The Influence of GRA and TOPSIS for Assortment of Green Supply Chain Management Strategies in Cement Industry

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Abstract- **The present paper aimed at proposing new strategies for evaluating the green supply chain management for enhancing the priority to environmental factors in cement manufacturing life cycle analysis, there by reducing the carbon foot prints. These strategies help in producing eco-friendly products there striking the balance between economy and environment. Initially green supply chain priorities are defined by using grey relational analysis (GRA). The priority weights obtained by GRA method is used to determine the weight for each indicator selected in the present study and then GRA is combined with TOPSIS methodology to obtain the priority for level-II measurement indicators used in the present study. These strategies will influence the decision making priorities during cement manufacturing.**

Keywords- Green Supply Chain Management (GSCM), strategy prioritization, Grey Relational Analysis (GRA), TOPSIS, Life Cycle Analysis (LCA).

1. Introduction

Nowadays, among various supply chain-related activities, the procurement of goods and services is playing vital role as a result of the globalization of the economy. Purchasing expenses towards material procurement can consume as much as 60% or more of 'business' revenues.

In the area of manufacturing arena, supplier selection is a crucial strategic decision that has long-term impacts on a company's profitability and efficiency [1], [2].The present research paper aimed at using GRA and TOPSIS methodologies to develop the green supply chain strategies for cement industry to improve the profitability and efficiency. Based on the priority weights obtained using grey relational analysis(GRA) and technique for order preference similar to ideal solution (TOPSIS) methodologies, the life cycle of the cement manufacturing is designed with the cement manufacturing and distribution [3], [4], [5].

1.1 Case study

The current research study is aimed at cement manufacturing process. The cement industry is producing mainly three types of cements namely Ordinary Portland Cement (OPC), Portland Pozzalona Cement (PPC) and Portland Slag Cement (PSG). The PSG based cement is fly-ash based cement which produces least carbon emission rate compared to other cements. PSG based cement production helps in reducing carbon foot prints into the atmosphere during the life cycle because of the recycled raw materials like fly ash is used in PSG based cement manufacturing. The fly ash used here is the waste product from thermal power plant which reduces carbon footprints, helps in manufacturing energy efficient and environment friendly cement. To define the GSCM strategies for cement manufacturing four level-II measurement indicators i.e B1, B2, B3, B4, are defined which covers the entire life cycle of the cement manufacturing. The hierarchy structure is shown in Fig.1. with three levels [6], [7], [8].

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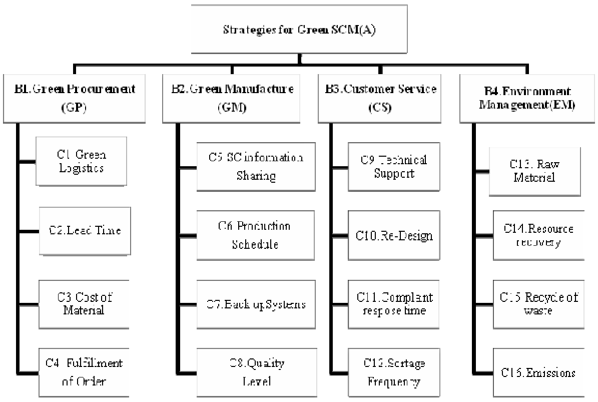

Fig.1. Strategiesfor green Supply Chain Measurement Indicators

The organization of the paper is done as follows Section 2 presents state of art of strategy prioritization/selection of problem using GRA.
Section 3 presents problem description and proposed TOPSIS approach.
Section 4 illustrates some of the experimental results.
Section 5 concludes the paper with some comparison of results obtained by using GRA and TOPSIS.

