Supply Chain Location Allocation in Multiple Stages and Dedicated Supply

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Abstract - *This paper presents a supply chain location allocation problem in multiple stages and dedicated supply. Here in this problem there are only two stages. Location of plant and location of warehouse are taken into consideration. For the customers they are satisfied by one one warehouse. No two warehouses are used to satisfy the any one customer demand. The problem was mathematically modelled and solved using LINGO software.*

Key Words: Location Allocation, LINGO, Multiple Stages, Supply Chain.

1. INTRODUCTION

A simple definition for a supply chain is that it is a set of organizations engaged in the delivery of a product or service to the customer or the end user. A supply chain consists of stages (eg suppliers, manufacturers, distributors, retailers and customers) which are physically different and geographically spaced out where inventory is kept or converted into value. Supply chain management integrates suppliers, manufacturers, warehouses and stores so that products are distributed in the right quantities to the right locations at the right time. The objective of every supply chain is to maximize the overall value generated. Organizations that successfully apply good supply chain practices usually incur lower costs than their competitors. A survey conducted in 2001 by the Supply Chain Council in the US found that on an average organizations spent about 11% of revenue on supply chain management. In contrast the corresponding figure for best-in-class organizations was between 3% and 6%. The impact of these numbers can be understood from the fact that supply chain management costs accounted for approximately 9.5% of the GDP of the US that year. A reduction of 5% in tese costs would result in a saving of about US $50 billion.

In addition, logistics is only one of the many cost components in the supply chain. If other costs such as order processing, materials acquisition and inventory, supply chain planning, supply chain financing and information management costs are considered, the potential savings from effective supply chain management would be much higher. Further more these figures do not consider a multitude of hidden or unknown costs. They also do not consider the possible benefits. These figures do not consider for example the increased market-share potential for supply chains that are able to respond faster to customer needs. Facility location is the right location of facilities so that it has sufficient access to customers, workers, transportation etc. Optimization is finding the right alternative with the most cost effective or highest achievable performance under the given constraints; by maximizing desired factors and minimizing the undesired ones. Linear programming is a mathematical technique for maximizing or minimizing a linear function of several variables such as output or cost.

2. LITERATURE REVIEW

Rattan Rana and Deepak Garg [1] have determined an optimal solution for the obnoxious facility location problem. C G Chentnik [2] had done a review of papers on fixed facility location techniques. R.P. Manatkar et al [3] have presented an integrated inventory distribution optimization model for multiple products in a multi-echelon supply chain environment. Riccardo Manzini and Elisa Gebennini [4] developed and .applied innovative mixed integer programming optimization models to design and manage dynamic (i.e. multi-period) multi-stage and multi-commodity location allocation problems. M.T. Melo et al [5] have identified basic features that models must capture to support decision-making involved in strategic supply chain planning. Susan Hesse Owen and Mark S. Daskin [6] reported on literature which explicitly addresses the strategic nature of facility location problems by considering either stochastic or dynamic problem characteristics. Zuo-Jun Max Shen et al [7] have study a reliable facility location problem wherein some facilities are subject to failure from time to time. 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.

3. THE MATHEMATICAL MODEL

There are situations where all the demands of a customer can be met from a single warehouse. The formulation becomes slightly different. The formulation where all the demands of a customer are met from a single warehouse is as follows:

Let $Y_i = 1$ if plant i is opened.

Let $W_j = 1$ if warehouse j is opened

Let $T_{jk} = 1$ if the demand for customer k is met entirely from warehouse j

Let X_{ij} be the quantity of the product transported from plant i to warehouse j.

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

Minimize $\sum_{i=1}^{m} fiyi + \sum_{j=1}^{p} gjWj + \sum_{i=1}^{m}\sum_{j=1}^{p} CijXij + \sum_{j=1}^{p}\sum_{k=1}^{n} dkCjkTjk$

Subject to

$\sum_{j=1}^{p} Xij \leq PiYi$ Ұi

$\sum_{i=1}^{m} Xij > \sum_{k=1}^{n} dkTjkWj$ Ұ j

$\sum_{j=1}^{p} Tjk = 1$ Ұ k

$Y_i, W_j, T_{jk} = 0,1$

$X_{ij} \geq 0$

4. THE PROBLEM

Consider a two stage network. The unit cost of transportation from the plants to the warehouses is given in the table 1 below.

