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Decision Support system for Suppliers

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***Abstract*—**Supplier selection is a multi criteria decision-making process that comprises tangible and intangible factors. The majority of previous supplier selection techniques do not consider strategic perspective. Besides, uncertainty is one of the most important obstacles in supplier selection. For the first, time in this paper, the idea of the algorithm " Knapsack " is used to select suppliers Moreover, an attempt has to be made to take the advantage of a simple numerical method for solving model .This is an innovation to resolve any ambiguity in choosing suppliers. This model has been tried in the suppliers selected in a competitive environment and according to all desired standards of quality and quantity to show the efficiency of the model, an industry sample has been uses.

***Keyword*—**Knapsack, linear programming, Supplier select, Supply chain management

I. INTRODUCTION

INCREASINGLY, companies are outsourcing portions of their business processes—from IT to raw material to after sales service to logistics and transportation. According to a recent survey carried out by Accenture, 80% of the companies' surveyed use some form of outsourcing and a majority of these companies are spending close to 45% of their total budget on outsourcing[1].Manufacturing outsourcing began in 1970s and the 1980s when US jobs in steel and textile moved from Northern states to Southern states. Outsourcing is defined as purchasing ongoing services and parts from an outside company that a company currently provides, or most organizations normally provide for themselves [2]. In a survey carried out by Accenture, it was found that the primary reason for outsourcing is not cost-reduction rather it is the ability to focus on the core competencies.

There are various reasons for outsourcing, most notably [3].

1. In many cases the third party can provide procurement services more efficiently. Outsourcing can provide access to specialized technology and operational platforms.
2. Outsourcing can help reduce the staffing levels.
3. The advancement in technologies has made procurement a very specialized service.

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Companies try to reduce costs and manage risks. It is important to know that one of the major portions of the firms' expenses is elated to logistics activities which mostly are more than 50% of all companies' costs [4]. Therefore, companies try to manage purchasing tasks. Experts believe that supplier selection is one of the most prominent activities of purchasing departments [5]. But, supplier selection is a difficult problem for managers because the performances of suppliers are varied based on each criterion [6]. In the previous investigations, several methods have been suggested to solve the supplier selection problem. However, most of them have not paid attention to the strategic perspective.

Basically there are two kinds of SSP (supplier selection problem):

(1) Single sourcing. Constraints are not considered in the supplier selection process. In other words, all suppliers can satisfy the buyer's requirements of demand, quality, delivery, etc. The buyer only needs to make one decision, which supplier is the best.

(2) Multiple sourcing. Some limitations such as supplier's capacity, quality, delivery are considered in the supplier selection process. In other words, no one supplier can satisfy the buyer's total requirements and the buyer needs to purchase some part of demand from one supplier and the other part from another supplier to compensate for the shortage of capacity or low quality of the first supplier. In these circumstances buyers need to make two decisions: which suppliers are the best, and how much should be purchased from each selected supplier?

The vast majority of the decision models applied to the supplier selection are linear weighting models and mathematical programming models. The proposed decision model is more comprehensive and competitive rather than other published MCDM models for supplier selection due to its dynamic nature and strategic oriented.

In this model the idea of a backpack algorithm is used. Suppose that the tourist wants to fill their Knapsack with the states may choose from a variety of devices that provide maximum comfort for him. This can be the means of numbers from 1 to n and define a vector of binary variables (Binary) (j = 1,2, ... n) is formulated as math. This means that:

If my object j is selected, otherwise when the tool is easily rate j provides the address and the weight and c is the size of a Knapsack We take the issue of choosing between the binary vectors x, which is provided the limitation. As its objective function takes the maximum value .

This model has been implemented in a company that manufactures Moisture insulation. The company intends to buy products from multiple supplies. Furthermore, we utilize a proposed linear programming model to determine the order quantity from each supplier. The majority of previous models suppose that there is a single product, but our model has been designed for multiple products. In addition, the capacity of warehouse is taken into account as a constraint.

