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An Integrated Method for the Quantity to be ordered to Supplier

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Abstract*:* Supplier selection is an essential task within the purchasing function. A well-selected set of suppliers makes a strategic deference to an organization's ability to reduce costs and improve the quality of its end products. This realization drives the search for new and better ways to evaluate and select suppliers. The correlated Analytic Hierarchy considers the correlation effect between criteria in the Analytic Hierarchy process. Linear physical programming(LPP) is a multi - objective opti mization method that develops an aggregate objective function of the criteria in a piecewise, goal - programming fashion. In order to think about multiple criteria LPP model allows decision maker (i.e., cost, customer service, and rejections) and to express criteria preferences in terms of degrees of desirability. This paper highlights an integrated method for dealing with such problems using correlated Analytic Hierarchy and linear physical programming techniques. The proposed method demonstrates selection of appropriate suppliers and allocates orders optimally among them

This paper proposes an integrated method for dealing with such problems using correlated Analytic Hierarchy– and linear physical programming techniques. The method proposed demonstrates selection of appropriate suppliers and allocates orders optimally among them finally model calculation is presented.

Index Terms - Correlated AHP ,linear physical programming, supplier selection, order allocation

1. INTRODUCTION

Today, organizations that wish to sustain growing path requires a robust strategic performance measurement and evaluation system . one of the important function of the purchasing decision makers is Supplier selection with order allocation, which determines the long - term viability of the company a good supplier selection makes a significant difference to an organization's future to reduce operational costs and improve the quality of its end products. in addition to this selling the product in a right market is equally important . hence in supply chain the transport of goods movement plays vital role. generally companies either on their own transport material with their fleet or through logistic suppliers. selection of right logistic supplier impacts the performance of the compa ny as it involves time, money, customer preference. Competitive advantage stems from the many discrete activities a company performs in designing, producing, marketing, delivering, and supporting its products.

The objective of the study includes Identifying the criteria for supplier selection Study of the factors whether they influence each other to find the correlation matrix between the criteria To find the weights considering the correlation by multi objective programming. To find the relative weight age factors to find the scores among the suppliers using AHP the quantity to be ordered on each supplier using linear physical programming.

2. LITERATURE SURVEY

There are comprehensive literature reviews performed for supplier selection application by Dickson [5], Weber et al. [6], De Boer et al. [7] and Sanayei et al. [8]. Ayhan [9]. Dickson"s [4] stated 23 creteria for supplier selection.

Cheraghi et al. [10] updated Dickson"s criteria with 13 more . As a brief of all criteria price, quality, and delivery performances are found as the most significant selection criteria s. various multi criteria decision making methods are put into practice , which can be catagorised broadly into into three

1) Value Models: AHP and multi attribute utility theory (MAUT) fall in this group.
2) Goal, Models: Goal programming , TOPSIS.VIKOR belong to the group.
3) Outranking Methods: PROMETHEE and ELECTRE etc belong to this group.to the group. 3) Outranking Methods: PROMETHEE and ELECTRE etc belong to this group. Decision Support System for Supplier Selection Using an Integrated Analytic Hierarchy Process and Linear Programming. Kilic,[12] suggested anAn integrated approach for supplier selection in multi item/multi supplier environment .Xia, W. and Wu, Z., [13] consider Supplier selection with multiple criteria in volume discount environments Opening hierarchy system. Yahya and Kingsman [14] used AHP to control priorities in selecting suppliers. Eventually Analytic Network Process (ANP) is also a multi attribute approach for decision making that allows the transformation of qualitative values to quantitative ones. AHP is a special case of ANP,The area of disassembly as a part of supply chain optimization has been the interest of many researchers. The recent book by Lambert and Gupta [15] presented the importance of the area of disassembly. Gungor and Gupta

[16] cited a comprehensive study of the product recovery in manufacturing industry .. Kongar and Gupta [17] presented a multi-criteria decision making approach where the objective was to find the best combination of EOL products. Imtanavanich and Gupta [18] modeled the supply chain problem with stochastic yields using multi-criteria decision making approach LPP technique is used in solving the supply chain problem by Imtanavanich and Gupta [19]. Massoud and Gupta [20] considered the multi-period order problem .Kongar and Gupta [21] focused for EOL electronic products and proposed a LPP model taking into account environmental, performance and financial goals

3. METHODOLOGY

The study is done in three phases for supplier selection. Before proceeding to various phases the various factors for supplier selection is considered in the phase one the inter relation ship among factors is considered. In the second phase the weights among the factors considered. In the third phase linear physical programming is considered.

