Development of a Suitable Methodology for Critical Evaluation of Vendors in Supply Chain Management

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***Abstract*—This paper describes a rule based model, to evaluate the performance of vendors, supplying components and raw materials to a multinational organization engaged in designing, manufacturing and delivering a range of products covering various stages of electric power transmission and distribution system.**
The model, described in this work, is utilized to select suitable vendors for the manufacturing organisation manufacturing customised products. The model is validated for real life situations in which voice of customers is focussed.

***Keywords*— Supply chain, Optimization, Vendor selection, Networking, Rule-based algorithm**

I. INTRODUCTION

Proper identification of vendors is important for increasing the efficiency of both service and manufacturing organizations. For this reason the emphasis of any organization is to select suitable vendors who can supply a host of materials and components to the organisation as per the need of the organisation. The purchased department normally focuses more on "A" types of items for administrative purposes. Most of the time the purchasing department uses certain tools to evaluate the vendors.

It is also pertinent to note that supply chains (SC), can be viewed as a network of vendors, manufacturers, distributors, and retailers. The efficiency of the network is dictated mainly by the characteristics of vendors and also is influenced by mode of transportation, information flow, and financial infrastructure of the organisation. The ability to represent a complex but realistic supply chain of any organization by using any single model is often difficult, particularly when the organization supplies customized products to its customers. The preferences of vendors from customers side create further problems. The variable market condition also requires that in any organization specific SC models must be developed and applied.

II. LITERATURE REVIEW

Many research methodologies of vendor analysis have been in use and published in literatures. For an extensive review of literatures, please refer Ho et al [24]. Also the works of Verma and Pullman[17] and Huang and Keskar[21] are very informative and contains reviews of previous researches. The work of Dickson [8] is considered as the first published research work in the direction of vendor selection and is meaningful for research purposes. The terms vendor and supplier are often mean same and used interchangeably here.

Traditional methods of vendors evaluation in the early 80s are mainly based on buyer's experience. Timmerman [5] and Zenz [9] have utilised the qualitative methodologies for performance evaluation of vendors. Qualitative methods may include tools for visualizing and analysing the decision-maker's perception of a problem situation and tools for brainstorming about possible (alternative) solutions.

In the domain of quantitative techniques, Degraeve and Roodhooft[26-28] had published a series of research papers addressed to solve cost based optimization problems. Weber, Current and Desai [2] had improvised the previous paper of Weber ,Current and Desai [1] and developed a multi objective programming model to fix number of suppliers/vendors. Though the list of such researches is wide and the techniques range from linear programming to highly complex mathematical modelling which are often found to be NP hard. Thus practical and realistic models are more preferred for vendor selection by industrial organisations. The quantitative techniques cause significant problems in considering qualitative factors. The models which can combine subjective and quantitative criteria are more useful for practical applications. Wang et al.[11] had implemented such hybrid system to solve vendor selection method. Verma and Pullman[17] had also attempted to quantify the attributes like quality, cost and delivery parameters so as to make the selection of vendors more justified.

For dealing with multi-level criteria for vendor selection, analytic hierarchy process (AHP) had widely been in use for solving such problems. Akarte et al. [16] have developed a web-based AHP system initially utilised by Saaty[22] to evaluate the suppliers of "casting " with respect to 18 different criteria. Murlidharan et al. [3] proposed a five-step AHP – based model to aid decision makers in rating and selecting suppliers with respect to nine evaluating criteria. Venkata Rao [18] also developed an AHP methodology based on a combined AHP and genetic algorithm (GA). The paper of Wang and Che[12] is another integrated model using GA. However GA in vendor selection is not much utilised.

Data envelopment approaches (DEA) is another technique which had been applied to fix alternative vendors on the basis of their performances. This approach is regarded as simple and can also accommodate subjective information like experience, insight and intuition of the selector in logical manner. Ho et al.[24] had reported that a majority of research work on vendor selection area is based on DEA. The work of Seydel[13], Talluri and Narasimhan [20] , and Wu et al. [23] are frequently cited DEA approaches.

Larson[10], Quin[15], and Ozdemir and Temur[4] had developed artificial neural network (ANN) based algorithms. ANN based algorithms are claimed to be helpful for practical industrial applications especially for dynamic situations.