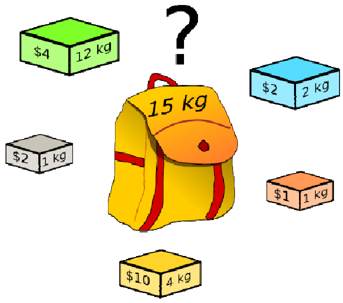

Fig. 1 Knapsack supplier

The organization of this paper is as follows: Section 2 discusses the literature review. Supplier selection model is presented in Section 3. In Section 4, a case study is illustrated. In the first phase, suppliers are assessed based. Then, the order quantity is determined by a linear programming model. Finally, conclusions are presented in Section 5.

II. Literature Review

Supplier selection is a multi criteria decision-making problem. Regulations and decision-making techniques are two important elements in a supplier selection problem. The first research was conducted in 1996, identified 23 different criteria to select suppliers based on questionnaires sent to directors of North American companies. These criteria include quality, delivery, performance, warrant and claim policy, production facilities and capacity, net price, and technical capabilities. Hence supplier selection problem (SSP) is a multiple criteria problem and it is necessary to make a trade-off between conflicting tangible and intangible factors to find the best suppliers. SSP is complicated by the fact that various criteria must be considered in the decision making process. SSP is further complicated by the fact that individual suppliers may have different performance characteristics for different criteria. For example, the supplier who can supply an item for the lowest per unit price may not have the best quality or service performance among the competing suppliers. Supplier selection is therefore an inherent multi-objective decision that seeks to minimize procurement cost, maximize quality and service performance concurrently. Often complicating the SSP for the buyer is the presence of price discounts, offered by supplier, that depend on the total value of sales volume, not on the quantity or variety of products purchased over a given period of time. In traditional quantity discount pricing schedules, price breaks are a function of the order quantity which existed for each product, irrespective of the total purchasing volume over a given period of time. With the advent of just-in-time (JIT) purchasing, the strategy that calls for ordering smaller lot-size is more practical and feasible. So suppliers are finding it more meaningful to give discounts based on the total value of multi-product orders (i.e. total business volume) placed by a given buyer [7].

In 1973, model was presented which focused on industry applications of computer-assisted supplier selection models [8]. Reviewing 74 articles, in 1991 a literature on supplier selection was conducted to identify price, delivery, quality, facilities, capacity, geographic location, and technology capability [9].

In 2001, more research identified four stages in supplier selection problem which consist of problem formulation, formulation of criteria, qualification and final selection. In that study was stated that the majority of authors have focused on final selection stage [10]. In 2004, was presented some published supplier selection models and compared their relative efficiency using the total cost of ownership [11]. Also a model was presented a framework for assessing the flexibility of a supply chain including the flexibility of product delivery system, production system, product development and supply system [12].

In 2007, researchers have presented another literature review according to the purchasing process. Proposed classification is based on single and multiple items and periods [4].

Some authors not only solve the supplier selection problem, but also they determine how much should be purchased from each selected supplier. Researchers combined analytical hierarchy process (AHP) and linear programming to consider both tangible and intangible factors in supplier selection problem [13]. However, their model is deterministic and does not consider uncertainty in human though. In this paper, we extend their model.

In 2000, was utilized DEA for evaluating the suppliers and multi-objective programming for determining the vendor order quantity [14]. Researchers considered a supply network consisting of a manufacturer and its suppliers. They formulated a nonlinear programming model and determined how much of each raw material and component part to order from which supplier according to the capacity of suppliers and manufacturer. It is assumed that demand is stochastic. However, they only determined the order quantity and they did not select the suppliers [15].

In 2007, was proposed a multi-objective supplier selection model under stochastic demand conditions. Stochastic supplier selection has been determined with simultaneous consideration of the cost, quality, delivery and flexibility according to the limitations of capacity [16]. In the same year, presented a new method based on analytical hierarchy process improved by rough sets theory and multi-objective to determine the number of suppliers and the order quantity allocated to these suppliers. In addition, was considered discount [5]. More research scholars optimized Price, lead-time and rejects (quality) to select the best vendor in the field of outsourcing. They applied quantity discount in the model [17].

