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Mathematical Programming Models in Sourcing context

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This compiled paper sets the ground on Supplier Decision making models explaining the broader classification amongst the models for supplier evaluation. The specific focus is on the Mathematical Programming models and gives a brief overview of the various popular methods getting covered under the discipline.

Introduction

Strategic sourcing as defined by the stalwarts in the industry is conscious effort of aligning the sourcing effort with the strategic objectives of the organization. As the interpretation suggests, there are numerous activities which would fall under the umbrella of strategic sourcing.

One of the important areas generally covered under strategic sourcing is Supplier Rationalization. Though in most cases it will be true, it is not always necessary that supplier rationalization would always be strategic initiative. But none the less, in the sourcing world, supplier rationalization is considered an important activity to undertake to have deeper relationships with your top performing suppliers, get rid of low performance to ensure your procurement risk is reduced from fulfillment perspective.

When we talk of identification of top performing suppliers and thus chucking out low performers, we have a sound methodology of supplier evaluation. While choosing any method for evaluation, two aspects need to be kept in mind. The first one is the parameters of evaluation and second one is the methodology by which these parameters will be evaluated. The choice of parameters will vary by the strategic objectives of the organization to ensure the model is context based for that organization. Lot of research has been done in this area with Dickson (1966) identifying 23 criterion/variables according to their relative importance in sourcing decisions. The choices of evaluation methodology however can be roughly grouped into four buckets.

1. Mathematical Programming Methods
2. Cost Based Methods
3. Multi-criterion Decision Methods
4. Simulation based Methods

Each of these sets of methods has strengths and weaknesses and the applicability of each of these would vary based on the context.

In this compiled paper, we will what different methods constitute the Mathematical Programming Models. The details provided here are at high level and it is recommended that the reader deep dive into each of these for better understanding.

Some of the popular methods under MP (Mathematical Programming) are

1. Linear Programming (LP)
2. Goal Programming (GP)
3. Multi-Objective Programming (MOP)
4. Economic Order Quantity (EOQ)
5. Mixed Integer Programming (MIP)

We will have a brief overview of each of these methods in order to understand the basics. The mathematical formulae and other deep mathematical references have been avoided in order to get high level overview.

Linear Programming (LP) [1]

Linear programming (LP; also called linear optimization) is a method to achieve the best outcome (such as maximum profit or lowest cost) in a mathematical model whose requirements are represented by linear relationships.

More formally, linear programming is a technique for the optimization of a linear objective function, subject to linear equality and linear inequality constraints. Its feasible region is a convex polytope, which is a set defined as the intersection of finitely many half spaces, each of which is defined by a linear inequality. Its objective function is a real-valued affine function defined on this polyhedron. A linear programming algorithm finds a point in the polyhedron where this function has the smallest (or largest) value if such a point exists.

Linear programming is a considerable field of optimization for several reasons. Many practical problems in operations research can be expressed as linear programming problems.

Goal Programming [2]

Goal Programming finds applicability in the sourcing scenarios where outcome is predefined and the criterion/constraints are quantifiable. This is an optimization program. It can be thought of as an extension or generalization of linear programming to handle multiple, normally conflicting objective measures. Each of these measures is given a goal or target value to be achieved. Unwanted deviations from this set of target values are then minimized in an achievement function. This can be a vector or a weighted sum dependent on the goal programming variant used. As satisfaction of the target is deemed to satisfy the decision maker(s), an underlying satisfying philosophy is assumed.

Goal programming is used to perform three types of analysis:

- Determine the required resources to achieve a desired set of objectives.
- Determine the degree of attainment of the goals with the available resources.
- Providing the best satisfying solution under a varying amount of resources and priorities of the goals.

A major strength of goal programming is its simplicity and ease of use. This accounts for a large number of goal programming applications in many and diverse fields. Linear Goal programs can be solved using linear programming software as either a single linear programs or in the case of the lexicographic variant, a series of connected linear programs.

Goal programming can hence handle relatively large numbers of variables, constraints and objectives. A debated weakness is the ability of goal programming to produce solutions that are not Pareto efficient. Pareto efficiency, or Pareto optimality, is a state of allocation of resources in which it is impossible to make any one individual better off without making at least one individual worse off.

Multi-Objective Programming (MOP) [3]

Multi-objective optimization (also known as multi-objective programming, vector optimization, multi-criteria optimization, multi attribute optimization or Pareto optimization) is an area of multiple criteria decision making, that is concerned with mathematical optimization problems involving more than one objective function to be optimized simultaneously. Multi-objective optimization has been applied in many fields of science, including engineering, economics and logistics (see the section on applications for detailed examples) where optimal decisions need to be taken in the presence of trade-offs between two or more conflicting objectives.

For a nontrivial multi-objective optimization problem, there does not exist a single solution that simultaneously optimizes each objective. In that case, the objective functions are said to be conflicting, and there exists a (possibly infinite) number of Pareto optimal solutions. A solution is called non dominated, Pareto optimal, Pareto efficient or non inferior, if none of the objective functions can be improved in value without degrading some of the other objective values. Without additional subjective preference information, all Pareto optimal solutions are considered equally good (as vectors cannot be ordered completely).

As there usually exist multiple Pareto optimal solutions for multi-objective optimization problems, what it means to solve such a problem is not as straightforward as it is for a conventional single-objective optimization problem. Therefore, different researchers have defined the term "solving a multi-objective optimization problem" in various ways. Many methods convert the original problem with multiple objectives into a single-objective optimization problem. This is called a scalarized problem. If scalarization is done carefully, Pareto optimality of the solutions obtained can be guaranteed.

Economic Order Quantity Model (EOQ) [4]

Economic order quantity (EOQ) is the order quantity that minimizes total inventory holding costs and ordering costs. It is one of the oldest classical production scheduling models.

EOQ applies only when demand for a product is constant over the year and each new order is delivered in full when inventory reaches zero. There is a fixed cost for each order placed, regardless of the number of units ordered. There is also a cost for each unit held in storage, commonly known as holding cost, sometimes expressed as a percentage of the purchase cost of the item.

We want to determine the optimal number of units to order so that we minimize the total cost associated with the purchase, delivery and storage of the product.

The required parameters to the solution are the total demand for the year, the purchase cost for each item, the fixed cost to place the order and the storage cost for each item per year. Note that the number of times an order is placed will also affect the total cost, though this number can be determined from the other parameters.

Several extensions can be made to the EOQ model developed by Pankaj Mane, including backordering costs and multiple items. Additionally, the economic order interval can be determined from the EOQ and the economic production quantity model (which determines the optimal production quantity) can be determined in a similar fashion.

A version of the model, the Baumol-Tobin model, has also been used to determine the money demand function, where a person's holdings of money balances can be seen in a way parallel to a firm's holdings of inventory.

Mixed Integer Programming (MIP) [5]

MIP is a variant of integer linear programming

An integer linear programming problem is a mathematical optimization or feasibility program in which some or all of the variables are restricted to be integers. In many settings the term refers to integer linear programming (ILP), in which the objective function and the constraints (other than the integer constraints) are linear. Integer programming is NP-hard.

Mixed integer linear programming (MILP) involves problems in which only some of the variables, xi, are constrained to be integers, while other variables are allowed to be non-integers.

Summary

This compiled paper sets the ground on Supplier Decision making models explaining the broader classification amongst the models for supplier evaluation. The specific focus is on the Mathematical Programming models and gives a brief overview of the various popular methods getting covered under Mathematical Programming discipline.

References

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