Mathematical model: In this paper, The supplier selection is followed by a process depicted in as per the flow diagram mentioned below.

Analytic hierarchy process was proposed by Saaty based on multiple attributes in a hierarchical system. It should be highlighted that all decision problems are considered as a hierarchical structure in the AHP.

In the second level, the goal is decomposed of several criteria and the lower levels divide into other sub criteria. Therefore, the general form of AHP can be illustrated as shown in Fig ure2. A.H.P. Analytic hierarchy process was suggested by Saaty to model subjective decision making processes based on multiple attributes in a hierarchical system. It has been widely used in corporate planning, portfolio selection, and benefit/cost analysis by government agencies for resource allocation purposes from that time onwards. It should be focused that all decision problems are considered as a hierarchical structure in the AHP. The initial level indicates the goal for the specific decision problem. In the second level, the goal is decomposed of several criteria and the lower levels can follow this principal to divide into other sub criteria. Accordingly, the general form of AHP can be depicted as shown in in Figure2.

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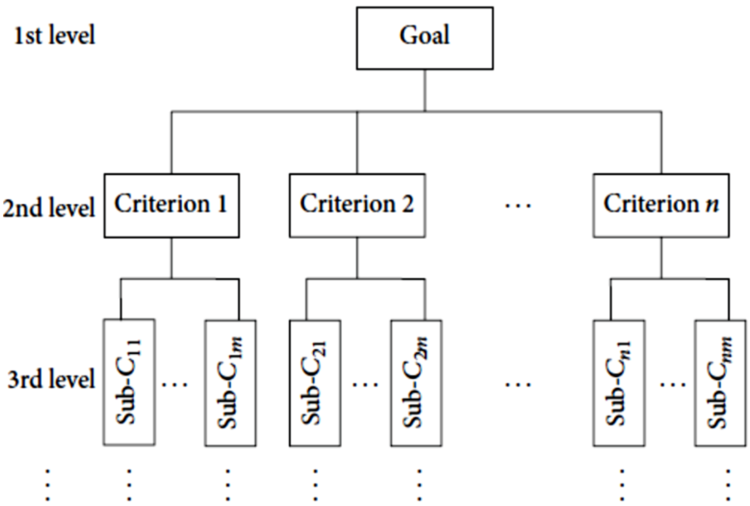


Fig. 2: The hierarchical structure of AHP

The main four steps of the AHP can be summarized as follows:

Step-1: Set up the hierarchical system by decomposing the problem into a hierarchy of interrelated elements/criteria.

Step-2: Compare the comparative weight between the attributes of the decision elements to form the reciprocal matrix.

Step-3: Synthesize the individual subjective judgment and estimate the relative weight.

Step-4: Aggregate the relative weights of the elements to determine the best alternatives/strategies.

If we wish to compare a set of n attributes pairwise according to their relative weights (importance), where the weights are

$W = [w_{ij}]_{n\times n}$,

where $W_{ij} = w_{ij}^{-1}$, $w_{ij} = w_{ik}w_{kj}$ and $w_{ij} = w_i/w_j$

$$W_w = \begin{bmatrix} \frac{w_1}{w_1} & \cdots & \frac{w_1}{w_j} & \cdots & \frac{w_1}{w_n} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ \frac{w_i}{w_1} & \cdots & \frac{w_i}{w_j} & \cdots & \frac{w_i}{w_n} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ \frac{w_n}{w_1} & \cdots & \frac{w_n}{w_j} & \cdots & \frac{w_n}{w_n} \end{bmatrix} \begin{bmatrix} w_1 \\ \vdots \\ w_j \\ \vdots \\ w_n \end{bmatrix} = n \begin{bmatrix} w_1 \\ \vdots \\ w_j \\ \vdots \\ w_n \end{bmatrix} = nw$$

