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Supplier Selection using Integer Linear Programming Model

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Abstract- Contemporary business organizations highly depend on outsourcing for success in today's competitive marketplace and selecting a suitable supplier is essential for developing new products. To ensure effective upstream management, supplier selection plays a key role in supply chain management. Nowadays to keep pace with the global competition, organizations tend to build a long-term relationship with the vendors. As a result, the direct and the indirect consequences of poor decision-making become more severe. There are a lot of methods to determine the best matched supplier for a particular product. In this study, at first, we have calculated the weighted values through MCDM process (Using AHP) for the different product for different vendors. Then we have proposed a vendor selection model using Integer Linear Programming (ILP) Model for multiproduct, multi-vendor environment. The research is intended to build up a generic model to be utilized in different scenarios in the decision making process according to the company's own preference. We check the validity of the model with a case study for managing the best suppliers for knit fabrics of a renowned textile industry of Bangladesh.

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I. Introduction

The supplier selection is a very crucial problem in today's highly dynamic business scenario involving many qualitative and quantitative criteria. Suppliers are considered as a key to a firm's ability to provide quality products in shorter time at lower costs and with greater flexibility and reduced risk [1]. The rise in outsourcing and off shoring practices due to globalization has also added to complexity of supplier selection problem. Moreover, the need to develop sustainable supply chain practices in organizations [2] [3] have made supplier selection problem even more challenging. Hence, in order to choose best suppliers, it is important to achieve a tradeoff between these criteria which may be conflicting in nature. Hence supplier selection is a multi-criteria decision making (MCDM) problem. We develop an integer linear programming (ILP) model for this purpose. Linear Programming (LP) is one the most widely used techniques in the world of optimization, where a particular objective function is developed for some unknown variables to be either maximized or minimized considering limitations or constraints. ILP is one of the LP techniques where the unknown variables are all bound to be integer numbers. There is another type of LP called the Binary Integer Programming (BIP), where the unknown variables can only be 0 or 1. This is, in fact, a special case of ILP. This special form gives the model a little more dimension in the process of decision making. The numbers in this case represent the selection choices instead of their arbitrary values. For instance, in our vendor selection method, the value for the corresponding unknown variable of a vendor signifies if the vendor is selected or not for supplying that particular product. The value 1 represents the selection of that vendor and the value 0 represents that the vendor is not selected. The model is developed to fit the preference of the company depending on their requirements and preference. In different circumstances, different vendors may be selected. There are multiple criteria that determine the optimized selection of the vendor. We develop this model keeping in consideration the weights of all the criteria and selecting the most optimal vendor to maximize profits and reduce risk in the overall purchasing process.

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II. Literature Review

There are a number of MCDM techniques applied in supplier selection process such as analytic hierarchy process (AHP) [4], analytic network process (ANP) [5], technique for order preference by similarity to ideal solution (TOPSIS) [6], Fuzzy set theory, elimination and choice expressing reality (ELECTRE), Preference ranking organization method for enrichment evaluation (PROMETHEE), data envelopment analysis (DEA), mathematical programming and their hybrids to supplier selection. There are plenty of supplier selection methods available in the literature. Linear Programming (LP) formulates the supplier selection problem in terms of a mathematical objective function which is a linear function that needs to be maximized (e.g., maximize profit, Productivity) or minimized (e.g., minimize costs, lead time). LP has some resource constraints which need to be satisfied. Some of the mathematical programming models [7] focus on the modeling of specific discounting environments. Akinc [8] concentrates on decision support regarding the number of vendors. Current and Weber use facility location model constructs for the vendor selection problem. Das

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function is to minimize the total cost of the wholesaling service by optimizing the selection of the manufacturer. Weber et al. [10] combine MP and the DEA method to negotiate with the vendors that are rejected to ensure the number of vendors to use. [11] Karpak et al. [12] use goal programming to minimize costs and maximize quality and delivery reliability when selecting vendors and allocating orders between them. Manoj Kumar et al. [13] develop a decision tool using multi-objective integer linear progr

III. Methodology

a) Assumptions

i. We didn't consider peak and off seasons for the process.

ii. We didn't account resource constraints or other constraints.

iii. We neglected some criteria for simplification of the case.

