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Supply Chain Design of Location and Allocation in Multiple Stages

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Abstract

In this article we design a supply chain with location and allocation in multiple stages. The data is collected based on a pump manufacturing company. It is then mathematically modeled and the model is optimized using LINGO software. The result is discussed with the management and readied for implementation.

Keywords: *supply chain, location, allocation, mathematical model, LINGO.*

1. Introduction

A supply chain is a set of activities which involve the collection of raw materials, production of products and distribution of the products to the customers within and external to the chain. Supply chain management is managing the flows between the stages to maximize profitability. The value a supply chain generates is the difference between the value of the final product and the costs the chain incurs in filling the customer order. Facility location problems also known as location analysis is a branch of operations research and computational geometry concerned with the optimal placement of facilities to minimize transportation costs. Optimization is the action of making the best or most effective use of a situation or a resource. Linear programming is a method to achieve the best outcome in a mathematical model whose requirements are represented by linear relationships.

2. Literature Review

Li Xia et al [1] have solved the banking facility location practical problem, by appling an existing hybrid nested partitions algorithm to the large-scale situation. Seyyed Amin et al [2] have discussed the current literature concerning the sustainability aspects of the location problem. Lucia Cazabal-Valencia et al [3] considered the ellipsoid as a more appropriate model of the Earth's surface and adapts the facility location problem to address this assumption. Moses Charikar and Sudipto Guha [4] present improved combinatorial approximation algorithms for the uncapacitated facility location problem. Ta-Chung Chu [5] presented a fuzzy TOPSIS model under group decisions for solving the facility location selection problem. Wei Gu et al [6] presents a new methodology for solving the Preventive Health Care Facility Location problem. A. Shahandeh Nookabadi et al [7] have proposed MIP model considers capacity of facilities and links as decision variables. Anand Jayakumar A and Krishnaraj C [8] have created a mathematical revenue model for multiple customer segments. Anand Jayakumar A et al [9] have optimized a p median problem using python. Anand Jayakumar A et al [10] have optimized a fixed charge problem using python. Anand Jayakumar A and Krishnaraj C [11] have created a mathematical model for pricing and revenue management of perishable assets. Anand Jayakumar A and Krishnaraj C [12] have suggested on implementation of quality circle. Anand Jayakumar A et al [13] have suggested a mixed strategy for aggreage planning. Anand Jayakumar A et al [14] have created a mathematical model for aggregate planning. Anand Jayakumar A et al [15] have created a mathematical model for supply chain network design. Anand Jayakumar A et al [16] have created a mathematical model for aggregate planning for a pump manufacturing company. Anand Jayakumar A et al [17] have improved productivity in a stitching section. Anand Jayakumar A et al [18] have created another model for aggregate planning. Anand Jayakumar A et al [19] have reviewed on the mathematical models for supply chain network design. Anand Jayakumar A et al [20] have created a chase strategy for aggregate production planning. Anand Jayakumar A and Krishnaraj C [21] have created a mathematical model for supply chain network optimization using gravity location method. Krishnaraj C et al [22] have solved a supply chain network optimization model. Anand Jayakumar A et al [23] have presented a supply chain location allocation problem in multiple stages and dedicated supply. Anand Jayakumar A et al [24] have presented a facility layout problem.

3. The Problem

Let us consider a two-stage location-allocation problem. Here we assume that the products are made in factories, transported to warehouses from which they are transported to the customers. A typical supply chain consists of 3 factories, 3 warehouses and 4 customers.

Each plant has a capacity Pi. Each warehouse has a capacity of Zj. There is a fixed cost fi of creating and operating plant i and a fixed cost gj of creating and operating warehouse j. There is a unit transportation cost Cij between plant i and warehouse j and a unit transportation cost of Cjk between warehouse j and customer k. The problem is to locate plants and warehouses and transport the product such that the total cost of location and allocation is minimized.

The mathematical programming formulation of the problem is as follows:

Let Yi = 1 if plant i is opened.

Let Wj = 1 if warehouse j is opened.

Let Xij be the quantity of the product transported from plant i to warehouse j.

Let Tjk be the quantity of the product transported from warehouse j to customer k.

The objective function is to minimize the total cost of location and allocation. This is to

Min $\sum_{i=1}^{m} fiYi + \sum_{j=1}^{p} gjWj + \sum_{i=1}^{m} \sum_{j=1}^{p} Cij\, Xij + \sum_{j=1}^{p} \sum_{k=1}^{n}$ Cjk Tjk

Subject to

$\sum_{j=1}^{p} Xij \leq$ Pi Yi for every i

$\sum_{i=1}^{m} Xij \geq \sum_{k=1}^{n} Tjk$ Wj for every j

$\sum_{j=1}^{p} Tjk >$ Dk for every k

Yi, Wj = 0,1

Xij, Tjk $\geq$ 0

4. Input Data

Table 1: Transportation cost between plants and warehouses.