2. Prioritization of GSM strategies using GRA

2.1. Grey Relational Analysis (GRA)

The grey system theory was developed by Deng (1982), which has been widely used for data analysis in different areas [9, 10, and 11]. Grey Relational Analysis method is quite useful to determine the strategies with little data or uncertain information. Using GRA weights are obtained for level-II indicators as shown in Fig.1. Then we used the weights obtained by GRA for determining the strategies of GSCM strategies using TOPSIS methodologies. The steps involved in GRA are as follows.

Step 1.Determine the problem and generate the data in analytical sequence

$$X_o = (d_{o1}, d_{o2}, d_{o3}, d_{o4} \dots d_{om})$$

Where m is the number of respondents and X_o is reference data and m represents the responses favorable to the situation.

Step 2: Determine the comparison data related to the problem X_i and presented in Table 1.

$$X_i = (d_{i1}, d_{i2}, d_{i3}, d_{i4} \dots d_{im}) \text{ where}$$

i =1,… K and K is the size of the scale from 1 to 5. So the data series consists of m values with k comparisons.

Step 3: The difference of the data for series is calculated Δ_i and presented Table 2.

Step 4: Then obtain the Global maxima value Δ_{max} and Global minima value Δ_{min} difference for the series of data.

Table 1: Rank Allocation Criteria

	GP	GM	CS	EM
Indicators	**X1/ op1**	**X2/op2**	**X3/op3**	**X4/op4**
C1	2	4	3	2
C2	3	3	4	1
C3	2	4	2	4
C4	3	4	1	3
C5	3	3	3	4
C6	2	4	2	1
C7	3	3	1	2
C8	2	4	5	3
C9	3	4	1	3
C10	2	4	2	4
C11	3	3	2	1
C12	3	3	3	2
C13	3	3	4	3
C14	3	4	3	2
C15	2	3	2	1
C16	4	4	1	4

$$\Delta_i = (|d_{o1} - d_{i1}|, |d_{o2} - d_{i2}|, \dots, |d_{om} - d_{im}|)$$

$$\Delta_{max} = \forall_i^{max}(\max \Delta_i)$$

Table 2: The difference data Indicators

Indicators	GP Δ1/ OP1	GM Δ2/ OP2	CS Δ3/ OP3	EM Δ4/ OP4
C1	3	1	2	3
C2	2	2	1	4
C3	3	1	3	1
C4	2	1	4	2
C5	2	2	2	1
C6	3	1	3	4
C7	2	2	4	3
C8	3	1	0	2
C9	2	1	4	2
C10	3	1	3	1
C11	2	2	3	4
C12	2	2	2	3
C13	2	2	1	2
C14	2	1	2	3
C15	3	2	3	4
C16	1	1	4	1

$$\Delta_{min} = \forall_i^{min}(\min \Delta_i)$$

Step 5: The variation in the data is calculated for overall indicators of data and grey relational coefficient is established. Here, the grey relational coefficient $\gamma_i(j)$, indicates the difference of the j^{th} data series of i^{th} data point, then

$$\gamma_i(j) = \frac{\Delta min + \varsigma \Delta max}{\Delta i\,(j) + \varsigma \Delta max}$$

Where $\Delta_i(j)$ represents the j^{th} value in Δ_I in difference data series, ζ value lies between 0 and 1. The coefficient ζ is used to compensate the effect of Δ_{max} should be extreme value in the data series. In general the value of ζ can be set to 0.5.

Step 6: The grey relational coefficient is calculated for entire difference data series of dataset and Γ_i represents the grey relational grade for the i^{th} scale item and believed that the data point in the series are of the same weights. Then

$$\Gamma_i = \frac{1}{m}\sum_{n=1}^{m} \gamma i(n)$$

The magnitude Γi reveals the overall standardized deviance of i^{th} original data series from the base data series. Normally a developed item with higher values of Γ indicates higher degree of ranking by the experts on the specific item.

Step 7: Sort Γ values into either descending order or ascending order to facilitate the managerial interpretation of results.