We considered only one decision maker.

b) General Model Formulation

Objective Function: The objective function represents the maximization of the preference weight.

$$Maximize\ Z = \sum_{i=1}^{n}\sum_{j=1}^{m} X_{ij} W_{ij}$$

Where,

$$i = Vendor\ index, i = 1,2,3 \dots \dots n$$

$$j = Product\ index, j = 1,2,3, \dots \dots m$$

$$X_{ij} = 1\ or\ 0, If\ it\ is\ 1\ then\ vendor\ 1\ is\ selected\ for\ product\ j.$$

$$W_{ij} = Preference\ weight\ of\ vendor\ i\ for\ product\ j$$

Constraints

Vendor constraint for each product:

$$\sum_{i=0}^{n} X_{ij} \geq P_j \qquad for\ j = 1,2,3, \dots \dots m$$

Maximum products that one vendor can provide:

$$\sum_{j=0}^{m} X_{ij} \leq Q_i \qquad for\ i = 1,2,3 \dots \dots n$$

Vendor availability constraint:

$$\sum_{i=1}^{n}\sum_{j=1}^{m} X_{ij} \leq R$$

Binary and non-negativity constraint:

$$X_{ij} = \{0\ or\ 1\}$$

Where,

$$P_j = Minimum\ requirement\ of\ vendors\ for\ product\ j$$

$$Q_i = Maximum\ number\ of\ products\ allocated\ to\ vendor\ j$$

$$R = Total\ number\ of\ products$$

c) Case study for supplier selection for four different products

There are four suppliers and four products to be selected. For each product, we applied AHP to rank the suppliers. We use All these weighted values are in the objective function.

$$\begin{aligned} Maximize\ Z = {} & 0.334X_{11} + 0.47X_{12} + 0.112X_{13} \\ & + 0.219X_{14} + 0.332X_{21} + 0.233X_{22} \\ & + 0.621X_{23} + 0.179X_{24} + 0.401X_{31} \\ & + 0.433X_{32} + 0.116X_{33} + 0.579X_{34} \\ & + 0.279X_{41} + 0.511X_{42} + 0.624X_{43} \\ & + 0.222X_{44} \end{aligned}$$

Constraints:

$$X_{11} + X_{21} + X_{31} + X_{41} \geq 1$$
$$X_{12} + X_{22} + X_{32} + X_{42} \geq 1$$
$$X_{13} + X_{23} + X_{33} + X_{43} \geq 1$$
$$X_{14} + X_{24} + X_{34} + X_{44} \geq 1$$
$$X_{11} + X_{12} + X_{13} + X_{14} \leq 3$$
$$X_{21} + X_{22} + X_{23} + X_{24} \leq 2$$
$$X_{31} + X_{32} + X_{33} + X_{34} \leq 2$$
$$X_{41} + X_{42} + X_{43} + X_{44} \leq 2$$

$$\begin{aligned} & X_{11} + X_{12} + X_{13} + X_{14} + X_{21} + X_{22} + X_{23} + X_{24} + X_{31} \\ & + X_{32} + X_{33} + X_{34} + X_{41} + X_{42} + X_{43} \\ & + X_{44} \leq 9 \end{aligned}$$

$$X_{11}, X_{12}, X_{13}, X_{14}, X_{21}, X_{22}, X_{23}, X_{24}, X_{31}, X_{32}, X_{33}, X_{34}, X_{41}, X_{42}, X_{43}, X_{44} = 0\ or\ 1$$

d) Solution and Result

The problem formulated in case study has been solved using excel solver. The solutions

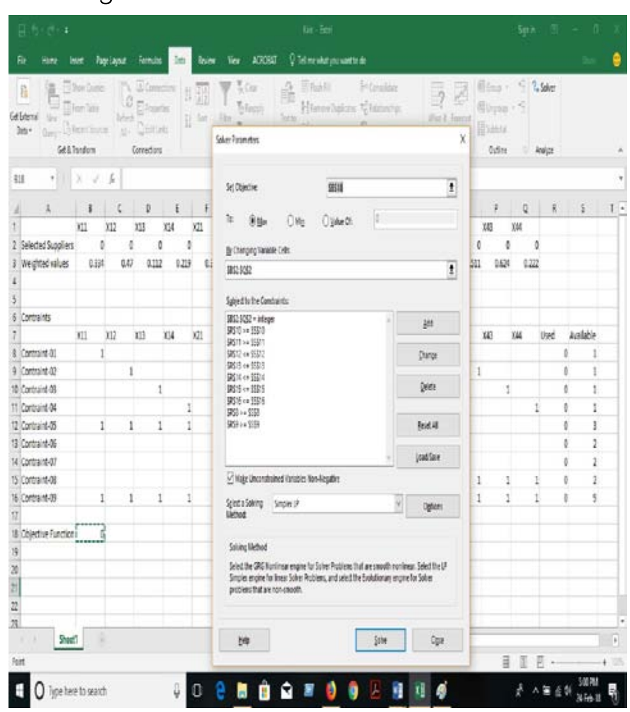

Figure 1: Excel solution for ILP problem is shown in fig 01 and fig-02.

Table 1: Summary of resul Summary of results is shown in table -01.