In many realistic applications, organisations have utilised their own methods as illustrated in [14,19]. The experience of the management staff is often seen to generate acceptable results in decision making processes by using rules of thumb and are not reported in literature. Dependency on use of theoretical models are avoided mostly by such industrial organisations.

III. CASE STUDY FOR A MANUFACTURING ORGANISATION

This paper considers the case of a manufacturing organisation which Seydel[13] provides comprehensive electrical solutions for utilities and electro-intensive industries engaged in (a) transmission, distribution and power generation, (b) railways, (c) industrial buildings and, (d) mining and metal industries. The manufacturing organisation, under consideration has multi-plants and are located in several countries. Vendors are distributed evenly in those countries and the organisation attempts to purchase raw materials and components from local suppliers.

Some of the customers of this organisation also require certain components (or raw materials) to be purchased directly from their selected vendors. Price may not be the criteria for these purchases. For these cases the manufacturer does not have the freedom to select the vendors themselves on the basis on cost or time parameters. No systematic procedure or mathematical model is fully applicable for such situations. A rule-based algorithm may therefore become effective.

The manufactured items are power transformers of various sizes and specifications. The types of transformers and the type of customers are tabulated in the Table 1. It may be noted that a customer may opt for any type of transformers as per their need. The table shows representative data only.

The processes required for the manufacturing activities are broadly subdivided and presented in Fig. 4. The numerical values of the process timings are approximate and shown in Table 2. The timings can be used for back scheduling to indicate the starting activity of manufacturing customised transformers.

The precedence forward relationships of these activities are developed by the organisations so that sub-activities are closely executed along with the follow-up of ordered items.

In case the organisation cannot accept the order from any customer due to its capacity restriction, it tries to offload the job to another plant located in other parts of the same country. Due to various governmental and legal restriction the organisation may not be able off-load to other plants located in other countries,

TABLE 1

TYPE OF POWER TRANSFORMERS MANUFACTURED

Type	Capacity	Customer type
1	100MVA	Medium sized organisation like UPPCL
2	150MVA	Large engineering organisation like NTPC
3	170MVA	Very large engineering organisation like BHEL
4	210MVA	Very large engg. organisation like Reliance
5	370MVA	Very large engg. organisation like Reliance

TABLE 2

TIMINGS FOR MANUFACTURING ACTIVITIES

S.N.	Process	Time Required (days)
1	Core cutting	7 -10
2	Core building	10
3	Winding	10
4	Dummy assembly	10
5	Electrical connections	10
6	Oil filling	10
7	Electrical test	7

The materials that are used in these manufacturing of the transformer contain around 250 major items/ components/materials for which the model/ algorithm is applied. However for the purpose of illustration a list of “A” items along with the percentage of cost of these items are shown hereunder in the table 3.

TABLE 3

“A” ITEM- COST ANALYSIS

Item	% of total cost
CRGO	30 to 35%
Copper	25 to 30%
Tank	10 to 15%
Oil	4 to 5%
Radiator	1 to 2%
Bushing	1 to 2%

TABLE 4

JAPANESE JIS C 2553 (1986)CRGO TYPES

Japanese specification of CRGO				
JIS C 2553 (1986)				
Classification		Density (kg/dm)	Iron loss (W/kg) W17/50	Magnetic flux density (T) B
Symbol	Thickness mm			
27 P 100	0.27	7.65	1.00 max.	1.85
27 P 100			1.00 max.	
27 G 120			1.20 max.	1.78
27 G 130			1.30 max.	
27 G 140			1.40 max.	1.75
30 P 110	0.30		1.10 max.	

Though the material, Cold Rolled Grain Oriented (CRGO) steel is having only one code allotted by the manufacturer, the material characteristic varies with various sub-types as shown in Table 4. It may be noted that the specification indicated is for Japanese (JIS C 2553 (1986)). Similarly BS 601 Part-2 ,the British standard. and USA standard(AISI (1983)) are also specified by customers. As the organisation being multinational, the customers demand various types of CRGO and also select the vendors supplying them. The organisation thus need to keep track of specifications of various CRGO so that the customised transformer is supplied. It is needless to say that there are many items for which the customers of the organisation have their pre-selected suppliers but ordering and other formalities are completed by the organisation only.

