International Journal of Application or Innovation in Engineering & Management (IJAIEM)
Web Site: www.ijaiem.org Email: editor@ijaiem.org
Volume 9, Issue 5, May 2020 **ISSN 2319 - 4847**

A Multi-Objective Transportation Problem in a Supply Chain Management System

Sandipa Bhattacharya [1*] and Seema Sarkar (Mondal) [2]

[1]Research Scholar
Department of Mathematics
National Institute of Technology, Durgapur
Mahatma Gandhi Avenue, West Bengal-713209, India

[2]Professor
Department of Mathematics
National Institute of Technology, Durgapur
Mahatma Gandhi Avenue, West Bengal-713209, India
* Corresponding Author

ABSTRACT

Minimization of total transportation cost is a common problem in a supply chain management system. It is considered as a single objective function of a supply chain management system. But, in a practical situation, it is not always possible for considering only one objective function. It is far comfortable with two or more relevant objective functions according to the situation in a supply chain management system. In this paper, we consider a multi-objective supply chain management system where our objectives are to minimize the total transportation cost and to reduce the deteriorating items while traveling from source to the destination. We determine how much amount of the item will be transported from one area to another and how much amount of the item will be deteriorated during transportation. The non-linear optimization technique is applied as a method of solution to our problem. Finally, the model is verified with a numerical example.

Keywords: Transportation cost, Supply chain management system, Deteriorating item, Source, Destination.

1. INTRODUCTION

A supply chain is a dynamic system where products are distributed from manufacturing plants to the demand markets in between with different stages. Effective and efficient movement of products from manufacturing plant to the demand market at the lowest transportation cost leads to the benefits of a business. In such a situation manager makes a distribution plan to optimize the transportation cost for the entire supply chain management system to make a competitor of the highly competitive business environment. Some literatures are surveyed for developing our model which is discussed below:

A theoretical approach of a multi-objective linear programming model in a transportation problem is discussed in [10]. Supply chain plays one of the key roles for the better improvement of businesses is discussed in [4].

A suitable activity-based cost-saving model in an entire supply chain management system is developed in [1]. In this paper, the decision-maker has the authority to make the right decision to reduce the entire cost by an attractive costsaving business plan.

A case study of the electronic industry is briefly discussed in [6] where the total cost is minimized for an entire supply chain management system for improvement of the business performance.

The performance of the supply chain depends on the effective and balanced distribution of the products from the manufacturer to the customer. Uninterrupted flow of the products from the manufacturing plant to the demand market can improve the performance of a business in the supply chain environment.

Unit transportation cost is directly proportional to the shipment quantity of a supply chain management system is discussed in [7].

The best strategy of distributing the product from the manufacturing house to the distribution center and from the distribution center to the demand market is discussed in [5]. In this paper, a heuristic approach based on Lagrangian relaxation is applied as a method of solution.

A hybrid genetic algorithm for a production problem in an entire supply chain management system is developed in [8].
A multi-objective transportation problem in a supply chain environment is developed in [9].

A combination of transportation and scheduling problems for multiple sources and multiple destinations for a supply chain management system is developed in [3]. Lagrangian decomposition algorithm is applied as a method of solution of this model.
A multi-objective model with minimization cost and maximization of customer satisfaction is developed in [2]. In this paper, the model is assigned from the plants to the warehouse and from the warehouse to the customer.
In this paper, we develop a multi-objective production-distribution problem in supply chain environment. Here, we consider multiple manufacturing plants, multiple distributors and multiple demand markets. The objectives of this model are: (i) to minimize the total transportation cost and (ii) to minimize the deteriorating items during transportation from source to the destination of the supply chain environment. The non-linear optimization technique is applied as a method of solution to our problem. Finally, the model is verified with a numerical example.

2. PROBLEM STATEMENT

The problem is considered for a production-distribution problem in a supply chain environment. The supply chain consists of multiple plants, multiple distributors and multiple demand markets. The products are produced in the plants then these are transported to the distributors and then to the demand markets. The demands of the products occur from the demand markets. It is assumed that the products are produced in the plants according to the customer demands and meet customer satisfaction at the highest level. The mathematical formulation of this problem consists of a set of plants (i=1,2) , set of distributors (j=1,2) and demand markets (k=1,2).
Assumptions:
The following assumptions are considered for our problem:
(a) Number of manufacturing plants and their capacities are known.
(b) Number of distributors and the capacity of the distributors are known.
(c) Demand meets completely according to the customer needs.
(d) Shortages are not allowed.
(e) Vehicle capacity for the produced products in plants for transporting to the distributors and the vehicle capacity for the distributed products in distributors for transporting to the demand markets are known.
(f) Lead is considered as zero.