or $(w - n_i)w = 0$

Next, in order to estimate the weight ratio w_{ij} by a_{ij}, where $A = [a_{ij}]_{n\times n}$, we can calculate the approximate weights by finding the eigenvector w with respect to λ_{max} which satisfies

$$Aw = \lambda_{max} w$$

where λ_{max} is the largest eigenvalue of the matrix A. in addition , since A is an approximate for W, we should calculate the consistency indexes (C.I.) to check if the consistency condition is almost satisfied for A using the following equation:

$$\text{C.I} = \frac{\lambda_{\max} - n}{n-1}$$

where λ_{max} is the largest eigenvalue and n denotes the numbers of the attributes. Satty suggested that the value of the C.I. should not exceed 0.1 for a confident result.

On the other hand, for the AHP, a near consistent matrix A with a small reciprocal multiplicative perturbation of a consistent matrix is given by

$$A = W \cdot E,$$

where · denotes the Handmard product, $W = [w_{ij}]_{n\times n}$ is the matrix of weight ratios, and $E = [\varepsilon_{ij}]_{n\times n}$ is the perturbation matrix, where $\varepsilon_{ij} = \varepsilon_{ij}^{-1}$.

From (4) and (6) it can be seen that

$$\sum_{j=1}^{n} a_{ij} w_j - \lambda_{\max} w_i = 0$$

$$\lambda_{\max} = \sum_{j=1}^{n} a_{ij} \frac{w_j}{w_i} = \sum_{j=1}^{n} \varepsilon_{ij}$$

On the other hand, the multiplicative perturbation can be transformed to an additive perturbation of a consistent matrix such that

$$\sum_{j=1}^{n} \frac{w_i}{w_j} \varepsilon_{ij} = \sum_{j=1}^{n} \frac{w_i}{w_j} + v_{ij}$$

where v_{ij} is the additive perturbation.

Since $\sum_{j}^{n} a_{ij} w_j / w_i = \sum_{j=1}^{n} \varepsilon_{ij}$, we can rewrite (8) as

$$\sum_{j=1}^{n} \left(\frac{w_i}{w_j} a_{ij} \frac{w_j}{w_i} \right) = \sum_{j=1}^{n} \left(\frac{w_i}{w_j} \varepsilon_{ij} \right) = \sum_{j=1}^{n} \left(\frac{w_i}{w_j} + v_{ij} \right),$$

$$\sum_{j=1}^{n} v_{ij} = \sum_{j=1}^{n} \left(a_{ij} - \frac{w_i}{w_j} \right).$$

On the basis of (8)-(10), it can be seen that $\lambda_{max} = n$ if and only if all $\varepsilon_{ij} = 1$ or $v_{ij} = 0$, which is equivalent to having all $a_{ij} = w_i/w_j$, indicates the consistent situation. Therefore, the problem of deriving the relative weights among criteria in the AHP is equivalent to solving the following mathematical programming to obtain w_i:

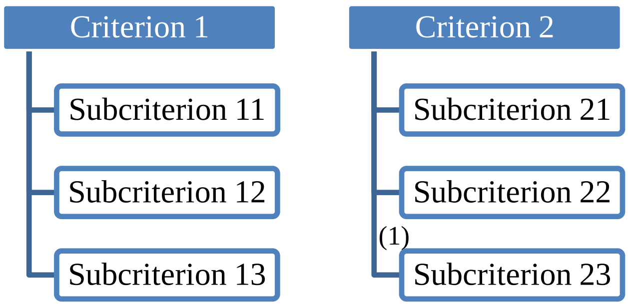
$$\text{Min} \sum_{j=1}^{n} \left\| a_{ij} - \frac{w_i}{w_j} \right\|_p$$

$$\text{s.t} \sum_{i=1}^{n} w_i = 1, \qquad \forall 1 \le i \le n \qquad (5)$$

where $\|.\|_p$ denotes the p-norm and $p \in \{1,2,\ldots.\}$.

Correlated AHP

Although the AHP is widely used in the field of decision making, it cannot deal with the situation of correlation between criteria. Hence, we propose the extension of the AHP by considering the correlation between criteria.



