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INVENTORY CONTROL THROUGH LATERAL TRANSSHIPMENT IN MULTI RETAILER SUPPLY CHAIN

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Lateral Transhipment is very an effective means of reducing total cost of the system, as well as improving the service level. The objective of this paper is, to explore the implication of pooling on multi-retailer supply chain inventory system, with one central ware house, with varying demand and varying lead time at each retail outlet. The product is either sold out or remains as a surplus. This surplus is transhipped to the other retailer having shortage. This way, both the holding costs and shortage costs of the total system are reduced and improvement in the service level. This work demonstrates the benefits of lateral transhipment in terms of reduced total system cost and improves in customer service level or overcoming the uncertainty of demand and lead-time.

Keywords: Supply Chain Management; Inventory Management; Lateral Transhipment.

INTRODUCTION

Supply chain management is concerned with the flow of *products* and *information* between the supply chain members. At the limit, it encompasses all of those organizations (i.e., suppliers, producers, service providers and customers) that link together to acquire, purchase, convert/manufacture, assemble, and distribute goods and services, from suppliers to the ultimate end users. One of the major trends facing organizations today is the demand for ever-higher levels of responsiveness and shorter defined cycle times for deliveries of goods and services. Furthermore, both customers and suppliers are becoming better at measuring performance. "Perfect orders" are being demanded, requiring a supply chain that is quick, precise, and provides a top-quality product every time [1, 2]. Major part of the cost in supply chain is due to the inventory and its efficient use; hence inventory should be managed properly. Lateral transshipment is a very effective tool to improve inventory level of the entire supply chain or of an individual retailer. Lateral transshipment can be divided into Emergency Lateral Transshipment (ELT) and Preventive Lateral Transshipment (PLT) [3, 4, 5, 6]. In this work a model has been formulated considering one central warehouse catering to 3 retailers. Model allows complete pooling between retailers. Initially mean demand, mean lead time and review period are taken as inputs and the resulting outputs are maximum inventory level, reorder level, demand and lead time variation. Then by introducing the demand and lead time which are randomly generated for 3 retailers for '*n*' number of days we are able to get in-hand inventory, surplus quantities, ordered quantities, in-transit inventory and inventory reached at a particular day for all the retailers and for all periods i.e. for complete '*n*' number of days. Holding cost and backorder cost are calculated for the case when there is no transshipment and transshipment cost is added when there is emergency lateral transshipment of in-hand stock amongst the retailers for the calculation of total cost associated with 3 retailers. Then a comparison is done for different aspects of inventory control using lateral transshipment.

By using example problem finally in this paper it has been found that by incorporating lateral transshipment transportation cost is increased, yet it is a better technique than a policy of no transshipments.

THE MODEL FORMULATION

We have considered periodic review inventory policy. Inventory is checked at the end of every single period and if inventory is less than or equal to reorder level quantity then an order is placed. All the calculation regarding inventory are as per following relations. Maximum level of inventory is given as $A = (Review\ Period + Mean\ Lead\ Time) * Mean\ Demand$ *or* $A = (R + |m)\ Dm$. Now we will discuss the relation for reorder level. Recorder level of inventory is given as per following relation.

$R_l = Mean\ Lead\ Time * Mean\ Demand$ *or* $R_l = |m\ Dm$. When inventory reaches at reorder level or below this level, an order is placed. Here in transit inventory is also included, to calculate the ordered quantity by retailer *i*. Hence ordered quantity can be calculated as per following relation, $Q_i = Maximum\ Level\ of\ Inventory - (In\ transit\ Inventory + Surplus\ Inventory)$ *or* $Q_i = A - (Q_{ti} + H_i)$. Surplus quantity

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of previous day is held by retailer. Thus total inventory for sale in particular period is given as, T_i = _Surplus Inventory of Previous Day + Inventory Reached That Day to Retailer i_ or $T_i = S_i + Q_{ri}$.

The applicable cost function include only holding, shortage and lateral transhipment cost terms, so expected cost for holding is given as, $E(CH)=\sum_{i=1}^{3}$ _Unit holding cost * surplus quantity of retailer i_

$$\text{or} \quad E(CH)=\sum_{i=1}^{3} C_h H_i \qquad (1)$$

Expected cost of shortage is given as $E(CH)=\sum_{i=1}^{3}$ _Unit penalty cost * Stock out quantity of retailer i_

$$\text{or} \quad E(CO)=\sum_{i=1}^{3} C_p O_i \qquad (2)$$

and expected cost of lateral transhipment is given by $E(CT)=\sum_{i=1,j=1,i\neq j}^{i=3,j=3}$ _Unit transhipment cost*transhipment quantity from retailer i to j_

$$\text{or} \quad E(CT)=\sum_{i=1,j=1,i\neq j}^{i=3,j=3} Unit \qquad (3)$$

Now expected cost per period, with transhipment, will be sum of expected holding cost, expected shortage cost, expected lateral transshipment cost. It can be given by following relationship. _$E_1(C)$ = Expected Holding Cost + Expected Shortage Cost + Expected Lateral Transshipment Cost_ or _$E_1(C)$ = E(CH) + E(CO) + E(CT)_

$$or \quad E_1(C)=\sum_{i=1}^{3} C_h H_i+\sum_{i=1}^{3} C_p O_i+\sum_{i=1,j=1,i\neq j}^{i=3,j=3} C_i X_{ij} \qquad (4)$$

In case of, without transshipment expected cost will be sum of expected holding cost and expected stock out cost. It can be written as following. _E2(C) = Expected Holding Cost + Expected Stock–Out Cost_ or _E2(C) = E(CH) + E(CO)_

$$E_2(C)=\sum_{i=1}^{3} C_h H_i+\sum_{i=1}^{3} C_p O_i \qquad (5)$$

We measure the performance of system by expected cost and service level. Demand service level can be written as $SL1$ = 1–Total stock out quantity/Total demand

$$\text{or} \quad SL1=1-\frac{\sum_{i=1}^{3} O_i}{\sum_{i=1}^{3} D_i} \qquad (6)$$

and period service level can be defined as $SL2$ = 1–Total No of Stock out Periods/Total No. of Periods or

$$SL2 = 1 - N_O / N_T \qquad (7)$$

One of the above relations can be used to measure the service level of system [7, 8]. We can measure, the service level for total system as well as for individual retailer.