IV. MODEL DEVELOPMENT

Once the customers supply their own specifications and indicate the particular supplier from whom the purchase is to be carried out (even with higher prices), the organisation must satisfy many other constraints to manufacture the products for customers. Power transformers of various capacities fall in the category of customised product.

The algorithm developed here has a set of following objectives:

- Selection of vendors as per the customers need.
- Identifying alternative vendors in case the pre-selected vendors cannot supply the items due to its capacity restriction.
- Re-schedule to manufacture the products in other plants where it was not planned for production.
- Sensitivity analysis of the capacities of the plants and the vendors and to investigate how much flexibility can be built in the system.
- Cost analysis of the product and identify the variations in respect to customers and plant locations.
- Minimise the number of tardy jobs and maintaining the proper delivery dates.
- The algorithm developed in this case contains four modules. The main algorithm is shown below. The four modules take into consideration (1) partitioning the vendor set in terms of preferences, (2) identifying alternate vendors in the preliminary stage of product manufacture planning, (3) identification of alternate plants for manufacture, and (4) reduction of tardy jobs through re-scheduling.

ALGORITHM

Make a list of vendors, component, unit cost ,lead time, max. capacity ,delay time.

Make a matrix MAT of p × q and assign each cell value 'n' which means infinity.

Make a list of customer comprised of customer no. Vendor preferred, required time and quantity.

If vendor preferred != 0

then MAT [customer no.][vendor no.] = 1;

Else

For all vendors

If _ lead time + delay time <= required days

Put it in another list 'A' Sort the list 'A'

in ascending order of unit cost.

i=1;

<u>while</u> required amount > 0 and list is not empty

<u>if</u> required amount > max. capacity

<u>then</u>

required amount = required amount – max.capacity

MAT[customer no.] [vendor no.]=i;

i++;

Else

MAT[customer no.] [vendor no.] = i;

Required amount = 0;

While end;

If(required amount > 0)

Print amount required is large.

Where, MAT → matrix name.

p→ customer no. row wise.

q → vendor no. column wise.

It can be mentioned that there are many input items to produce the products (here power transformers). Only one input material CRGO is shown here as illustration.

EXAMPLE

An example of the above algorithm can be illustrated with the data shown in Table 5. For simplicity only one component (CRGO) is taken here. The interactions of all other components are not shown. The customer (indicated here as C_i) demands the component (CRGO) within 90 days (a tentative value).

Let:

C1 → prefers only S06 vendor, demands 500 units.

C2 → No preference, demands 450 units.

C3 → No preference, demands 900 units.

Consider a hypothetical seven customers and seven vendors case. Table-5 shows the cost, delivery time and supply capacity of vendors. The algorithm as developed for the organisation is utilised. The sorted list as per the time and ascending order of unit cost is prepared. The initial matrix is shown as Fig.1 and the final matrix which generate the result is shown in Fig. 2. For simplicity only vendor selection is indicated and amount that is to be purchased is not shown.

TABLE 5

VENDOR DATA

Vendor	Unit cost(Rs.)	Delivery time (days)	Max. Supply (units)
S 01	1.85 LAC/T	55	15
S 02	2.68 LAC/T	54	440
S 03	2.31 LAC/T	87	500
S 04	2.55 LAC/T	93	600
S 05	2.01 LAC/T	90	450
S 06	2.71 LAC/T	92	1780
S 07	2.85 LAC/T	80	150

V. Applications of the Algorithm

The method developed in this paper relates to a special case in which the selection of vendors is partly decided by the customers themselves. The pre-selection of vendors is not based on cost or time parameters. No quantitative analysis can be carried out fully for this particular case. Customers preferences of any specific vendor are dictated merely by the customers choices and not through any optimisation procedure, as many of the systems parameters are not fully known. With the increasing significance of the purchasing functions, purchasing decisions become more crucial due to such preferential choices. As this organization manufactures customised products, the direct and indirect consequences of the decision-making for vendors selection become more subjective and less cost-effective.

$$\begin{bmatrix} & S1 & S2 & S3 & S4 & S5 & S6 & Sq \\ C1 & n & n & n & n & n & n & n \\ C2 & n & n & n & n & n & n & n \\ C3 & n & n & n & n & n & n & n \\ C4 & n & n & n & n & n & n & n \\ C5 & n & n & n & n & n & n & n \\ C6 & n & n & n & n & n & n & n \\ - & n & n & n & n & n & n & n \\ - & n & n & n & n & n & n & n \\ Cp & n & n & n & n & n & n & n \end{bmatrix}$$