	W1	W2	W3
Plant 1	4	5	4.5
Plant 2	3	3.6	4
Plant 3	4.2	5	4.5

Table 2: Transportation cost between warehouses and customers.

	C1	C2	C3	C4
Warehouse1	2	1.8	2.2	3
Warehouse2	4	3.8	3.2	3.6
Warehouse3	2.4	2	2.3	2

The capacities of the three potential plants are 3000, 2000 and 2600 units. The fixed costs for the plants are Rs 8000, Rs 7000 and Rs 9000 respectively. The capacities of the three potential warehouses are 2500, 2400 and 2000 units. The fixed costs for the warehouses are Rs 5000, Rs 6000 and Rs 4000 respectively. The demands at the customers are 1000, 800, 1200 and 900 units.

The problem is to solve the two-stage location-allocation model to minimize the sum of fixed costs and the transportation costs.

5. LINGO Program

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Model:

F1 = 8000; F2 = 7000; F3 = 9000;
G1 = 5000; G2 = 6000; G3 = 4000;
P1 = 3000; P2 = 2000; P3 = 2600;
Z1 = 2500; Z2 = 2400; Z3 = 2000;
D1 = 1000; D2 = 800; D3 = 1200; D4 =
900;

C11 = 4; C12 = 5; C13 = 4.5;
C21 = 3; C22 = 3.6; C23 = 4;
C31 = 4.2; C32 = 5; C33 = 4.5;

E11 = 2; E12 = 1.8; E13 = 2.2; E14 = 3;
E21 = 4; E22 = 3.8; E23 = 3.2; E24 =
3.6;
E31 = 2.4; E32 = 2; E33 = 2.3; E34 = 2;

MIN = F1*Y1 + F2*Y2 + F3*Y3 + G1*W1 +
G2*W2 + G3*W3
    + C11*X11 + C12*X12 + C13*X13
    + C21*X21 + C22*X22 + C23*X23
    + C31*X31 + C32*X32 + C33*X33
    + E11*T11 + E12*T12 + E13*T13 +
E14*T14
    + E21*T21 + E22*T22 + E23*T23 +
E24*T24
    + E31*T31 + E32*T32 + E33*T33 +
E34*T34;

X11 + X12 + X13 < P1*Y1;
X21 + X22 + X23 < P2*Y2;
X31 + X32 + X33 < P3*Y3;

X11 + X21 + X31 > T11*W1 + T12*W1 +
T13*W1 + T14*W1;
X12 + X22 + X32 > T21*W2 + T22*W2 +
T23*W2 + T24*W2;
X13 + X23 + X33 > T31*W3 + T32*W3 +
T33*W3 + T34*W3;

T11 + T21 + T31  > D1;
T12 + T22 + T32  > D2;
T13 + T23 + T33  > D3;
T14 + T24 + T34  > D4;
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T11 + T12 + T13 + T14 < Z1*W1;
T21 + T22 + T23 + T24 < Z2*W2;
T31 + T32 + T33 + T34 < Z3*W3;

@BIN(Y1); @BIN(Y2);@BIN(Y3);
@BIN(W1); @BIN(W2);@BIN(W3);

X11 > 0; X12 > 0; X13 > 0;
X21 > 0; X22 > 0; X23 > 0;
X31 > 0; X32 > 0; X33 > 0;

T11 > 0; T12 > 0; T13 > 0; T14 > 0;
T21 > 0; T22 > 0; T23 > 0; T24 > 0;
T31 > 0; T32 > 0; T33 > 0; T34 > 0;

END
```

6. Result and Discussion

The plants Y1 and Y2 are opened.
The warehouses W1 and W3 are opened.
Table 1 shows the amount of products transported from plants to warehouse. Table 2 shows the amount of products transported from warehouse to customers. Fig 1 shows the final result.

Table 1: From plant to warehouse

	W1	W2	W3
Y1	500	0	1400
Y2	2000	0	0
Y3	0	0	0

Table 2: From warehouse to customers

	C1	C2	C3	C4
W1	1000	800	700	0
W2	0	0	0	0
W3	0	0	500	900

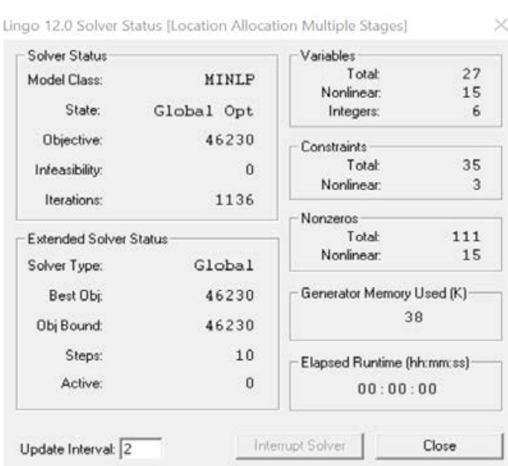

Fig 1: Result

7. Conclusion

Thus the problem is solved using LINGO software.

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