Integrated Approach on Inventory and Distribution System

Nagendra Sohani[1], Hemangi Panvalkar[2]

[1]Institute of Engineering Technology, Mechanical department
Devi Ahilya Vishwa Vidyalaya, Khandwa road Indore (M.P) India
nagendrasohani@yahoo.com

[2]Institute of Engineering Technology, Mechanical department
Devi Ahilya Vishwa Vidyalaya, Khandwa road Indore (M.P) India
Hemangi110888@gmail.com

Abstract: ***This paper is the integrated approach of inventory and distribution system to achieve the goal of competitive advantage through cost reduction and service enhancement. Total logistic cost mainly depends on the transportation, facility and inventory cost. This paper includes inventory and distribution policy decisions, by the proper integration of which it is possible to optimize the cost and ensure for better responsiveness. The integration is explained with the practical example of a single supply and multiple demand system. The paper includes Vendor managed inventory as a tool for inventory management at every stage of the supply chain and travelling salesman problem is considered for optimizing the transportation cost.***

Keywords: logistics, competitive advantage, Vendor managed Inventory, Vehicle routing problem, Traveling salesman problem**.**

1. Introduction

Today's Business scenario is changing frequently due to the enormous pressure on industries to survive in the competitive environment. Industries are continuously searching for the alternatives to optimize the production cost in order to increase the productivity. After years of concentrating on the production cost, now Industries are beginning to look for reducing the logistic cost as their last hope for cost reduction for being competitive in business environment.

For any industry to be competitive, it must have a productivity advantage or a value advantage or both. Productivity advantage gives a product of lower price than competitive product. Value advantage gives better service, better values than competitive products.

[1]Basic concept used in this project is that optimize the decision variables of one function (inventory) and then its output is use as input for the optimization of other function (distribution).

In this proposal, an integrated inventory and distribution system is proposed with the goal of coordinating between the important and interrelated decisions related to production schedules, inventory decisions and vehicle allocation. In this project Inventory levels are first set by basic Economic order quantity model (EOQ) and for proper management of inventory at every stage of supply chain Vendor managed inventory (VMI) is used. Once the inventory levels are set up then, vehicle routing problem is solved for instance and for this traveling salesman problem is used in order to optimize the transportation cost.

[1]On basis of dependency of decisions of inventory and distribution systems, there are two types of decisions based on supply and demand.

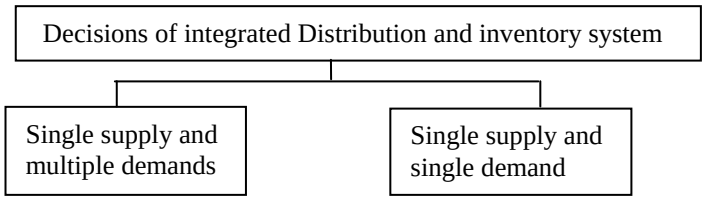


Figure 1. Block diagram of inventory and distribution system

Focus of project is on single supply and multiple demands, i.e.; one warehouse and multiple retailers system.

1.1 Introduction to Single supply and multiple demands system

In this type of system, there is a single supplier, it can be a depot, a warehouse and it supplies the inventory to various demand locations. This type of system is generally used for the mass production inventories and for the batch production inventories. [6] The main target of the system is to allocate the inventory (product, an item) to geographically scattered retailers, in such a way that the total logistic cost can be minimized and also serving the retailers with high responsiveness to achieve competitive advantage.

1.2 One warehouse and multiple retailer system

In this system the single depot fulfills the demand of many retailers. The objective of system is to find the [6] replenishment policy including replenishment periods and delivery routes.

1.3 Introduction to inventory decisions

[13] According to D. Chandra Bose (Inventory management). "Inventory is stock in hand at a given time and it may be held for the purpose of later use or sale". Inventory decisions are affected by mainly four important characteristics. These can be called as inventory policy decisions.

Inventory cost

Cost associated with purchasing, ordering, holding the inventory and stock outs.

Lead Time

Lead time is the gap between placing an order and the inventory item in hand.

Stock levels

Stock levels are not fixed on permanent basis but depend on the changes in factors determining the level.