(1)

(2)

Fig. 3:

According to the presentation of Fig.3it can be identified that Criteria 1 and 2 are considered to change the decision of the problem. Criterion 1 can be divided into 3 independent sub criteria and so can Criterion 2. We should highlight that since Criteria 1 and 2 are correlated with each other, this problem cannot be solved neither by the AHP nor by the ANP. In order to consider the correlation effect in the AHP, we should first quantify the correlation matrix between criteria which is given by an expertise. Take Fig.3 as the example. We can rewrite the above correlation matrix or we can obtain the following correlation matrix. we should first quantify the correlation matrix between criteria which is given by an expertise. Take Fig.3 as the example. (3) (4)

We can obtain the following correlation matrix

$$R = \begin{bmatrix} r_{11} & r_{12} & r_{13} & r_{14} & r_{15} & r_{16} \\ r_{21} & r_{22} & r_{23} & r_{24} & r_{25} & r_{26} \\ r_{31} & r_{32} & r_{33} & r_{34} & r_{35} & r_{36} \\ r_{41} & r_{42} & r_{43} & r_{44} & r_{45} & r_{46} \\ r_{51} & r_{52} & r_{53} & r_{54} & r_{55} & r_{56} \\ r_{61} & r_{62} & r_{63} & r_{64} & r_{65} & r_{66} \end{bmatrix}$$

or we can rewrite the above correlation matrix as,

where $R_{11}=\begin{bmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{23} \\ r_{31} & r_{32} & r_{33} \end{bmatrix}$, $R_{12}=\begin{bmatrix} r_{14} & r_{15} & r_{16} \\ r_{24} & r_{25} & r_{26} \\ r_{34} & r_{35} & r_{36} \end{bmatrix}$, $R_{21}=\begin{bmatrix} r_{41} & r_{42} & r_{43} \\ r_{51} & r_{52} & r_{53} \\ r_{61} & r_{62} & r_{63} \end{bmatrix}$ $R_{11}=\begin{bmatrix} r_{44} & r_{45} & r_{46} \\ r_{54} & r_{55} & r_{56} \\ r_{64} & r_{65} & r_{66} \end{bmatrix}$

Self-correlation effect:

Note that the self-correlation effect could happen in other situations. In addition, it should be highlighted that **R***ji* = **R***ij*, ∀*i*,*j*, because the correlation effect is symmetric.

4. LINEAR PHYSICAL PROGRAMMING

Linear Physical Programming (LPP), as a multi-objective optimization method, aggregates objective function of the criteria in a piece-wise Archimedean goal programming style. Developed by Messac et al. [10], LPP simplifies physical programming procedure by defining preference functions as piece-wise linear functions [10]. LPP has been successfully applied to different multi-objective problems ma etc. [11]. LPP has the ability to avoid the weight assignment by providing a preference function. DM (decision maker) determines a suitable preference function and specifies ranges of different degrees of desirability (ideal, desirable, tolerable, undesirable, highly undesirable, and unacceptable) for each criterion the physical programming algorithm requires that the decision maker expresses his/her preferences with respect to each criterion using one of the eight different classes. The first four classes are “Soft class functions”, and represent minimization (Class-1S), maximization (Class-2S), value (Class 3S), and range (Class 4S) optimization. The remaining four are “Hard class functions” and are used to introduce inequality and range restrictions into the problem environment. In this regard, Class 1H and Class 2H define

Then, we assume that if Criterion *i* is highly correlated to Criterion *j*, they have similar weights or influence to the problem. Hence, if we obtain the correlation matrix between criteria, we can objective to maximize the correlation, that is, $w'\mathbf{R}w$.

upper and lower bounds, respectively, while Class 3H imposes equality and Class 4H imposes range related restrictions to the problem environment. The qualitative and quantitative depiction of each class is provided in Figures 1 and 2. The soft class functions allow the DM to express varying levels of preferences for each criterion. This is done by introducing corresponding constraints for each preference level in each of the classes. To provide better understanding, consider Class 1-S and Class 2-S, depicted in Figure 1, which are used for “Smaller is Better” and “Larger is Better” cases respectively. Table 1 demonstrates the ranges and corresponding constraints for the problem. Note that all the soft class functions will be embedded in the aggregate objective function to be minimized.