The Data Set

The demand for the three retailers is randomly generated for 45 demand periods of 15 each (retail outlet) cost parameters for all the retailers are assumed to be same for the entire group. Holding cost for each surplus unit is Rs. 4 per unit. Shortage at each retailer is charged with Rs. 7 per unit, and transhipment cost of the group is taken as Rs. 3 per unit. Mean demand is taken as 10 units and its standard deviation is 2, and mean of lead-time is taken 3 and its standard deviation is taken as 1.

Now, all the data are determined, so we will discuss the solution as per following steps.

The Solution Steps

Now we will discuss the steps to solve the problem. Above-mentioned problem will be solved as per following steps.

Calculate demand variation and lead time variation up to ± 3σ level and compute randomly generated normally distributed demand and lead time for 45 different periods. Now the given model is solved for given demand and lead time. Surplus and shortage of each retailer is calculated for one set demand. Now transshipment comes into action and surplus items from one retailer are transshiped to other retailer whom is having shortage. Holding, surplus and transshipment costs are now calculated for both the cases of transshipment and without transshipment by using equations 1–5. Service levels are calculated with equations 6 & 7.

RESULTS AND DISCUSSIONS

Emergency lateral transshipment in multi retailer system has been studied. Different aspects for two cases, with transshipment and without transshipment have been compared. Figure 1 shows holding inventories or surplus quantities for 3 retailers and it has been found that surplus quantities are lesser in case of transhipment as compared to without transhipment. Backorder quantities and different costs are shown in Figure 2 and in Figure 3 and again it has been observed that lateral transhipment is an effective tool for the reduction of backorder quantities and reduction in costs.

Demand service level has been found 0.786 for without transshipment and 0.84 for with transshipment and period

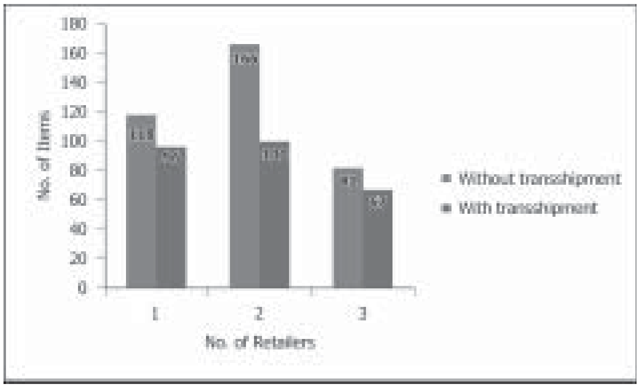

Figure 1: Comparison for Holding Inventories

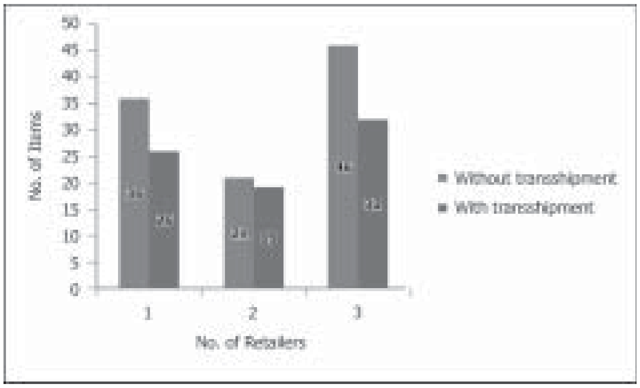

Figure 2: Comparison for Backorder Quantities

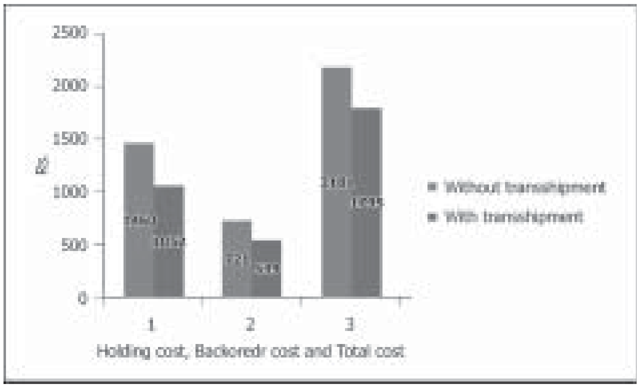

Figure 2: Comparison of Holding, Backorder and Total Cost

service level is 0.4 in the case of without transshipment and 0.66 with transshipment. So it's very much clear that lateral transshipment transportation cost is increased, yet it is a better approach than a policy of no transshipments because total cost associated is less.

CONCLUSION

Emergency lateral transshipment in multi retailer system has been studied. Different aspects for two cases, with transshipment and without transshipment have been compared. The total expected cost is less, in case of lateral transshipment than without transshipment. It is true for individual retailer, as well as group of retailers, participating in sharing of inventory in emergency. Therefore lateral transshipment is an effective tool to reduce the total system cost, as well as individual retailer's inventory cost. It is win-win situation to all the retailers.

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