A Solution of a Transportation Problem with Deterministic Demand

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ABSTRACT
A decision-maker has the responsibility to make an effective plan to distribute the products producing in a manufacturing house to the customer directly or indirectly according to the customer demand with the lowest transportation cost for an organizational aspect. Minimizing a transportation cost is a fundamental business policy of an entire supply chain management system for a highly competitive business environment. In this paper, we develop an application-oriented mathematical model to determine the optimum transportation plan which leads to the lowest transportation cost from source to destination. The non-linear optimization technique is applied as a method of solution of this model. Finally, the model is verified with a numerical example.

Keywords: Transportation plan, Non-linear optimization technique, Business policy, Supply chain management system.

1. INTRODUCTION

To be a successful competitor in a highly competitive market a company must struggle for seeking a permanent position in the market by the utilization of their efficiency of all their activities. Among all possible activities, cost reduction is an important factor for achieving their goal in the supply chain management system.

The total number of units is transported with a maximum time from the source to destination is reduced in [2]. Some bi-criteria linear transportation problem is discussed in [1].

Time minimization of a transportation problem in an entire supply chain management system is developed in [5] where a heuristic-based algorithm is applied as a method of solution.

Supply chain management is often defined in [7] where it is referred to as the art of distributing the products of the right amount of the right product to the right place at the right time.

Two echelon facility location problems in a supply chain management system are developed in [8]. Single and multi-objective production and operations management models are developed in [4].

A manufacturer produces products according to the customer’s need to fulfill the customer satisfaction level is discussed in [6].

Proper distribution has become a key factor for every supply chain management system through which a business organization can achieve its target easily is discussed in [3].

In this paper, we develop a production-distribution problem in a supply chain environment. Here, we consider multiple manufacturing plants, multiple distributors and multiple demand markets. The objective of this model is to minimize the total transportation cost in an entire supply chain management system. 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 a 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 the 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). The objective of this model is to minimize the total transportation cost from source to the destination.

Assumptions:

(i) Number of manufacturing plants and their capacities are known.
(ii) Number of distributors and the capacity of the distributors are known.
(iii) Demand meets completely according to the customer needs.
(iv) Shortages are not allowed.
(v) Vehicle capacity for the produced products in plants for transporting to the distribution center and the vehicle capacity for the distributed products in distribution centers for transporting to the demand markets are known.

3.MODEL FORMULATION

We consider our problem as a production-distribution problem where the objective is to minimize the total transportation cost from the manufacturing plants to the demand markets through the distributors. 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 distributors, $j \in J$
k=set of demand markets, $k \in K$
t_{1ij} =Distance between manufacturing plant i and distributor j
c_{1ij} =Unit transportation cost between manufacturing plant i and distributor j
t_{2jk} =Distance between distributor j and demand market k
c_{2jk} =Unit transportation cost between distributor 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 distributor j to demand market 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

Objective:

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

Constraints:

(I) Capacity constraint of 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 plants.

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

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

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

(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 markets.

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

(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.

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

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 table:

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:

x_{11}	x_{12}	x_{21}	x_{22}	y_{11}	y_{12}	y_{21}	y_{22}	v_t	v_{t1}	Z_1
96	16	76	13	15	14	96	16	10	16	24120

We obtain the transportation cost is Rs. 24,120 from our problem which is least in an entire supply chain environment. The number of trips of transportation from distributors to the demand markets is 10 and from the manufacturing plants to the distributors is 16. The present study highlights the minimum transportation cost from manufacturing plants to the distributors and from the distributors to the demand markets in an entire supply chain environment. 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.

5. CONCLUSION

In this paper, a production-distribution transportation problem is considered. The demand is considered in deterministic nature but in a real-life situation, it is not always possible. We can extend our demand in an uncertain environment in the future. The model is considered only for one objective function but some other objective functions like maximizing customer satisfaction level, minimum delivery time during transportation, a minimum deteriorating items etc. can also be associated with our roblem in the future. In this paper, the non-linear optimization technique is applied as a method of solution to our problem but some other advanced heuristic-based methodology can be applied for our model as a future aspect.

REFERENCES

[1] Aneya Y.P., and Nair K.P.K., "*Bicriteria transportation problem*", Management Science, 5, pp.73-78, 1979.
[2] Barasov A.S., "*Linear Programming*", Fizmatgiz, Moskva, 1961. (in Russian)
[3] Claesson F. and Hilletofth P., "*In-transit Distribution as a Strategy in a Global Distribution System*", International Journal of Shipping and Transport Logistics, Vol. 3, No. 2, pp.198–209, 2011.
[4] Gen M. and Cheng, R., "*Genetic Algorithms and Engineering Optimization*, New York: Wiley, 2000.
[5] Hammer P.L., "*Time Minimizing Transportation Problems*", Nawal Research Quarterly, pp. 345-357, 1969.
[6] Jain R., Chandrasekaran, A. and Erol, O., "*A Framework for End-to-End Approach to Systems Integration*", International Journal of Industrial and Systems Engineering, Vol. 5, No. 1, pp.79–109, 2010.
[7] Tilanus B., "*Introduction to Information System in Logistics and Transportation*", In: Tilanus B (ed) Information Systems in Logistics and Transportation, Elsevier, Amsterdam, pp. 7–16, 1997.
[8] Tragantalerngsak S., Holt J. and Ronnqvist M., "*An Exact Method for Two-Echelon, Single-Source, Capacitated Facility Location Problem*", European Journal of Operational Research, Vol. 123, pp. 473–489, 2000.

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