III. Supplier Selection Model

A. Parameters in the model

MAX_{Profit_s}	Show that this matrix, each of which suppliers have produced the raw material and what points are earned according to the algorithm.
P_i	Price per unit of raw material i.
G_i	Returns the amount of raw material i.
P_{max_s}	Maximum price of raw materials provided by the supplier s.
C_i	Amount of raw material i needed to make unit of product j.
dem_j	Predicted value for the product j.
r_s	Supplier price discount rate s.
d=1,2,…,D	Desired criteria for supplier selection.
i=1,2,…,I	Raw material
s=1,2,…,S	Supplier
j=1,2,…,J	The criteria for selecting suppliers.
T	Period
$stor_i^t$	Storage Capacity
$capacity^t$	Production capacity
Line	Production line
H_j^t	Production capacity of each production line
W_s	Supplier Rating Owner.
B_s	Vector producing value for supplier selection.
Cu	
M	Maximum points are looking for supplier selection.
X	If $W_d \leq Cu$ then $X_d = 1$ else $0 \leq X_d < 1$

B. Variables in the model

F_j	Amount of product j produced.
$Q_{s,d}$	Total amount of raw materials purchased from supplier s.
O	If the material i is supplied by supplier s equal one, otherwise is zero.
V_s	Trade volume with the supplier s.
Profit	The value obtained for the supplier according to criteria d.
Q_s	Total amount of material purchased from supplier s.

C. Mathematical formulation of supplier selection model

Step 1

First, we specify the criteria that we want to choose their supplier based. These criteria may be different for the purchase of raw materials or standards changes in different conditions. D variable in this model represents criteria. (d = 1, 2, 3, ..., D)

Step 2

B & W vector to produce the selected criteria. According to the manufacturer will impact how much the selected criteria for choosing their supplier from 1 to 7 are used to form the vector W. According to the criteria selected, each candidate is a supplier of absence from 1 to 7 we use to express these conditions and form a vector B.

Very Low=1, Low=2, Medium Low=3, Medium=4, Medium High =5, High=6, Very High=7

Step 3

In order to express the criteria for selection which will be B or W and the vector which are superior to selection criteria, for each criterion in the above vectors obtains ratio $\frac{B_d}{W_d}$ Based on the $\frac{B_1}{W_1} \geq \frac{B_2}{W_2} \geq \ldots \geq \frac{B_D}{W_D}$ We evaluated the model.

Means for each measure is bigger than it is the criteria for excellence. If this ratio is equal to two criteria, which criterion is select that the vector of the point is greater than B .

Step 4

For each producer to be resolved under the model with initial values:

$X_d = 0$, Profit = 0 , Cu = M .

$$M = \sum_{d=1}^{D} B_d \tag{1}$$

$$MAX_{Profit} = \sum_{d=1}^{D} \begin{cases} X_d = Cu/W_d \\ Profit = Profit + X_d \times W_d \end{cases} \Bigg| W_d > Cu \tag{2}$$

$$\begin{cases} X_d = 1 \\ Cu = Cu - B_d \\ Profit = Profit + W_d \end{cases} \Bigg| W_d \leq Cu \tag{3}$$

$$\sum_{d=1}^{D} X_d W_d \leq M \tag{4}$$

MAX_{Profit} represents is a privilege for any supplier what intended to conditions obtains with regard to measures and it is used to select Providers. For convenience put the results of the above algorithm in a matrix. Rows are the raw materials and columns are providers. Score for the provider put in front of material that can provide. Any supplier who bring gotten more points, will be selected to provide the desired ingredients.

