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Integer Programming Model for Vendor Selection in Supply Chain Management

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Abstract

In this paper I have proposed a vendor selection model using Integer Linear Programming (ILP) Model for multi-product,multi-vendor companies. The contribution of this research lies in the implementation of this model as a customized decision support system according to the expectation of any company. The model is validated with a case study by implementing the model for agricultural equipments wholesale company.

Key Words

Vendor Selection, Integer Linear Programming (ILP) Model, Supply Chain, Vendor Assignment.

INTRODUCTION

ILP is a linear programming model in which there is a particular function to be maximized or minimized subject to several constraints. As the unknown variables are all required to be integers, then the problem is called an integer programming (IP) or integer linear programming (ILP) problem. 0-1 Integer programming or binary integer programming (BIP) is the special case of integer programming where variables are required to be 0 or 1 (rather than arbitrary integers). In ILP problem constraints force the variables to take on binary values only. Much of the modelling flexibility provided by integer linear programming is due to the use of 0-1 variables. In vendor selection, 0-1 variables provide selections or choices with the value of the variable equal to 1 if a vendor is assigned to supply a product and equal to 0 if the vendor is not assigned. The decision variables defined in this model will determine the allocation of the products to the vendors. In this paper, the integer linear programming (ILP) problem is applied to develop a supplier selection model that can fulfill the requirements of the company.

Supplier selection is widely considered to be one of the most important responsibilities of the purchasing function of management. An organization's suppliers directly affect the price, quality, delivery reliability, and availability of its products–all of which have a profound impact on customer satisfaction. Determining the most suitable suppliers is an important problem to deal with when managing supply chain of a company. The main objective of supplier selection process is to reduce purchase risk, maximize overall value to the purchaser, and develop closeness and long-term relationships between buyers and suppliers. It is vital in enhancing the competitiveness of the company and has a positive impact on expanding the lifespan of the company. There are several supplier selection applications available in the literature. Given an appropriate decision setting, Mathematical Programming (MP) allows the decision-maker to formulate the vendor selection problem in terms of a mathematical objective function that subsequently needs to be maximized (e.g., maximize profit) or minimized (e.g., minimize costs) by varying the values of the variables in the objective function (e.g., the amount ordered with vendor X).

$$V_1 \rightarrow \quad W_S \rightarrow C_1$$

$$V_2 \rightarrow W_S \rightarrow C_2$$

where, W_s - Wholesaler, V_i = Vendor and C_j = Customers

Two Stage Supply Chain

GENERAL VENDOR ASSIGNMENT PROBLEM USING ILP

Vendor selection problem is formulated using General Assignment Problem. The General Assignment Problem (Fred Glover et al., 2003) can be mapped onto the current vendor assignment problem defined in this paper. The preference of each vendor of all the products is found out by analytical hierarchy process. Since a product can be allocated to multiple vendors and a vendor can be assigned with multiple products, there is a scope for maximizing the preference weightage while doing this assignment. This is stated in the objective function of the mathematical model developed in this work. The base for this research is derived from John Rajan et al. (2007).

The required number of vendors for each item depends upon the requirement of the buying organization. This is considered as the first constraint. By considering the past performance of the vendor, the maximum number of products that can be allotted to each vendor is considered as the second constraint.

The total number of vendor assignments required for a set of products is considered as the third constraint. This mathematical model is formulated as an Integer Linear Programming model and it is presented below.

It can be observed that the most popular retail format in India is the 'supermarket', beside the corner shop/grocery store/'mom and pop' store. Hypermarkets have very recently come into being and are negligible in number though most retail chains do intend to expand their presence through this format as well. 'Discount chains' are also substantial in number and are growing at a fast pace through the country, predominantly in the southern region.

Decision Variable

X_{ij} = {1, vendor is allocated i to product j &
{0, otherwise

where,

i - Vendor index, i = 1, 2, ...T, T = Number of vendors in a set
j - Product index, j = 1, 2, ...M, M = Number of products in a set
W_{ij} - Preference weightage of vendor 'i' for product 'j'
N_j - Minimum requirement of vendors for product 'j'
O_i - Maximum number of products allocated to vendor 'i'
A - Total number of vendor assignments needed for 'M' number of products

Maximize $Z=\sum_{i=1}^{T}\sum_{j=1}^{M} X_{ij}W_{ij}$

where,

i - Vendor index, i = 1, 2, ...T, T = Number of vendors in a set
j - Product index, j = 1, 2, ...M, M = Number of products in a set
W_{ij} - Preference weightage of vendor 'i' for product 'j'
N_j - Minimum requirement of vendors for product 'j'
O_i - Maximum number of products allocated to vendor 'i'
A - Total number of vendor assignments needed for 'M' number of products

The objective function represents the maximization of the preference weightage. (W_{ij} - Preference weightage of vendor 'i' for the product 'j').

Subject to

$$Z=\sum_{i=1}^{T} X_{ij} > N_j \qquad j = 1, 2, 3................M$$

This constraint ensures the minimum requirement of the number of vendors for each product.

$$Z=\sum_{j=1}^{M} X_{ij} < O_i \qquad j = 1, 2, 3 \ldots\ldots\ldots\ldots T$$

This constraint ensures that the maximum permissible number of products is allocated to each vendor. The number of products allocated to each vendor is estimated based on the ratio of total preference weightage of individual vendor and total preference weightage of all the vendors multiplied by the total number of products in a set.

$$Z=\sum_{i=1}^{T} X_{ij} < A$$

This constraint ensures that the total number of vendor assignments does not exceed the availability.

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

This constraint enforces binary and non-negative restrictions on the decision variables

References

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