Products \ Suppliers	Supplier-01	Supplier-02	Supplier-03	Supplier-04
Product-01	1	0	0	0
Product-02	2	0	0	0
Product-03	0	2	0	2
Product-04	0	0	2	0

So, the company wants to select nine products from four suppliers. The result shows that product one and two are selected from vendor one, product three (two items each) is selected from two vendors (vendor two and vendor four) and product four (two items) is selected from vendor three.

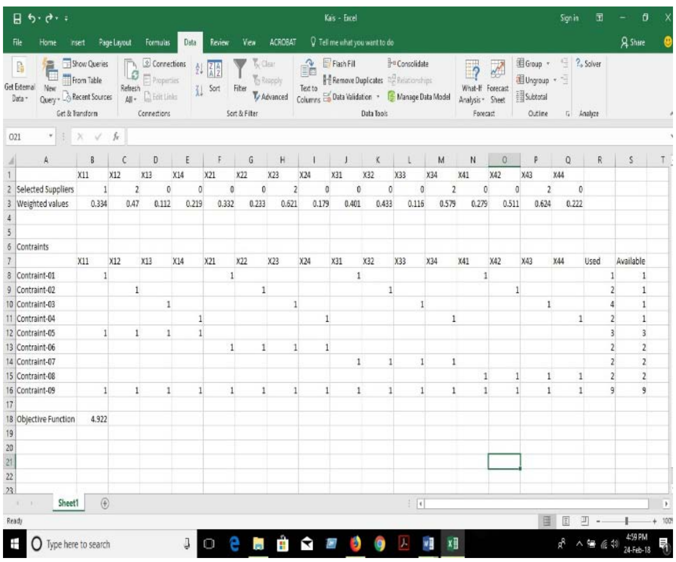

Figure 2: Final solution for ILP problem

IV. Conclusion

Vendor selection model using ILP is developed to select the vendors for a business environment having two-stage supply chain. The model is tested in knit fabrics wholesaler and is effectively working out. We can also use this model in real-life cases of other domains like automobile, textiles, electronic equipment and food industries. The model can be further improved by splitting the allocation of each product among vendors and by considering the limited capacity vendors. For more accuracy, periodic review of the key criteria should be conducted. The mathematical model used in this study work can be further extended towards multi-objective optimization to minimize overall procurement cost. Companies should choose the appropriate method for their problem according to the situation and the structure of the problem they have.

References Références Referencias

1. R. M. T. R. J. &. C. T. J. Monczka, "Supply base strategies to maximize supplier performance," International Journal of Physical Distribution & Logistics Management, vol. 23, no. 4, pp. 42-54, 1993.
2. C. R. &. R. D. S. Carter, "A framework of sustainable supply chain management: moving toward new theory," International Journal of Physical Distribution & Logistics Management, vol. 38, no. 5, pp. 360-387, 2008.
3. M. &. W. Z. Pagell, "Building a more complete theory of sustainable supply chain management using case studies of 10 exemplars," Journal of Supply Chain Management, vol. 45, no. 2, pp. 37-56, 2009.
4. W. a. X. X. a. D. P. K. Ho, "Multi-criteria decision making approaches for supplier evaluation and selection: A literature review," European Journal of operational research, vol. 202, no. 1, pp. 16--24, 2010.
5. C. a. G. D. Gencer, "Analytic network process in supplier selection: A case study in an electronic firm," Applied mathematical modelling, vol. 31, no. 11, pp. 2475--2486, 2007.
6. F. E. a. G. S. a. K. M. a. A. D. Boran, "A multi-criteria intuitionistic fuzzy group decision making for supplier selection with TOPSIS method," Expert Systems with Applications, vol. 36, no. 8, pp. 11363--11368, 2009.
7. F. F. a. Z. J. Chaudhry S.S., "Vendor selection with price breaks," European Journal of Operational Research, vol. 70, pp. 52-66, 1993.
8. A. U., "Selecting a set of vendors in a manufacturing environment," Journal of , vol. 11, pp. 107-122, 1993.
9. D. a. T. R, "Wholesaler: A Decision Support System for Wholesale," International Journal of Physical Distribution and Logistics Management,, vol. 24, no. 10, pp. 4-12, 1994.
10. C. J. a. D. A. Weber C.A., "Non-cooperative negotiation strategies for vendor selection," European Journal of Operational Research, vol. 108, pp. 208-223, 1998.
11. C. J. a. D. A. Weber C.A., "An optimization approach to determining the number of vendors to employ," Supply Chain Management: an International Journa, vol. 5, no. 2, pp. 90-98, 2000.

12. K. E. a. K. R. Karpak B., "An application of visual interactive goal programming: a case in vendor selection decisions," Journal of Multi-Criteria Decision Analysis, vol. 8, pp. 93-105, 1999.
13. M. V. P. a. R. s. Kumar, "A fuzzy programming approach for vendor selection problem in a supply chain," International Journal of Production Economic, vol. 101, no. 2, pp. 73-85, 2005.