Step 5

According to the matrix MAX_{Profit} we form the matrix $O_{i,s}$ them. The matrix $O_{i,s}$ put one the name in front of what selected supplier for raw material desired and treat the rest zero.

$$O_{i,s} \in \{1,0\} \tag{5}$$

Step 6

To obtain the amount of materials purchased from selected suppliers, according to the amount of materials needed to build one unit of product, will operate as follows:

A first set of constraints express that demand must be satisfied for each product:

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$$\sum_r F_j = dem_j \qquad \forall j \tag{6}$$

Plant production capacity is equal to production capacity of each production line:

$$capacity^t = Line \times \sum_j H_j^t \qquad \forall j \tag{7}$$

Demand should be less than the capacity of the factory:

$$dem_j \leq capacity^t \tag{8}$$

Define the total quantity of ingredients purchased from each supplier:

$$Q_s^t = \sum_i O_{i,s} \times \sum_j C_i F_j - G_i^t \qquad \forall s \tag{9}$$

If not part of the materials purchased in accordance Order (Raw Material Returns) must be less than the amount of trade volume with the supplier (Returns amount be deducted from the total amount purchased).
Total amount of materials purchased should be less than storage capacity:

$$Q_s^t \leq stor_i^t \tag{10}$$

Step 7:

Using Q_s Price for each unit provided by the supplier of raw materials, trade volume can be achieved with the selected supplier.

$$\sum_s V_s = \sum_i Q_s^t P_i \qquad \forall s \tag{11}$$

$$V_s \leq P_{max_s} \times Q_s^t \qquad \forall s \tag{12}$$

$$P_i \geq 0 \tag{13}$$

Step 8:

Considering the volume of trade with selected suppliers and the amount of the Concession provider considers time fee, you can obtain what raw material purchase costs for the product or products.

$$\min cost = \sum_s (1 - r_s) \times V_s \tag{14}$$

IV. Case Study

At this stage the decision maker has the choice between quantitative and qualitative criteria, tangible and intangible d1= geographical location, d2= cost, d3= Quality, d4= Mutual trust, d5=time delivery, d6= Management stability for the decision. These criteria make up the D vector ($D = [d_1, d_2, d_3, d_4, d_5, d_6]$) .

Vectors based on level D, we create the W vector. Then we create for each supplier of the vector B. B vectors are indicated in Table 1. As can be seen in Table 1, for each raw material is considered the third supplier.

W=[7,7,1,6,5,5]

Obtains $\frac{B_d}{W_d}$ for each supplier according to the criteria vector d, and then we sort this ratio (Table I) .

TABLE I
INFORMATION OF SUPPLIER

materials	Suppliers	$B[d_1,d_2,d_3,d_4,d_5,d_6]$	
	S_1	B_1=[7,1,6,5,5,7]	[1,0.14,6,0.83,1,1.4]
I_1	S_2	B_2=[7,7,6,5,5,1]	[1,1,6,0.83,1,0.2]
	S_3	B_3=[7,6,5,5,1,7]	[1,0.86,5,0.83,0.2,1.4]
	S_4	B_4=[7,7,6,5,1,5]	[1,1,6,0.83,0.2,1]
I_2	S_5	B_5=[1,5,6,7,7,5]	[0.14,0.71,6,1.17,1.4,1]
	S_6	B_6=[1,7,5,5,6,7]	[0.14,1,5,0.83,1.2,1.4]
	S_2	B_2=[7,7,6,5,5,1]	[1,1,6,0.83,1,0.2]
I_3	S_3	B_3=[7,6,5,5,1,7]	[1,0.86,5,0.83,0.2,1.4]
	S_7	B_7=[5,5,1,5,7,7]	[0.72,0.72,1,0.83,1.4,1.4]
	S_8	B_8=[6,5,5,7,1,7]	[0.86,0.72,5,1.17,0.2,1.4]
I_4	S_9	B_9=[1,5,5,7,6,7]	[0.14,0.72,5,1.17,1.2,1.4]
	S_{10}	B_{10}=[7,7,6,5,1,5]	[1,1,6,0.83,0.2,1]
	S_{11}	B_{11}=[7,7,5,1,6,6]	[1,1,5,0.17,1.2,1.2]
I_5	S_{12}	B_{12}=[5,1,5,6,7,7]	[0.72,0.14,5,1,1.4,1.4]
	S_{13}	B_{13}=[1,5,6,5,7,7]	[0.14,0.72,6,0.83,1.4,1.4]
	S_{14}'	B_{14}=[7,1,6,7,5,5]	[1,0.14,6,1.17,1,1]
I_6	S_{15}	B_{15}=[7,6,5,5,1,7]	[1,0.86,5,0.83,0.2,1.4]
	S_{16}	B_{16}=[7,7,5,5,1,6]	[1,1,5,0.83,0.2,1.2]
	S_{17}	B_{17}=[1,5,7,7,6,5]	[0.14,0.72,7,1.17,1.2,1]
I_7	S_{18}	B_{18}=[7,6,1,7,5,5]	[1,0.86,1,1.17,1,1]
	S_{19}	B_{19}=[7,7,5,6,5,1]	[1,1,5,1,1,0.2]
	S_{20}	B_{20}=[7,7,6,5,5,1]	[1,1,6,0.83,1,0.2]
I_8	S_{21}	B_{21}=[7,6,5,5,1,7]	[1,0.86,5,0.83,0.2,1.4]
	S_{22}	B_{22}=[7,7,5,5,6,1]	[1,1,5,0.83,1.2,0.2]