In Figure 1, the u^{th} generic criterion is indicated as $g_u(x)$ where x is the decision variable vector. The goal value, g_u is represented on the horizontal axis while, z_u, the class function that is subject to minimization is represented on the vertical axis. Since LPP algorithm considers the lower values of the class functions as “better” values but prohibits negative values, the class function that corresponds to the ideal value is set to zero.

Table 1

Soft Classes			Hard Classes		
Class-1S	Smaller is better	Minimization	Class-1H	Must be smaller	$g_u < t_{u,max}$
Class-2S	Larger is better	Maximization	Class-2H	Must be larger	$g_u > t_{u,min}$
Class-3S	Value is better	Target optimization	Class-3H	Must be equal	$g_u = t_{u,max}$
Class-4S	Range is better	Range optimization	Class-4H	Must be in range	$t_{u,max} < g_u < t_{u,min}$

Model **:** To identify the key selection criteria in a manufacturing industry in order to place orders on on each manufacturer called as supplier a considerable study was conducted. Constructed a decision hierarchy, identified the factors whether they influence each other to find the correlation matrix between the criteria. Normalized weights of factors are found considering the correlation by multi objective programming. the scores among the suppliers using correlated a hp are found. Finally the quantity to be ordered on each supplier using LPP taking into consideration of target level s ore obtained

Phase one : The selection of criteria scores are obtained as per satty guide lines

*.ahp weight calculation***:** The meaning of the terminology used.

- Operation speed: . It indicates generally which supplier will deliver fast because of the process capability
- Operating Readiness**:** Preparation of stores which can be used straightaway without a bit of damage.
- Operation accuracy**:** It includes many aspects like adherence to transportation time, on-time delivery
- Order processing: Order processing starts from picking, packaging and packed items delivery
- Operating cos**t:** Operating costs are the expenses for conducting the a business or facility

- Storage cost &Transportation cost: it includes the cost of moving and storing possessions
- Information technology**:** it is the application of computers and data acquisition and data management for conduct of business or other manufacturing and allied activities.
- Storage Technology**:** the technology implemented for storage
- Transportation technology**:** the technology implemented for transporting
- Customer satisfaction**:** It is a measure of how goods and services supplied by a company
- Compatibility : it is the ability of the manufacturer, its vendors and their customers work in collaboration
- Financial easiness**:** Ensures continuity in services., better cash flow, sound balance sheet are indicators

Table2 : Factors of suppliers selection

Operating efficiency (B1):	C1. Operation speed
	C2. Operating readiness
	C3. Operation accuracy
Cost(B2)	C4. Transportation cost
	C5. Storage cost
	C6. Order processing cost
Technology level satisfaction (B3):	C7. Information technology
	C8. Storage technology
	C9.Transportation technology
Service Quality (B4)	C10. Customer satisfaction
	C11. Compatibility
	C12.Financial easiness

.

Table 4: Relation between various factors(first level)

	B1	B2	B3	B4
B1	1	2	3	2
B2	½	1	2	1
B3	1/3	½	1	½
B4	½	1	2	1

Table5: column sum of the various factors

A	B1	B2	B3	B4
B1	1	2	3	2
B2	½	1	2	1
B3	1/3	½	1	½
B4	½	1	2	1
SUM	2.3333	4.5	8	4.5

operating efficiency, cost, technology level and service quality are represented by B1, B2, B3 and B4 respectively.

Step 1:column sum s(table 5). After considering the relations between different aspects .the column Sum for the normalization purpose is performed.,ex Sum 1 = B11+B21+B31+B41 = 1+0.5+0.333+0.5 = 2.3333

Step2: column normalization see table 6: B11= $1/_{2.3333}$=0.4285; … the remaining all calculated.

Table 6: column normalization of factors

A	B1	B2	B3	B4
B1	0.4285	0.4444	0.375	0.4444
B2	0.2142	0.2222	0.25	0.2222
B3	0.1428	0.1111	0.125	0.1111
B4	0.2142	0.2222	0.25	0.2222

Table7: Row sum of the various factors

A	B1	B2	B3	B4	SUM
B1	0.4285	0.4444	0.375	0.4444	1.6923
B2	0.2142	0.2222	0.25	0.2222	0.9086
B3	0.1428	0.1111	0.125	0.1111	0.49
B4	0.2142	0.2222	0.25	0.2222	0.9086
TOTAL					3.9995

Step3: Row sums (table 7):row wise totalling ex Sum1 = (0.4285+0.4444+0.375+0.4444) = 1.6923 .