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

The unit cost of transportation from the warehouse to the customers is given in the table 2 below.

Table-2: Transportation cost between warehouse and customers

	C1	C2	C3	C4
WH1	2	1.8	2.2	3
WH2	4	3.8	3.2	3.6
WH3	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 aim is to solve a two-stage location allocation model to minimize the sum of fixed costs and the transportation costs.

5. SYSTEM CONFIGURATION

The problem was solved in a system with Windows 10 operating system. Intel i7 8th generation processor was used with 16 GB RAM. LINGO version 12 software package was used for solving the problem as shown in Fig 1 below.

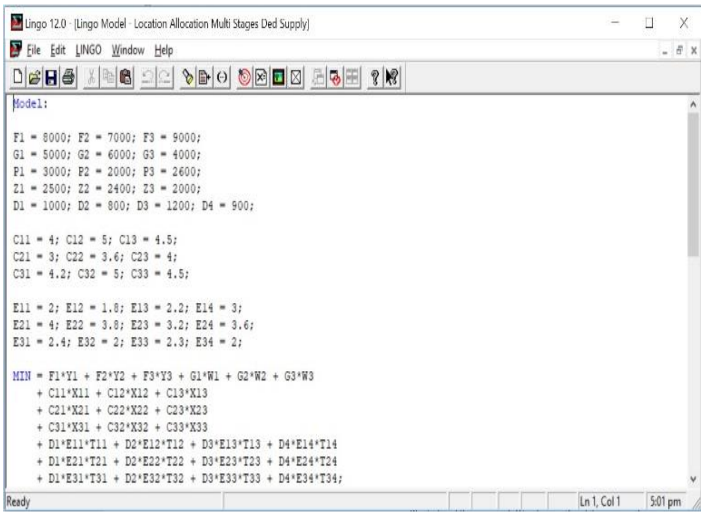

Fig-1: LINGO Software.

6. LINGO

LINGO is a simple tool for solving linear and non linear optimization problems and also to analyze them. Optimization problems are generally classified into linear and non linear problems based on the relationship with the variables whether it is linear or non linear. LINGO uses a set of built in solvers to solve a wide variety of problems. Local solvers are used to solve till a local optima in reached. There may be a number of local optima. 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.

7. 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
  + D1*E11*T11 + D2*E12*T12 + D3*E13*T13 +
D4*E14*T14
  + D1*E21*T21 + D2*E22*T22 + D3*E23*T23 +
D4*E24*T24
  + D1*E31*T31 + D2*E32*T32 + D3*E33*T33 +
D4*E34*T34;

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

X11 + X21 + X31 > D1*T11*W1 + D2*T12*W1 +
D3*T13*W1 + D4*T14*W1;
X12 + X22 + X32 > D1*T21*W2 + D2*T22*W2 +
D3*T23*W2 + D4*T24*W2;
X13 + X23 + X33 > D1*T31*W3 + D2*T32*W3 +
D3*T33*W3 + D4*T34*W3;

T11 + T21 + T31  = 1 ;
T12 + T22 + T32  = 1 ;
T13 + T23 + T33  = 1 ;
T14 + T24 + T34  = 1 ;
Z1 > D1*T11*W1 + D2*T12*W1 + D3*T13*W1 +
D4*T14*W1;
Z2 > D1*T21*W2 + D2*T22*W2 + D3*T23*W2 +
D4*T24*W2;
Z3 > D1*T31*W3 + D2*T32*W3 + D3*T33*W3 +
D4*T34*W3;

P1*Y1 + P2*Y2 + P3*Y3 > D1 + D2 + D3 + D4;
Z1*W1 + Z2*W2 +Z3*W3 > D1 + D2 + D3 + D4;

@BIN(Y1); @BIN(Y2);@BIN(Y3);
@BIN(W1); @BIN(W2);@BIN(W3);
@BIN(T11);@BIN(T12);@BIN(T13);@BIN(T14);
@BIN(T21);@BIN(T22);@BIN(T23);@BIN(T24);
@BIN(T31);@BIN(T32);@BIN(T33);@BIN(T34);

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

END
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8. RESULT AND DISCUSSION

Plants 1 and 2 are opened. Warehouses 2 and 3 are opened.

