Solving Supply Chain Network Design Problem using Center of Gravity Location Model for Pump Manufacturing Companies

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Abstract - *A supply chain network can be strategically designed in such a way as to reduce the cost of the supply chain; it has been suggested by experts that 80% of supply chain costs are determined by location of facilities and the flow of product between the facilities. Supply chain network design is sometimes referred to as 'Network Modelling'. Companies have been led to modify their basic supply chain, investing in the tools and resources to develop an improved SCN design that takes into account taxation regulations, new entrants into their industry and availability of resources, has resulted in more complex network designs .Designing a SCN involves creating a network that incorporates all the facilities, means of production, products, and transportation assets owned by the organisation or those not owned by the organisation but which immediately support the supply chain operations and product flow. The design should also include details of the number and location of facilities: plants, warehouses, and supplier base. Therefore, it can be said that a SCN design is the combination of nodes with capability and capacity, connected by lanes to help products move between facilities. Gravity location models can be useful when identifying suitable geographic locations within a region. Gravity models are used to find locations that minimize the cost of transporting raw materials from suppliers and finished goods to the markets served. In this paper we discuss a typical scenario in which gravity models can be used.*

Key Words: **Supply chain, Network modelling, Gravity location Model, Transport, Geographic**

1. INTRODUCTION

A company might consider investing in the construction of new facilities for a variety of reasons, such as, increasing its production capacity of an existing product, or extending its product range by new product introduction, or entering new markets with the existing and/ or new products. Here facility refers to the smallest productive entity that manufactures a single commodity (or, at most a single family of commodities). A plant however, refers to a collection of facilities in the same location, and hence in general will be producing multiple commodities. Construction of a new facility therefore, might mean expansion of an existing plant if it takes place at that site, or otherwise would require opening a new plant. In many investment projects, decisions regarding the location and the size of a new facility to be established are interrelated since capacity acquisition costs are location dependent. A typical example is new facility investments in the international context, where subsidized financing as well as low tax rates are provided by the national governments to attract the multinational companies to locate production plants in their country. In this case, it is clear that not only the fixed costs that occur due to opening the new facility at a particular site but also the capacity acquisition costs that vary with the size of the new facility are location specific A manager identifies potential locations in each region where the company has decided to locate a plant. As a preliminary step, the manager needs to identify the geographic location where potential sites may be considered. Gravity location models can be useful when identifying suitable geographic locations within a region. Gravity models are used to find locations that minimize the cost of transporting raw materials from suppliers and finished goods to the markets served. Next, we discuss a typical scenario in which gravity models can be used.

2. LITERATURE REVIEW

Anand Jayakumar A and Krishnaraj C [1] have created a mathematical revenue model for multiple customer segments. Anand Jayakumar A et al [2] have optimized a p median problem using python. Anand Jayakumar A et al [3] have optimized a fixed charge problem using python. Anand Jayakumar A and Krishnaraj C [4] have created a mathematical model for pricing and revenue management of perishable assets. Anand Jayakumar A and Krishnaraj C [5] have suggested on implementation of quality circle. Anand Jayakumar A et al [6] have suggested a mixed strategy for aggreage planning. Anand Jayakumar A et al [7] have created a mathematical model for aggregate planning. Anand Jayakumar A et al [8] have created a mathematical model for supply chain network design. Anand Jayakumar A et al [9] have created a mathematical model for aggregate planning for a pump manufacturing company. Anand Jayakumar A et al [10] have improved productivity in a stitching section. Anand Jayakumar A et al [11] have created another model for aggregate planning. Anand Jayakumar A et al [12] have reviewed on the mathematical models for supply chain network design. Anand Jayakumar A et al [13] have created a chase strategy for aggregate production planning. Anand Jayakumar A and Krishnaraj C [14] have created a mathematical model for supply chain network optimization using gravity location method. Krishnaraj C et al [15] have solved a supply chain network optimization model. Anand Jayakumar A et al [16] have presented a supply chain location allocation problem in multiple stages and dedicated supply. Anand Jayakumar A et al [17] have presented a facility layout problem.