3.0. TOPSIS Approach

The TOPSIS (Technique for Order Performance by similarity to Ideal Solution) is very much useful in determining the ranks [12, 13, 14].Using TOPSIS the best alternative would be the one that is nearest to the positive ideal solution (PIS) and farthest from the negative ideal solution (NIS). The PIS is a solution that maximizes the benefit criteria and minimizes the cost criteria and the NIS is vice versa. This paper combines TOPSIS with GRA to evaluate the strategies of green supply chain management [15, 16].

Table 3.a: Global Weight Priority Matrix

Indicators	GP	GM	CS	EM
C1	0.4	0.67	0.5	0.4
C2	0.5	0.5	0.67	0.34
C3	0.4	0.67	0.4	0.67
C4	0.5	0.67	0.34	0.5
C5	0.5	0.5	0.5	0.67
C6	0.4	0.67	0.4	0.34
C7	0.5	0.5	0.34	0.4
C8	0.4	0.67	1	0.5
C9	0.5	0.67	0.34	0.5

C10	0.4	0.67	0.4	0.67
C11	0.5	0.5	0.4	0.34
C12	0.5	0.5	0.5	0.4
C13	0.5	0.5	0.67	0.5
C14	0.5	0.67	0.5	0.4
C15	0.4	0.5	0.4	0.34
C16	0.67	0.67	0.34	0.67
AVG	**0.4856**	**0.57**	**0.41**	**0.477**

The priority weights obtained using GRA for is as follows.

Table 3.b Final weights table using GRA

SNO	**Name of the indicator**	**Weight obtained**
1	Green Purchasing(GP)	0.4856
2	Green manufacturing(GM)	057
3	Customer service(CS)	0.41
4	Environment management(EM)	0.477

3.1. TOPSIS Methodology

The TOPSIS approach is based on

- Qualitative attributes benefits
- Quantitative attributes benefits
- Cost attributes criteria

In TOPSIS methodology it's assumed that we have m alternatives (options) and n attributes, we have the score of each option with respect to each criterion

Step 1: Construct the normalized decision matrix a dn normalized scores are as follows $r_{ij} = X_{ij}/ (\Sigma x_{ij})^{½}$ for i = 1, …, m; j = 1, …, n and for each indicator weights are taken from experts for a scale of 10 scores are potred in the Table 4.

Step 2: Construct the weighted normalized decision matrix.

Obtain the weights Wj where j=1…n from GRA method and global weights (Wj) are calculated they are (48.56%,57%, 41%, 47.7%) for GP, GM , CS, EM respectively.

Then calculate the U_{ij}= Wj r_{ij}. The weights are calculated by using GRA and results are tabulated in Table 5.a and Table 5.b respectively.

Table 4: Weight Criteria Allocation for measurement Indicators

Indicators	**GP**	**GM**	**CS**	**EM**
C1	7	6	7	8
C2	6	7	6	7
C3	8	5	7	8
C4	6	7	6	8
C5	7	6	6	8
C6	8	7	7	8
C7	6	8	6	7
C8	7	7	7	8
C9	6	7	7	7
C10	6	8	7	8
C11	7	8	7	8
C12	5	7	6	7
C13	8	7	8	9
C14	7	7	8	7
C15	8	6	8	8
C16	7	6	8	8
($\sum X_{ij}^2$)	755	753	779	966
($\sum X_{ij}^2$)$^{1/2}$	**27.477**	**27.441**	**27.911**	**31.081**

Step 3: Determine the positive ideal and negative ideal solution from Table 5.a and 5.b.