1.4 Introduction to distribution decisions

Distribution is one of the important factors in supply chain. Distribution is driver which refers to the steps taken to move and store the product from one stage of supply chain to other .According to [9] *Sunil chopra, "Designing the Distribution Network in a Supply Chain"* Distribution is a key driver of the overall profitability of a firm because it directly impacts both the supply chain cost and the customer experience". The distribution network design affects the Inventory cost, Transportation cost, Facilities and handling cost and Information cost. Total logistics costs are the sum of inventory, transportation, and facility costs for a supply chain network. As the number of facilities is increased, total logistics costs first decrease and then increase. Each firm should have at least the number of facilities that minimize total logistics costs. For an efficient network design it is must to trade off between these costs.

Design Options for a Distribution Network: On the basis of the requirement and network effecting factors that are inventory, facility, transportation, information and responsiveness, There are six distinct distribution network designs according to [9] Sunil chopra, "Designing the Distribution Network in a Supply Chain" that are classified as follows:

- Manufacturer storage with direct shipping
- Manufacturer storage with direct shipping and in-transit merge
- Distributor storage with package carrier delivery
- Distributor storage with last mile delivery
- Manufacturer / distributor storage with costumer pickup
- Retail storage with customer pickup

[9]"For deciding an appropriate delivery network, product characteristics as well as network requirement must be considered. Most companies are served with combination of network".

The distribution center is responsible for assigning the vehicles to visit a set of customers and replenishes inventory as per the demand of customers. There are many modes of transportation like road (truck), air (aero plane), water (ship), rail (train) etc .Though rail being the cheapest of all, but ,have the constraint that, many towns yet not have proper rail facility thus here, in this project truck load (road) as a mode of transportation is taken in consideration.

1.5 One warehouse and multiple retailer system

In this system the single depot (warehouse) fulfills the demand of many retailers. FTL (full truck load) vehicles are loaded at the depot and serve each and every retailer in order to fulfill their demands and come back to the depot with empty vehicles. That is no holding inventory at depot.

[6] The objective of system is to find the replenishment policy including replenishment periods and delivery routes. In order to routing the vehicles TSP (travelling salesman problem) is taken into consideration. Inventory is managed by using the classical EOQ model and VMI (vendor managed inventory) approach. The one warehouse and multi-retailer is an integrated approach of inventory and distribution systems thus in this the inventory is managed accordingly by VMI and for the distribution the main aim is to minimize the transportation cost so here TSP is used to minimize the transportation cost.

[6]The assumptions of the one warehouse and multiple retailer system are:

- The product is a single item
- Cost associated is only fixed cost
- Though basic EOQ is used thus lead time are known and demand is constant, and no stock outs allowed.
- No items held at warehouse
- Mode of transportation is truck (FTL)

[6]The parameters which affect the transportation cost are;

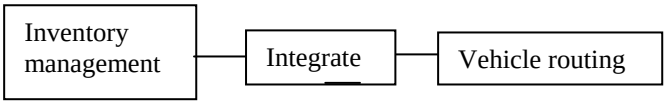
- Travelling distance and
- Number of trips.

The transportation cost can be minimized by proper managing these two factors. If the vehicle capacity is utilized properly, then, this optimizes the no of trips and thus travelling distance. And it can also be possible to assigning a vehicle to such a group of dealers which are close together. This also minimizes the travelling distance. This concept is used here to route the retailers and after that travelling salesman problem is used for the clusters.

Here it is assumed that there are four FTL vehicles which are capable to satisfy demand of each cluster at various replenishment periods.

It is explained by taking the practical example of an automobile industry.

2. Methodology



[6] **Figure 2.** Block diagram showing methodology

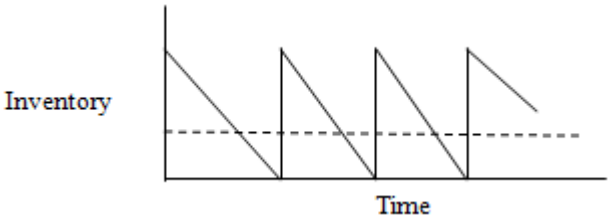
Here the problem is associated with the Optimization of inventory cost and transportation cost. [6]Thus here inventory management is integrated with the vehicle routing problem (VRP). The main decision variables associated with the problem are inventory levels, replenishment period, number of vehicles, vehicle routes and number of vehicle trips. Here, Inventory is managed through vendor managed inventory and for setting up of inventory levels, and replenishment periods including lead time, classical EOQ model is used. For optimizing the transportation cost, routing the vehicles and managing the number of trips of vehicle, Vehicle routing problem (VRP) is used. For solving the VRP travelling salesman problem is taken into consideration.