Step4: (table 8). The individual row sums are divided by the total sum to get weights.$W_1 = s_1/s$ = 1.69/3.99 = 0.4231

Step5:Consistencyindex: The consistency index (CI) measures the consistency set of data. consistence ratio (cr).oo4 which is acceptable for first level. Ahp weights are considered for next level B1,B2,B3,B4**Phase 2:***7.2 : Correlation Matrix* :By considering individual operation speed and corresponding Order processing cost rate are in correlation with each other (table 14).The correlation is calculated as mentioned below. The correlation coefficient is $r = \frac{SSxy}{\sqrt{(SSxx)(SSyy)}} = \frac{6.5}{\sqrt{(11)(84)}}$ =0.213 ≈ 0.2all correlation coefficients(table13)

3 Multi Objective Programming: Multi Objectives function is performed to find out correlation weights

Min n= -((.2 * w11 * w21) +(.3 * w11 * w22) +(.2 *w11 *w23) +(.4 *w12 * w21) +(.5 *w12 * w22) + (.3 * w12 * w23) + (.2 *w13 * w21) +(.4 *w13 *w22) + (.3 *w13 *w23));

Table8: Row normalization of the factors

A	B1	B2	B3	B4	Weights
B1	0.4285	0.4444	0.375	0.4444	0.4231
B2	0.2142	0.2222	0.25	0.2222	0.2271
B3	0.1428	0.1111	0.125	0.1111	0.1225
B4	0.2142	0.2222	0.25	0.2222	0.2271

Table 9: Relation between internal factors of B1

B1	C1	C2	C3	Normal ahp Weights
C1	1	3	2	0.55
C2	1/3	1	1	0.21
C3	½	1	1	0.2422

Table 9the consistency ratio are found in order Cr = .001

Table 10: Relation between internal factors of B2

B2	C4	C5	C6	Normal ahp Weights
C4	1	2	3	0.55
C5	1/2	1	1	.25
C6	1/3	1	1	.20

Table 11: Relation between internal factors of B3

B3	C7	C8	C9	W
C7	1	.25	2	0.20
C8	4	1	4	0.66
C9	.5	1/4	1	0.14

The table 10 consistency ratio are found in order Cr =.001Table 11 the consistency ratio found in order . Cr =.05

Table 12: Relation between internal factors of B4

B4	C10	C11	C12	Normal
C10	1	.2	2	.19
C11	5	1	3	0.69
C12	½	1/3	1	0.12

The consistency ratio found in order .cr =.09

Table 13 correlation table

	C4	C5	C6
C1	.2	.3	.2
C2	.4	.5	.3
C3	.2	.4	.3

Table 14. correlation data for c1 and c6

	C1	C6		C1	C6		C1	C6
Serial No.	Operation Speed (Days)	Order Processing Cost (Rs)	Serial No.	Operation Speed (Days)	Order Processing Cost (Rs)	Serial No.	Operation Speed (Days)	Order Processing Cost (Rs)
1	3	4	7	4	11	13	4	8
2	4	5	8	3.5	8	14	5	9
3	5	6	9	4.5	9	15	3	11
4	4	7	10	3	4	16	4	10
5	5.5	10	11	4	5	17	3	7
6	3	9	12	5	7	18	4.5	8