3.MODEL FORMULATION

We consider our problem as multi-objective production-distribution problem where the objective is to minimize the total transportation cost from the manufacturing plants to the demand markets through the distributors and to minimize the deteriorating items during transportation from source to destination. The non-linear optimization technique is applied in our model as a method of solution. Finally, the model is verified with a numerical example.

Notations:

Set of index:
i=set of plants, $i \in I$
j=set of distribution centers, $j \in J$
k=set of demand markets, $k \in K$
t_{1ij} =Distance between manufacturing plant i and distribution center j

c_{1ij} =Unit transportation cost between manufacturing plant i and distributors j
t_{2jk} =Distance between distributors j and demand market k
c_{2jk} =Unit transportation cost between distributors j and demand market k
d_k =Maximum capacity of the demand market k
a_i = Capacity at manufacturing plant i
b_j = Capacity at distributor j

Decision variables:

x_{ij} = Quantity transported from manufacturing plant to distributor j

y_{jk} = Quantity transported from distribution center j to demand market k

d_{1ij} =Quantity of deteriorating items during transportation between manufacturing plant i to distributor j

d_{2jk} =Quantity of deteriorating items during transportation between distributor j to demand markets k

v_{t1} = Number of trip for transportation from manufacturing plants to distributors

v_t = Number of trip for transportation from distributors to demand markets

Objectives:

$$Minimize Z_1 = \sum_{i=1}^{2}\sum_{j=1}^{2} x_{ij} \times t_{1ij} \times c_{1ij} + \sum_{j=1}^{2}\sum_{k=1}^{2} y_{jk} \times t_{2jk} \times c_{1jk}$$

$$Minimize Z_2 = \sum_{i=1}^{2}\sum_{j=1}^{2} x_{ij} \times d_{1ij} + \sum_{j=1}^{2}\sum_{k=1}^{2} y_{jk} \times d_{2jk}$$

Constraints:

(I) Capacity constraint of the plants: It implies that the quantities which are produced in the manufacturing plants for transporting to the distributors cannot be more than the current capacity at the manufacturing plant.

$$\sum_{j=1}^{2} x_{ij} \le a_i \quad \text{(for i=1,2)}$$

(II) Capacity constraint of the distributors: It implies that the quantities which are distributed to the demand markets from the distributors cannot be more than capacity of the distributors.

$$\sum_{k=1}^{2} y_{jk} \le b_j \quad \text{(for j=1,2)}$$

(III) Demand market constraint: It implies that the total demand of the demand markets. Quantities received from various distributors are equal to the maximum capacity of the demand market.

$$\sum_{j=1}^{2} y_{jk} = d_k \quad \text{(for k=1,2)}$$

(IV) Non-negative constraint: Quantity transported from the manufacturing plants to the distributors and from the distributors to the demand markets must be non-negative and should be integers.

$$x_{ij}, y_{jk} \ge 0 \ (\forall \text{ i, j and k})$$

4. RESULTS AND DISCUSSION

The non-linear optimization technique is applied to our problem. LINGO software is applied as a method of solution and the results are shown in the following tables:

Input parameters:

t_{111}=5; t_{112}=10; t_{121}=8; t_{122}=12;
t_{211}=15; t_{212}=10; t_{221}=18; t_{222}=20;
c_{111}=120; c_{112}=140; c_{121}=100; c_{122}=130;
c_{211}=120; c_{212}=140; c_{221}=100; c_{222}=130;
v_{cp}=50; v_{cd}=40;
a_1=50; a_2=80;
b_1=70; b_2=90;
d_1=15; d_2=10;

Results:

Table-1:

X_{11}	X_{12}	X_{21}	X_{22}	Y_{11}	Y_{12}	Y_{21}	Y_{22}	v_t	v_{t1}
94	18	78	11	17	15	98	14	12	19

Table-2:

D_{111}	D_{112}	D_{121}	D_{122}	D_{211}	D_{212}	D_{221}	D_{222}	Z_1	Z_2
12	4	13	0	4	1	2	0	26150	36

We obtain the minimum transportation cost of Rs. 26,150 and the minimum deteriorating items are 36 during transportation. The number of trips is required for the shipment of products from manufacturing plants to the distributors is 19 and from the distributors to the demand markets is 12.

5.MANAGERIAL IMPLICATION

A successful supply chain involves lower transportation costs, shorter lead time, minimum delivery time and better customer satisfaction. In this paper, we develop a mathematical model of the production-distribution problem of supply chain management system. The objective of this model is to minimize the total transportation cost satisfying the supply and demand constraints and to minimize the deteriorating items during transportation for the entire supply chain environment.

