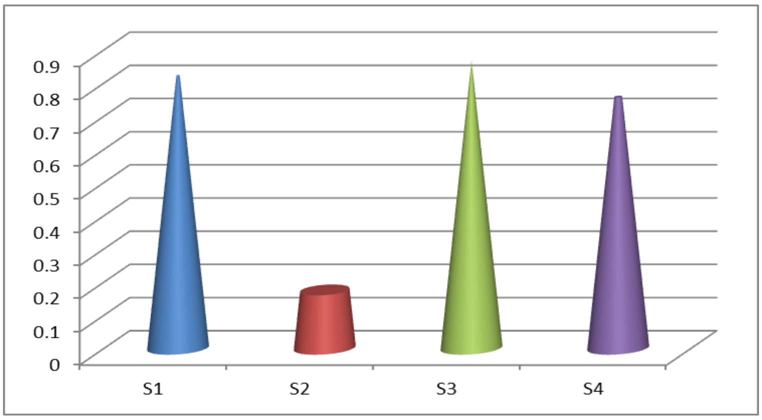

Fig. 3 relative closeness to the ideal solution

4. Conclusion

Thus, it is vivid from the result that cost is the major criteria over the alternatives considered followed by delivery & transportation. Quality is the third factor since there is not a major difference in the material. Using Topsis, found out that supplier S3 is the best alternative who meets all the criteria efficiently.

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