$$\text{Min } m = -\left\|\left(2-\frac{w_1}{w_2}\right)+\left(3-\frac{w_1}{w_3}\right)+\left(2-\frac{w_1}{w_4}\right)+\left(1/2-\frac{w_2}{w_1}\right)+\left(2-\frac{w_2}{w_3}\right)+\left(1-\frac{w_2}{w_4}\right)+\left(1/3-\frac{w_3}{w_1}\right)+\left(1/2-\frac{w_3}{w_2}\right)+\left(1/2-\frac{w_3}{w_4}\right)+\left(1/2-\frac{w_4}{w_1}\right)+\left(1-\frac{w_4}{w_2}\right)+\left(2-\frac{w_4}{w_3}\right)\right\| + \left\|\left(3-\frac{w_{11}}{w_{12}}\right)+\left(2-\frac{w_{11}}{w_{13}}\right)+\left(1/3-\frac{w_{12}}{w_{11}}\right)+\left(1-\frac{w_{12}}{w_{13}}\right)+\left(1/2-\frac{w_{13}}{w_{11}}\right)+\left(1-\frac{w_{13}}{w_{12}}\right)+\left(2-\frac{w_{21}}{w_{22}}\right)+\left(3-\frac{w_{21}}{w_{23}}\right)+\left(1/2-\frac{w_{22}}{w_{21}}\right)+\left(1-\frac{w_{22}}{w_{23}}\right)+\left(1/3-\frac{w_{23}}{w_{21}}\right)+\left(1-\frac{w_{23}}{w_{22}}\right)+\left(0.25-\frac{w_{31}}{w_{32}}\right)+\left(2-\frac{w_{31}}{w_{33}}\right)+\left(4-\frac{w_{32}}{w_{231}}\right)+\left(4-\frac{w_{32}}{w_{33}}\right)+\left(1/2-\frac{w_{33}}{w_{31}}\right)+\left(0.25-\frac{w_{33}}{w_{32}}\right)+\left(0.2\frac{w_{41}}{w_{42}}\right)+\left(2-\frac{w_{41}}{w_{43}}\right)+\left(5-\frac{w_{42}}{w_{41}}\right)+\left(3-\frac{w_{42}}{w_{43}}\right)+\left(1/2-\frac{w_{43}}{w_{41}}\right)+\left(1/3-\frac{w_{43}}{w_{42}}\right)\right\|$$

W1+w2+w3+w4=1; W1 =w11 + w12 + w13; W2 =w21 +w22 +w23; W3 =w31 +w32 +w33; w4 =w41+w42 +w43;W1 > =0; w2 >=0; w3 >= 0; w4 >=0;W11 > =0; w12 >=0; w13 >= 0;W21 > =0; w22 >=0; w23 >= 0; W31 > =0; w32 >=0; w33 >= 0;W41 > =0; w42 >=0; w43 >= 0; Where w1 ,w2,w3,w4 are weights of b1,b2.b3,b4 respectively . and w11,w12,w13 w21,w22,w23,w31,w32,w33,w41,w42,w43are weights of c1,c2,c3,c4,c5,c6,c7,c8,c9,c10,c11,c12,c23 respectively.

Table 15.The results of correlated weights

Top-Level Factors	Weights	Second Level	Weights	Second Level	Weights	Second Level	Weights
B1	0.1142675	c1	0.062939	c5	0.04732	c9	0.029755
B2	0.1421024	c2	0.023208	c6	0.071051	c10	0.18665
B3	0.1814302	c3	0.027676	c7	0.060235	c11	0.2811
B4	0.5621999	c4	0.023731	c8	0.090715	c12	0.092201

The table(15) clearly demonstrates the correlated ahp values are different from normal ahp values. First normal ahp is performed to check the consistency.

7.4 supplier wise ranks are calculated .Each supplier is given weight with respect to each factor. On a scale of 1 ---10.Supplier weights are calculatedin table 16 and 17

Table 16 Supplier global weighed scores

	Supplier 1 (1)	Weights (2)	Product (1*2)	Supplier 2 (4)	Weights (5)	Product (4*5)	Supplier 3 (7)	Weights (8)	Product (7*8)	Supplier 4 (10)	Weights (11)	Product (10*11)
Operating Efficiency	8	0.1143	0.9141	5	0.1143	0.5713	7	0.1143	0.7999	6	0.1143	0.68561
Order Processing Cost	5	0.1421	0.7105	8	0.1421	1.1368	6	0.1421	0.8526	8	0.1421	1.13682
Technology Satisfaction	7	0.1814	1.27	6	0.1814	1.0886	6	0.1814	1.0886	8	0.1814	1.45144
Service Quality	7	0.5622	3.9354	7	0.5622	3.9354	5	0.5622	2.811	6	0.5622	3.3732
Total			6.8301			6.7321			5.5521			6.6471
Normalized Weights			0.2651			0.26134			0.21553			0.25804

<u>Phase 3</u>

7.5 linear physical programming<u>**:**</u> the data considered for this part of section is mentioned in tables18,19,20.