3. WHAT IS LINGO?

LINGO is a simple tool for utilizing the power of linear and nonlinear optimization to formulate large problems concisely, solve them, and analyze the solution. Optimization helps you find the answer that yields the best result; attains the highest profit, output, or happiness; or achieves the lowest cost, waste, or discomfort. Often these problems involve making the most efficient use of your resources—including money, time, machinery, staff, inventory, and more. Optimization problems are often classified as linear or nonlinear, depending on whether the relationships in the problem are linear with respect to the variables. LINGO includes a set of built-in solvers to tackle a wide variety of problems. Unlike many modeling packages, all of the LINGO solvers are directly linked to the modeling environment. This seamless integration allows LINGO to pass the problem to the appropriate solver directly in memory rather than through more sluggish intermediate files. This direct link also minimizes compatibility problems between the modeling language component and the solver components. Local search solvers are generally designed to search only until they have identified a local optimum. If the model is non-convex, other local optima may exist that yield significantly better solutions. Rather than stopping after the first local optimum is found, the Global solver will search until the global optimum is confirmed. The Global solver converts the original non-convex, nonlinear problem into several convex, linear subproblems. Then, it uses the branch-and-bound technique to exhaustively search over these subproblems for the global solution. The Nonlinear and Global license options are required to utilize the global optimization capabilities.

4. THE MODELING FRAMEWORK

Gravity models assume that both the markets and supply sources can be located as grid points on a plane. All distances are calculated as the geometric distance between two points on the plane. These models also assume that the transportation costs grows linearly with the quantity shipped. We discuss a gravity model for locating a single facility that receives raw material from the supply sources and ships finished product to markets. The basic input to the model are as follows:

xn, yn = coordinate location of either a market or supply source n

Fn = cost of shipping one unit for one mile between the facility and either market or supply source n

Dn = quantity to be shipped between facility and market or supply source n

If (x,y) is the location selected for the facility, the distance dn between the facility at location (x,y) and the supply source or market n is given by

$$\sqrt{(x-x_n)^2+(y-y_n)^2}$$

the total transportation cost (TC) is given by

$$TC=\sum_{n=1}^{k} d_n D_n F_n$$

The optimal solution is one that minimizes the total TC in equ

5. DATA COLLECTION

The data was collected from four different companies in Coimbatore district of Tamil Nadu, India.

- Best Engineers Pumps (India) Pvt Ltd
- Alpha Pump Industry (India) Pvt Ltd
- Asthra Pumps (India) Pvt Ltd
- Sigma Pump Industry (India) Pvt Ltd

6. RESULT AND DISCUSSION

For Best Engineers pumps company the place Aasara, Durg district, Chattisgarh state is the new location of ware house based on geographical data collected from the existing distribution centres for that company and its latitude is 20.88º ,longitude is 81.03º. For Alpha pump company the region Lakkumanaicken Patti, Tirupur, Tamilnadu is the new location of ware house based on geographical data collected from the existing distribution centres for that company and its latitude is 10.87º ,longitude is 77.65º. For Asthra pump company the region Kalamarahalli, Chitradurga District, Karnataka state is the location for new warehouse based on geographical data collected from the existing distribution centres for that company and its latitude is 14.11º ,longitude is 76.77º thereby we can reduce the transportation cost and time for transportation. For Sigma pump company the region Matar, Kheda District, Gujarat state is the new location for warehouse based on geographical data collected from the existing distribution centres for that company and its latitude is 22.06º , longitude is 73.01º.

7. CONCLUSION

From this project we determined the location of new warehouses for four pump manufacturing companies by solving supply chain network design problem using centre of gravity location model in Lingo 12.0 software hence wereduce the transportation cost for supplying pumps to various dealers.

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