According to the initial values M=Cu=3, $X_d = 0$, $Profit = 0$ to calculate the amount MAX_{Profit} for each supplier. As can be seen in Table II, may be a more than one supplier can provide the raw material. Score for each supplier is placed against a raw material what can provide. Rate this supplier is marked in red in Table II . The supplier is selected who earn more point. In the absence of suppliers have achieved the same score, a supplier is selected who has achieved more points of quality (Table I).

TABLE II
MATRIX OF SUPPLIER'S POINT

MAX_P	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8
S_1	24.98	0	0	0	0	0	0	0
S_2	26.2	0	26.2	0	0	0	0	0
S_3	26.2	0	26.2	0	0	0	0	0
S_4	0	26.2	0	0	0	0	0	0
S_5	0	17.86	0	0	0	0	0	0
S_6	0	22.43	0	0	0	0	0	0
S_7	0	0	24.86	0	0	0	0	0
S_8	0	0	0	19.86	0	0	0	0
S_9	0	0	0	17.86	0	0	0	0
S_{10}	0	0	0	26.2	0	0	0	0
S_{11}	0	0	0	0	25	0	0	0
S_{12}	0	0	0	0	17.86	0	0	0
S_{13}	0	0	0	0	17.86	0	0	0
S_{14}	0	0	0	0	0	24.14	0	0
S_{15}	0	0	0	0	0	26.2	0	0
S_{16}	0	0	0	0	0	26.4	0	0
S_{17}	0	0	0	0	0	0	17.86	0
S_{18}	0	0	0	0	0	0	24.86	0
S_{19}	0	0	0	0	0	0	26.2	0
S_{20}	0	0	0	0	0	0	0	26.2
S_{21}	0	0	0	0	0	0	0	26.2
S_{22}	0	0	0	0	0	0	0	26.4

Against the raw material and supplier selection in Table II, put $O_{i,s}=1$.(Table III)

In this case study is all cash purchases ($r_s = 0$) and returns the amount of material is zero ($G_i = 0$) . Production value has been investigated in a month (t=30).

TABLE III
MATRIX OF SUPPLIER SELECTION

$O_{i,s}$	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8
S_1	0	0	0	0	0	0	0	0
S_2	1	0	1	0	0	0	0	0
S_3	0	0	0	0	0	0	0	0
S_4	0	1	0	0	0	0	0	0
S_5	0	0	0	0	0	0	0	0
S_6	0	0	0	0	0	0	0	0
S_7	0	0	0	0	0	0	0	0
S_8	0	0	0	0	0	0	0	0
S_9	0	0	0	0	0	0	0	0
S_{10}	0	0	0	1	0	0	0	0
S_{11}	0	0	0	0	1	0	0	0
S_{12}	0	0	0	0	0	0	0	0
S_{13}	0	0	0	0	0	0	0	0
S_{14}	0	0	0	0	0	0	0	0
S_{15}	0	0	0	0	0	0	0	0
S_{16}	0	0	0	0	0	1	0	0
S_{17}	0	0	0	0	0	0	0	0
S_{18}	0	0	0	0	0	0	0	0
S_{19}	0	0	0	0	0	0	1	0
S_{20}	0	0	0	0	0	0	0	0
S_{21}	0	0	0	0	0	0	0	0
S_{22}	0	0	0	0	0	0	0	1