Thus, to solve this integrated inventory and distribution system, both the inventory problem and the vehicle routing problem are integrated. Thus at first here classical EOQ model is used for specifying the need of replenishment policies, delivery intervals and then the scheduling and routing vehicles as per the shortest distance so as to optimize both inventory and transportation costs.

Steps of work being carried are:

- Using classical EOQ model for specifying the replenishment policies and delivery intervals.
- Inventory is properly managed at depot as well as retailers through using Vendor managed inventory (VMI) approach.
- Identifying the data's of the warehouse and its dealers all over the state (Madhya Pradesh) from an automobile industry.
- Clustering the neighboring retailers based on distance and direction and vehicle constraints.
- Routing by solving the Travelling salesman problem for every set of customer.

2.1 Inventory model (classical EOQ model)



[13] **Figure 2.** Classical EOQ model

The classical EOQ model is based on the following assumptions:

The demand is deterministic, constant and continuous, the lead time is known and constant, No stock outs are allowed; The costs associated in the system are fixed: order or set-up costs are the same.

[6] Total annual cost = purchase cost + order cost + holding cost.

2.2 Vendor managed inventory

Vendor Managed Inventory (VMI) is an important tool of inventory management and order fulfillment. VMI involves collaboration between suppliers and their customers (e.g. distributor, retailer, or a product end user) which changes the traditional ordering process.

In this customers electronically send daily demand directly to the supplier. Supplier generates replenishment orders on the basis of customers demand. The process depends on the type of sharing of information and channel of information sharing between both the stages of supply chain.

2.3 Vehicle routing problem

The main aim of using this model is to find the number of trips per vehicle, number of vehicles, and total number of routes. [6] Each route starts at the warehouse, serves a particular route of customers and returns to the warehouse without disobeying the supply constraint. This model only considers transportation cost.

[6]The basic assumptions for the model are

- One route per vehicle
- Vehicle starts and finishes its route at the depot

[6]On the basis of these two assumptions there are two approaches to solve the model

- Cluster first - route second
- Route first - cluster second

{Focus of project is on Cluster first-route second approach}

For giving the practical approach to the project example of an automobile industry is taken into consideration.
The project is based on the single supply and multiple demand location that is one warehouse and multiple retailers system. [6] The system begins by clustering the retailers on the basis that neighboring retailers into one cluster so that travel cost and time can be minimized.

2.4 Travelling salesman problem

According to Prof G. Shrinivasan (department of advanced studies IIT Madras) "TSP is a problem associated with a given set of points to visit every node once and only once and come back to starting point travelling minimum distance in least cost incurred".

[6]The basic procedure of the model is classified into two phases

- First phase involves clustering of dealers or retailers based on location of customers and vehicle capacity constraint.
- Second phase involves the routing of clustered dealers or retailers by solving every cluster by using travelling salesman problem.

3. Data's are taken into consideration for giving practical approach to the problem:

For giving the practical approach to the project data's of an automobile industry (situated in Pithampur district Indore state Madhya Pradesh) are taken into consideration.

The actual road distances between the central warehouse and various scattered dealers in a state (Madhya Pradesh) are taken into consideration. Warehouse (depot) is situated at the automobile industry plant at pithampur.

Here the distance taken is the actual road distance.

On the basis of the data's provided by the company here it is assumed that

- The cost associated with transportation is only fixed cost and tariffs, other taxes are not included in it.
- Product is only one item.
- Mode of transportation is truck (FTL)
- It is assumed that the company owns four Trucks as per the norms and thus there must be four clusters that can be served by the distribution network.
- It is assumed that demand is constant.

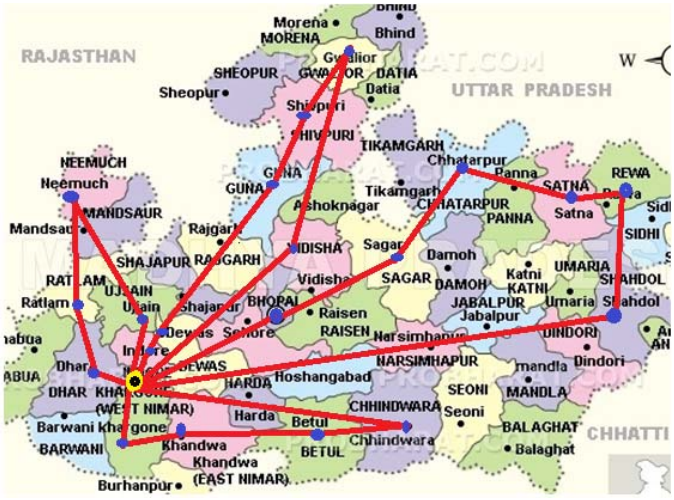


Figure 3. Map of Madhya Pradesh showing the clustered dealers of the automobile industry taken into consideration.