The present study highlights the minimum transportation cost and minimum deteriorating items during transportation from manufacturing plants to the distributors and from the distributors to the demand markets. The implementation of this study is the cost-saving decision for the business manager and its impact falls on an effective improvement of any business organization.

6. CONCLUSION

In this paper, a production distribution transportation problem is considered. The demand is considered in deterministic nature but in real-life situation it is not always possible. We can extend our demand in an uncertain environment in future.

The model is considered only for two objective functions but some other objective functions like maximization of customer satisfaction level, minimization of delivery time during transportation etc. can also be associated with our problem in future. Demand market constraint and the capacity constraints of plants and distributors are considered as the certain constraints of our problem but we can include some more constraints like total budgetary constraints in the supply chain, binary constraints of opening plants for production etc. in our model. In this paper, the non-linear optimization technique is applied as a method of solution of our problem but some other advanced heuristic-based methodology can be applied for our model as a future aspects.

REFERENCES

[1] Amiri A., “Designing a Distribution Network in a Supply Chain System: Formulation and Efficient Solution Procedure”, European Journal of Operational Research, Vol. 171, No. 2, pp. 567-576, 2006.
[2] Erol, I. and Ferrell, W. G. Jr.,. “A Methodology to Support Decision Making across the Supply Chain of an Industrial Distributor”, International Journal of Production Economics, Vol. 89, No. 2, pp. 119-129, 2004.
[3] Equi, L., Gallo, G., Marziale, S., Weintraub, A., “A Combined Transportation and Scheduling Problem. European Journal of Operational Research, Vol. 97, No. 1, pp. 94–104, 1997.
[4] Khang, T.S., Arumugam, V., Chong, A.Y-L. and Chan, F.T.S., “Relationship between Supply Chain Management Practices and Organization Performance: A Case Study in the Malaysian Service Industry”, International Journal of Modelling in Operations Management, Vol. 1, No. 1, pp.84–106, 2010.
[5] Khataie, A.H. and Bulgak, A.A., “A Review on the Role of Activity-Based Costing Information and Costs Structure Integration in Supply Chain and Operations’, International Journal of Modelling in Operations Management, Vol. 1, No. 4, pp.382–395, 2011.
[6] Kumar, G.A., Devadasan, S.R., Shalij, P.R., Vinodh, S., Rajanayagam, D. and Edinbarough, I., “Implementation of Agile Supply Chain Model in an Electronic Switches Manufacturing Company”, International Journal of Services and Operations Management, Vol. 6, No. 4, pp.452–469, 2010.
[7] Sajjadi, S.R. and Cheraghi, S.H., “Multi-Products Location-Routing Problem Integrated with Inventory under Stochastic Demand”, International Journal of Industrial and Systems Engineering, Vol. 7, No. 4, 2011.
[8] Syarif A. and Gen M., “Double Spanning Tree-Based Genetic Algorithm for Two Stage Transportation Problem”, International Journal of Knowledge-Based Intelligent Engineering Systems, Vol. 7, No. 4, 2003.
[9] Taghrid I. and Hassan F., “Linear Programming and Sensitivity Analysis in Production Planning”, IJCSNS International Journal of Computer Science and Network Security. 456-465, 2009.
[10] Tanino, T., Tanaka, T., and Inuiguchi, M., (eds.), “Multi-Objective Programming and Goal Programming”, Springer Verlag, Berlin, 2003.

AUTHOR

Sandipa Bhattacharya is PhD research scholar from Department of Mathematics of National Institute of Technology Durgapur, West Bengal, India. She received her B.Sc. degree in Mathematics from Burdwan University, West Bengal and Masters in Computer Applications from West Bengal University of Technology, (Presently MAKAUT). She obtained her M.Tech degree in Operations Research from Department of Mathematics of National Institute of Technology Durgapur. She has participated in many National and International Workshops and Conferences in India.
Her research interests include in Operations Research, Supply Chain Management, Soft Computing and some other related fields in Applied Mathematics.

Dr. Seema Sarkar (Mondal) is Professor of Department of Mathematics of National Institute of Technology Durgapur, West Bengal, India. She received her B.Sc. degree in Mathematics from Presidency College (Presently Presidency University) Kolkata and M.Sc , M.Phil & PhD degree in Applied Mathematics from University of Calcutta, Kolkata.
Her research interests include Geophysics, Operations Research and some other related fields. She has authored/coauthored more than 25 publications and received 'Best Paper Award' in International Conference on ‘Information and Management Science’ in China during August, 2010. She had also received “National Scholarship” during Secondary Examination.
Six students have completed their PhD and awarded doctorate degree under her supervision and 6 more are pursuing their doctoral study.
She is a Life Member of 'Calcutta Mathematical Society' and 'Operational Research Society of India', Kolkata Chapter.