For product A : $F_j = dem_j = 5570$ meter
For product B : $F_j = dem_j = 580$ meter

The total amount of fees paid is **Min cost=162,023,500 RIALS**[1] for product A and product B (Table IV & Table V).

TABLE IV
PRODUCTION INFORMATION

materials	Maximum production	Product A	Product B
I_1	300000m/24 h	288.5	29
I_2	5000kg/24h	865.5	57
I_3	40000 kg/24h	865.5	0
I_4	1000000kg/24h	15002	1508
I_5	100000kg/24h	1442.5	145
I_6	20000kg/24h	1731	174
I_7	20000kg/24h	1154	116
I_8	20000kg/24h	1731	174

C_i = kilogram

TABLE V
PRODUCTION INFORMATION

Q^t_s		V^t_s
317.5	2,000	635,000
922.5	18,500	17,066,250
865.5	46,500	40,245,750
16510	5,350	88,328,500
1587.5	400	635,000
1905	4,000	7620,000
1270	1,100	1,397,000
1905	3,200	6,096,000
Min cost		162,023,500

Q^t_s =kilogram , P_i = RIAL, V_s^t = RIAL **(1$ U.S =** 10,454 RIAL) .

As shown in Figure 2 if a preliminary matter, the two providers will earn the same score, a supplier is selected who has more points of quality. (I_1 , I_3)

[1] Iran Money

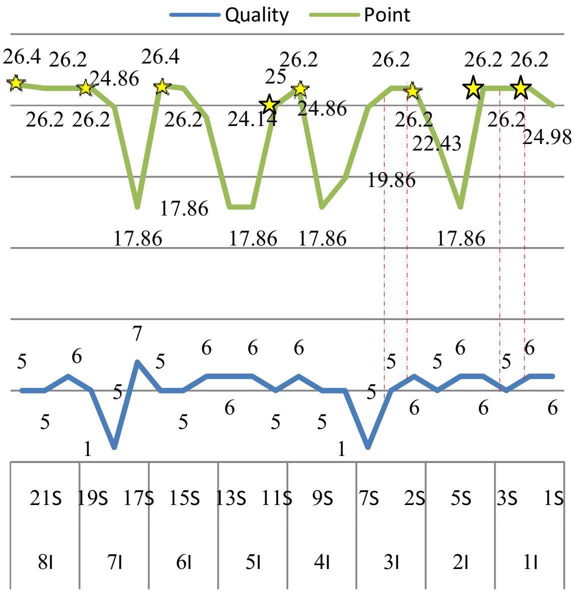

Fig. 2 Chart of Supplier Selection model

V. CONCLUSIONS

Select suppliers are difficult given the qualitative and quantitative criteria. This research is done in two phases. In the first, phase in a competitive environment to assess pay suppliers according to desired criteria. The second phase will determine the amount of the purchase of selected suppliers. Advantage of this algorithm can be pointed to the following:

Strategic vision in selecting suppliers, consider the qualitative and quantitative factors together, considering the amount of the order, storage capacity and production capacity as one of the selected parameters. This algorithm can be easily implemented with a spreadsheet package and its computation is fast. Therefore, the proposed model can be applied easily in practical situations. Expertise, experience, authority, and the responsibilities of decision makers are not equal in practice. Furthermore, in the mathematical model, the weights of internal and external criteria are determined by decision makers. It is useful to propose a scientific method for determining these weights. In addition, this paper has focused on manufacturing environment. Another future research may be the proposing mathematical model with stochastic parameters.

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