Ideal solution P* = { U_1^*, …, U_n^*}, where

$$U_j^* = \{ \max (U_{ij}) \text{ if } j \in J ; \ \min (U_{ij}) \text{ if } j \in J' \}$$

The positive ideal solution is and

Negative Ideal solution

P' = { U_1', …,U_n' }, where

$U' = \{ \min (U_{ij}) \text{ if } j \in J ; \ \max (U_{ij}) \text{ if } j \in J' \}$

Step 4: Calculate separate measures for each alternative and results are presented in the Table 5.b

$$P_i^* = [\Sigma (U_j^* - U_{ij})^2]^{½} \quad i = 1, \ldots, m$$

There fore Positive Ideal Solution

$P_i^* = (0.141, 0.166, 0.118, 0.123)$

Similarly the separation from the negative ideal solution

$$P_i' = [\Sigma (U'_j - U_{ij})^2]^{½} \quad i = 1, \ldots, m \ i$$

There fore Negative Ideal Solution

$P'_i = (0.088, 0.125, 0.088, 0.046)$

Step 5: Calculate the relative closeness to the ideal solution C_i^* and tabulated in Table 6.

$$\mathbf{C_i^* = P_i' / (P_i^* + P_i'), \qquad 0 < C_i^* < 1}$$

Then select the option closeness to 1

4. Results:

The integrated GRA-TOPSIS method of present research study portrayed priority weights, ranks are obtained for various Green Supply chain Strategies, priority weight for Green manufacturing is shows 89%, priority weight for Green Purchasing shows 88% and results are tabulated in Table 6.

Table 5.a Calculation U_{ij} values

Weight(Wj)	**0.485**	**0.57**	**0.41**	**0.477**
Indicators	**GP**	**GM**	**CS**	**EM**
C1	0.255	0.219	0.251	0.257
C2	0.218	0.255	0.215	0.225
C3	0.291	0.182	0.251	0.257
C4	0.218	0.255	0.215	0.257
C5	0.255	0.219	0.215	0.257
C6	0.291	0.255	0.251	0.257
C7	0.218	0.292	0.215	0.225
C8	0.255	0.255	0.251	0.257
C9	0.218	0.255	0.251	0.225
C10	0.218	0.292	0.251	0.257
C11	0.255	0.292	0.251	0.257
C12	0.182	0.255	0.215	0.225
C13	0.291	0.255	0.287	0.290
C14	0.255	0.255	0.287	0.225
C15	0.291	0.219	0.287	0.257
C16	0.255	0.219	0.287	0.257

Table 5.b Determination of NIS and PIS

Indicators	**GP**	**GM**	**CS**	**EM**
C1	0.124	0.125	0.103	0.123
C2	0.106	0.145	0.088	0.107
C3	**0.141**	0.104	0.103	0.123
C4	0.106	0.145	0.088	0.123
C5	0.124	0.125	0.088	0.123
C6	0.141	0.145	0.103	0.046
C7	0.106	**0.166**	0.088	0.107
C8	0.124	0.145	0.103	0.123
C9	0.106	0.145	0.103	0.107
C10	0.106	0.166	0.103	0.123
C11	0.124	0.166	0.103	0.123
C12	**0.088**	0.145	0.088	0.107
C13	0.141	0.145	0.118	0.138
C14	0.124	0.145	0.118	0.107
C15	0.141	0.125	0.118	0.123
C16	0.124	0.125	0.118	0.123

Table 6: Final ranking strategy from GRA -TOPSIS approach

GSCM Strategy	Results from Positive Ideal Solution (1)	Results from Negative Ideal Solution (2)	Relative closeness Determination (3= 2/(1+2))	Rank (4)
GP	0.011086	0.085715	0.885472	**2**
GM	0.011209	0.099156	0.898435	**1**
CS	0.011335	0.033571	0.747584	**3**
EM	0.011463	0.02245	0.661979	**4**

5. Conclusions

The present paper aimed at enhancing the priority for environmental related activities in life cycle of Cement manufacturing. The results obtained in the study portrayed that the environmental priority will help in reducing the carbon foot prints in cement manufacturing supply chain. It is strongly recommended that if fly ash is used as primary raw material in cement manufacturing system, it will significantly reduce carbon foot prints and load on the environment. The ranking strategies obtained in the present research paper using GRA-TOPSIS also will help in making the life cycle of cement manufacturing more greener.

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