<u>*7.6 Formulation of equation*</u>

Operating efficiency Goal = g_1 = 0 .78 x_1 +0.81 x_2 +0.80 x_3 + 0.81 x_4

Technology satisfaction Goal = g_2= 0.84 x_1 +0.82 x_2 +0.82 x_3 +0.85 x_4

service quality Goal = g_3 = 0.7 x_1 +0.7 x_2 +0.5 x_3 +0.6x_4

cost Goal = g_4 = 110 x_1 +150 x_2 +145 x_3 +120 x_4

Subject to Total quantity to be procured$x_1 + x_2 + x_3 + x_4 = 1500$;

the maximum limit that can be procured from supplier

$x_1<800$, $x_2<500$, $x_3<700$, $x_4<600$; $x_1 \geq 0$, $x_2 \geq 0$; , $x_3 \geq 0$, $x_4 \geq 0$

x_1 , x_2, x_3, x_4 are the quantities to be ordered on suppliers1,2,3 and 4

<u>5.5.2Based on linear physical programming, the equations are reformulated</u>

Objective function Min z = $\sum_{i=2}^{5} \widetilde{w_{2i}^{-}} * d_{2i}^{-} + \widetilde{w_{3i}^{-}} * d_{3i}^{-} + \widetilde{w_{1i}^{-}} * d_{1i}^{-}$

Where $\widetilde{w_{2i}^{-}}$,$\widetilde{w_{3i}^{-}}\widetilde{w_{1i}^{-}}$ = weights calculated as per weighted algorithm

Table 17 .Supplier weighed scores of individual factors

	Supplier 1 (1)	Weights (2)	Product (1*2)	Supplier 2 (4)	Weights (5)	Product (4*5)	Supplier 3 (7)	Weights (8)	Product (7*8)	Supplier 4 (10)	Weights (11)	Product (10*11)
Operation Accuracy	8	0.02768	0.2214	5	0.02768	0.13838	7	0.02768	0.19373	6	0.02768	0.166054
Operating Efficiency	5	0.071051	0.35526	8	0.071051	0.56841	6	0.071051	0.42631	8	0.071051	0.568408
Transportation Technology	7	0.029755	0.20829	6	0.071051	0.42631	6	0.029755	0.17853	8	0.029755	0.23804
Financial Easiness	7	0.092201	0.64541	7	0.092201	0.64541	5	0.092201	0.46101	6	0.092201	0.553206

Table 18 .**Data of product**

Suppliers	Cost (rupees)	Operating efficiency fraction	Technology satisfaction fraction	service quality (fraction)	Capacity in numbers
Supplier 1	110	.78	.84	.7	800
Supplier2	150	.81	.82	.7	500
Supplier 3	145	.80	.82	.5	700
Supplier 4	120	.81	.85	.6	600

Table 19 Soft criteria

goals	ideal	desirable	tolerable	undesirable	Highly undesirable	unacceptable
operating efficiency	>950	900-950	700-900	500-700	300-500	<300
Technology satisfaction	>900	800-900	700-800	600-700	300-600	<300
service quality	>900	800-900	700-800	500-700	400-500	<400

Table 20Hard criteria

goals	Unacceptable	Acceptable
Cost	**>200000**	**<200000**

x1	x2	x3	x4	goal1	goal2	goal3	goal 4
143	500	257	600	1208	1250	938	199595

8. CONCLUSION

The problem is solved using software lingo 11 Multi objective technique is used to find out the correlated weights of criteria in supplier selection. Implementation of linear physical programming technique which has the capability to represent decision maker preference by using a utility function and to manage problem in multi criteria environment for order allocation is presented. The study gives ample scope for Future scope: such as The model can be further extended accommodating more variables such as power requirements infrastructure requirements, product recycling etc. this can be extended to new areas with fuzziness in consideration

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