C1 – Cp – Customer no. 1 to p
S1 – Sq – Vendor no. 1 to q

Fig. 1 Initial matrix inputted to algorithm

$$\begin{bmatrix} & S1 & S2 & S3 & S4 & S5 & S6 & S7 \\ C1 & n & n & n & n & n & 1 & n \\ C2 & 1 & n & n & n & 2 & n & n \\ C3 & n & 3 & 2 & n & 1 & n & n \\ C4 & n & n & n & n & n & n & n \\ C5 & n & n & n & n & n & n & n \\ C6 & n & n & n & n & n & n & n \\ C7 & n & n & n & n & n & n & n \end{bmatrix}$$

C1 – C7 – Customer no. 1 to 7
S1 – S7 – Vendor no. 1 to7

Fig. 2 Final matrix of given data

VII. Conclusions

This paper considers selection of vendors for a manufacturing organisation supplying customised power transformers to its customers. The organisation gets the input materials from its vendors. For certain items, the customers identify the vendors themselves from whom the material is to be purchased. For these type of manufacturing organisations the system of vendors selection cannot be completed by using any conventional model. A customised algorithm is therefore needed. In this paper one such algorithm has been developed and used to justify the selection of vendors for all the "A" items. The validation of the model is also carried out and the model is found satisfactory.

Contemporary operations research (OR) techniques do not offer many suitable methods or techniques that may support the complexity in decision making in vendor selection. Algorithmic models which may include multi-criteria decision aid, problem structuring approaches, and data mining techniques may enhance the effectiveness of purchasing decisions.

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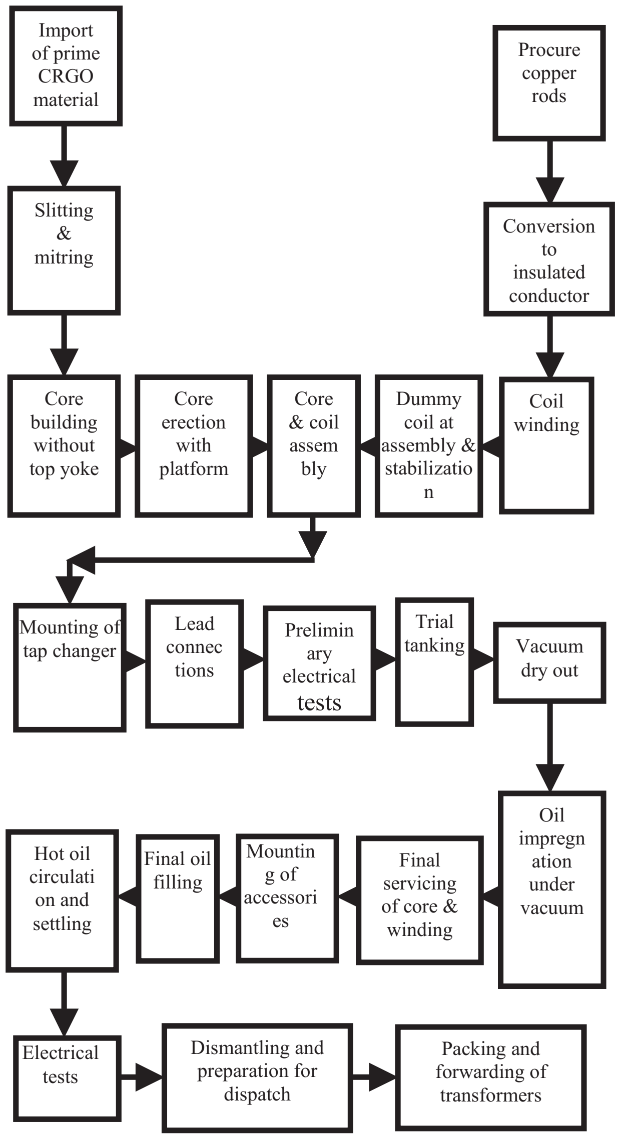

Fig.4 Construction of a simple transformer