This is the optimum solution to the problem.

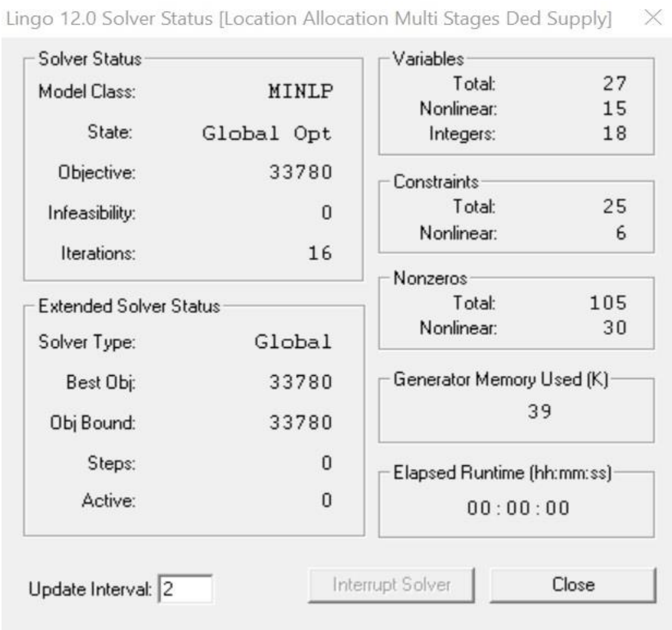

Fig-2: Result in LINGO

A global optimum of Rs 33780 was obtained as shown in Fig 2.

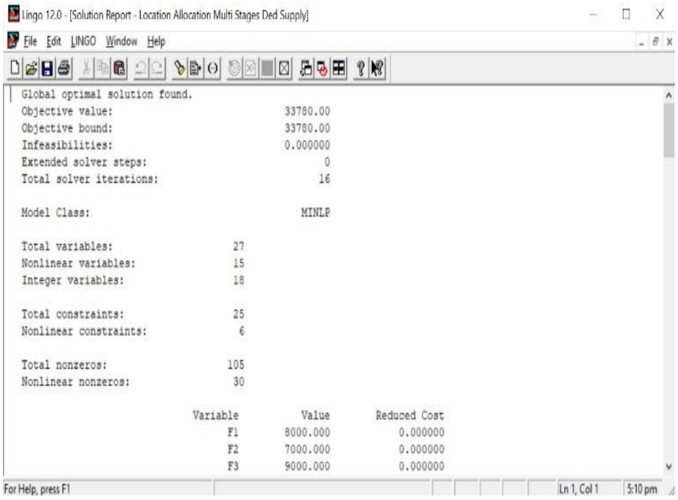

Fig-3: Final solution.

9. CONCLUSION

Thus we have solved the supply chain location and allocation in multiple stages and dedicated supply problem.

REFERENCES

[1] Rattan Rana and Deepak Garg, "Algorithm for Obnoxious Facility Location Problem", International Journal of Advancements in Technology, Vol 5, No 2, pp 96 – 106.

[2] C G Chentnik, "Fixed Facility Location Technique", Physical Distribution, Vol 4, Issue 1, pp 16 – 25.

[3] R.P. Manatkar, Kondapaneni Karthik, Sri Krishna Kumar & Manoj Kumar Tiwari, "An integrated inventory optimization model for facility location-allocation problem", International Journal of Production Research, Vol 54, Issue 12, pp 3640-3658.

[4] Riccardo Manzini and Elisa Gebennini, "Optimization models for the dynamic facility location and allocation problem", International Journal of Production Research, Vol 46, Issue 8, pp 2061–2086.

[5] M.T. Melo, S. Nickel, F. Saldanha-da-Gama, "Facility location and supply chain management – A review", European Journal of Operational Research, Vol 196, pp 401 – 412.