On the basis of the above map there are 21 dealers which must be present in at least a cluster and there are four clusters as there are 4 FTL as stated earlier. These dealers are clustered on the basis of the nearest neighboring so that the transportation cost can be optimized. It is assumed that there are four clusters that is each cluster in a direction (EWNS) (east, west, north, south).

3.1 On the basis of west direction cluster matrix in road distance is

	1	2	3	4	5
1	-	46	120	230	70
2	46	-	132	260	117
3	120	132	-	169	107
4	230	260	169	-	274
5	70	117	107	274	-

Figure 4. Matrix of road distance of cluster in west direction

Where,

1=Pithampur
2=dhar
3=ratlam
4=neemuch
5=ujjain

After solving TSP problem for this cluster, Route found is 1-2-4-3-5-1

3.2 On the basis of north direction cluster matrix in road distance is

	1	2	3	4	5	6	7
1	-	27	57	290	385	484	248
2	27	-	34	278	376	494	278
3	57	34	-	244	342	460	226
4	290	278	244	-	98	217	164
5	385	376	342	98	-	119	237
6	484	494	460	217	119	-	386
7	248	278	226	164	237	386	-

Figure 5. Matrix of road distance of cluster in north direction

Where,

1= pithampur(warehouse)
2= indore
3= dewas
4= guna
5= shivpuri
6= Gwalior
7= vidisha

After solving TSP problem for this cluster, Route found is 1-7-4-5-6-3-2-1

3.3 On the basis of east direction cluster matrix in road distance is

	1	2	3	4	5	6	7	8
1	-	217	351	482	570	620	595	511
2	217	-	181	347	449	513	517	384
3	351	181	-	168	270	343	336	205
4	482	347	168	-	140	191	330	193
5	570	449	270	140	-	53	209	107
6	620	513	343	191	53	-	176	136
7	595	517	336	330	209	176	-	133
8	511	384	205	193	107	136	133	-

Figure 6. Matrix of road distance of cluster in east direction

Where,

1= pithampur
2= Bhopal
3= sagar
4= chhatarpur
5= satna
6= rewa
7= shahdol
8= katni

After solving TSP problem for this cluster, Route found is
1-2-3-4-5-6-7-8-1

3.4 On the basis of south direction cluster matrix in road distance is

	1	2	3	4	5
1	-	109	144	332	460
2	109	-	86	286	420
3	144	86	-	203	334
4	332	286	203	-	138
5	460	420	334	138	-

Figure 7. Matrix of road distance of cluster in south direction

Where,

1= pithampur
2= khargone
3= khandwa
4= betul
5= chindwara

After solving TSP problem for this cluster, Route found is
1-2-4-5-3-1

4. Result

All the four matrices are solved by using TSP and the optimal route is found. These routes follow the lower bound cost and thus results in least transportation cost. VMI is used for managing the inventory in the system thus no stock outs are there and no extra inventory is held, so no extra holding cost. Thus this integrated system is results in lowering the inventory and transportation costs.

5. Power of two policies

Though here it is assumed that the quantity of inventory is determinable and constant, but Since India is festival country, thus it might be possible that some dealers have frequent consumption rate at festival seasons.[6] For this it is impractical to set such replenishment periods which can directly replenishes inventory at some pre fixed period of time at the dealers end. Thus for this it is practical to consider the power of two policy which restricts the replenishment periods in power of two so that inventories may replenish at a particular week, day . This leads to have a clarity (confusions are avoided) about the uncertainty in replenishment rate at warehouse and at dealers end about the time of replenishment vanishes.

6. Conclusions

The study of the automobile industry for the integrated inventory and distribution system shows that total cost can be minimized by integrating the inventory and distribution system. Inventory management is necessary to minimize the overall cost, VRP is beneficial for lowering the transportation costs and thus its integration is necessary to be in the competitive market. Also, by using TSP a firm can provide high responsive time so as to increase the value advantage of the firm. Thus integration of inventory and distribution are necessary to achieve the goal of competitive advantage as they support both cost reduction and service enhancement.

7. Future research scope

This paper considers only trucks as a transportation mode as the automobile industry from which data's are collected uses FTL (full truck load). This integration problem can be researched for the intermodal transportation for minimizing the further transportation cost.

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