[6] Susan Hesse Owen, Mark S. Daskin, "Strategic facility location: A review", European Journal of Operational Research, Vol 111, pp 423-447.

[7] Zuo-Jun Max Shen, Roger Lezhou Zhan, Jiawei Zhang, "The Reliable Facility Location Problem: Formulations, Heuristics, and Approximation Algorithms", INFORMS Journal on Computing, Vol. 23, No. 3, pp. 470–482.

[8] Anand Jayakumar A and Krishnaraj C, "Lingo Based Pricing And Revenue Management For Multiple Customer Segments",ARPN Journal of Engineering and Applied Sciences, Vol 10, NO 14, August 2015, pp 6167-6171.

[9] Anand Jayakumar A, Krishnaraj C and Aravith Kumar A, "Optimization of P Median Problem in PythonUsing PuLP Package", International Journal of Control Theory and Applications, Vol 10, Issue 2, pp. 437-442, 2017

[10] Anand Jayakumar A, Krishnaraj C and Raghunayagan P, "Optimization of Fixed Charge Problem in Python using PuLP Package", International Journal of Control Theory and Applications, Vol 10, Issue 2, pp. 443-447, 2017

[11] Anand Jayakumar A, Krishnaraj C, "Pricing and Revenue Management for Perishable Assets Using LINGO", International Journal of Emerging Researches in Engineering Science and Technology, Vol 2, Issue 3, April 2015, pp 65-68.

[12] Anand Jayakumar A, Krishnaraj C, "Quality Circle – Formation and Implementation", International Journal of Emerging Researches in Engineering Science andTechnology, Vol 2, Issue 2, March 2015.

[13] Anand Jayakumar A, Krishnaraj C, A K Nachimuthu, "Aggregate Production Planning: Mixed Strategy", Pakistan Journal of Biotechnology, Vol 14, Issue 3, 2017

[14] Anand Jayakumar A, Krishnaraj C, and S. R. Kasthuri Raj, "Lingo Based Revenue Maximization Using Aggregate Planning", ARPN Journal of Engineering and Applied Sciences, Vol. 11, NO. 9, MAY 2016, pp .6075-6081

[15] Anand Jayakumar A, Krishnaraj C, Aravinth Kumar A, "LINGO Based Supply Chain Network Design", Journal of Applied Sciences Research, Vol 11, No 22, pp 19-23, Nov 2015.

[16] Anand Jayakumar A, Krishnaraj C, Aravinth Kumar A, "Aggregate Production Planning For A Pump Manufacturing Company: Level Strategy", International Research Journal of Engineering and Technology, Volume 4, Issue 12, December 2017

[17] Anand Jayakumar A, Krishnaraj C, Aravinth Kumar A,"Productivity Improvements in Stitching Section of a Garment Manufacturing Company",International Journal of Innovative Research in Advanced Engineering, Volume 4, Issue 12, December 2017

[18] Anand Jayakumar A, Krishnaraj C, Balakrishnan S, "Solving Aggregate Planning Problem Using LINGO", International Journal of Innovative Science,

Engineering and Technology, Volume 4, Issue 12, December 2017

[19] Anand Jayakumar A, Krishnaraj C, Raghunayagan P, "A Review of Mathematical Models for Supply Chain Network Design", International Journal of Innovative Research in Advanced Engineering, Volume 4, Issue 12, December 2017.

[20] Anand Jayakumar A, Krishnaraj C, Raghunayagan P, "Aggregate Production Planning For A Pump Manufacturing Company: Chase Strategy", International Research Journal of Engineering and Technology, Volume 4, Issue 12, December 2017

[21] Anand Jayakumar, A., C. Krishnaraj, "Solving Supply Chain Network Gravity Location Model Using LINGO", International Journal of Innovative Science Engineering and Technology", Vol 2, No 4, pp 32-35, 2015.

[22] Krishnaraj, C., A. Anand Jayakumar, S. Deepa Shri, "Solving Supply Chain Network Optimization Models Using LINGO", International Journal of Applied Engineering Research, Vol 10, No 19, pp 14715-14718, 2015