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Comparative Analysis of Two Echelon Inventory Method in a Large Scale Iron and Steel Industry

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Abstract: A two echelon system of a supply chain may consider the two stages as separate or simultaneous. This paper studies a two-echelon inventory system with a large steel company warehouse and analyses the effect of applying two approaches in supply chain management. The dispatch data of one year is taken for the dispatch of goods from warehouse and retailers and the total cost of ordering is calculated for the past data under two scenarios. In particular inventory management system approach considering separate system is having more cost comparing to simultaneously inventory management. The cost component in a supply chain is particularly very crucial for a heavy and capital chain like steel industry where the operating margins and business leverage are very narrow. Study has been done analyzing the cost component but the approach adopted in paper can also be applied to analyze value addition in a supply chain using different approach.

Keywords: EOQ, Inventory management, two-echelon inventory system, cost optimization.

1. INTRODUCTION

Now days the extremely volatile market pressure on the companies managers they improve their supply chain activities of their organizations. The most challenging issue is that to faces the market challenges in form of supply and demand. Inventory management in warehouse is a complex management of the different types of item and they have different types of characteristics

In two echelon inventory method we have 2 stations, station 1, and station 2. In station 1 we can say be the wholesaler, station 2 can be retailer, or station 1 can be a manufacturer and station 2 can be a retailer (Figure. 1). So, in this situation measure the particularly station and simultaneous station in an supply chain process. In this situation, consider the conventional system only a particular station and manage the inventory only for one single entity. Here, if we do that, means if we start managing the inventory separately for these different entities. We will lose the very core of supply chain management.

In separate optimization of the two echelon inventory management are consider to the particular warehouse and particular retailer in system. Then we use the particular system are manage the inventory and the quantity in two echelon system.

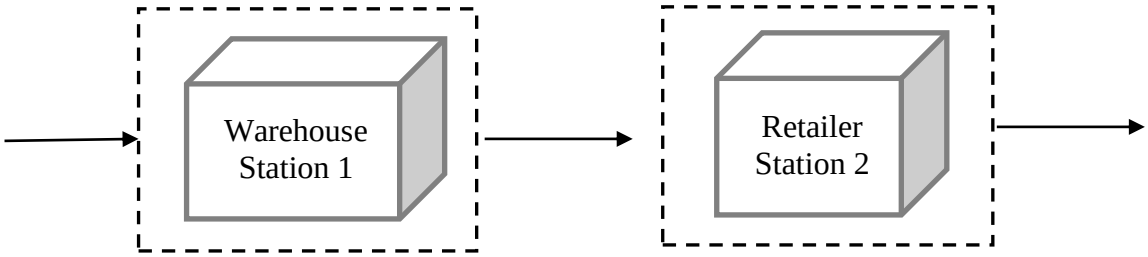

Figure 1: Separate stations in a two echelon system

In simultaneous process in two echelon inventory management we calculate two stations in process station 1 and station 2 which have contain the inventory and in this process backorder is not allowed, we are going to left to right (warehouse to retailer), we added the value in process in form of holding material, then holding cost are increases left to right ($h_2 > h_1$). So now we calculate the total cost.

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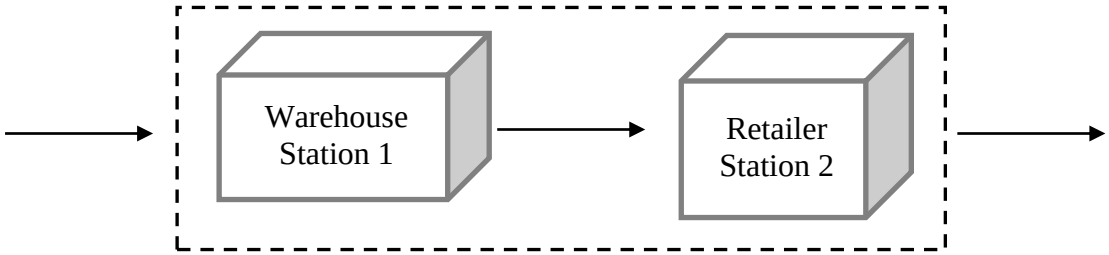

Figure 2: Simultaneously stations in a two echelon system

2. LITERATURE REVIEW

Many researchers have given their opinions about two echelon method and their importance in various fields. These methods are applied in various industries to reduce the quantity of inventory and its variable cost. The previous year's research work is as follows:

Table 1: Research work on two echelon and multi echelon method

Author	Year	Summary of findings
Sang Jin Kweon	2013	This paper suggests the set of all possible optimal order quantities and corresponding minimum total costs for the deterministic serial two-echelon inventory model
HuaxiaoShen et al.	2019	This paper suggests the objective is to minimize the long-run average system cost over an infinite horizon
Roya Tat et al.	2013	This paper suggests the derive the total inventory cost, the optimal order and the shortage quantities as the performance measures
Stephen C.H.Leung et al.	2008	Constructed a two-period model for a dominant retailer in a manufacturer–retailer supply chain with demand uncertainty in a declining price environment, which requires integration of demand forecast, pricing and ordering decision.
SubrataMitra	2009	Two-echelon inventory system with returns under generalized conditions, and developed a deterministic and a stochastic model for the system.

3. METHODOLOGY

The system of inventory management and the ordering and holding of material in a large steel company warehouse was put to study and in turn the costs associated were established. The ordering of material in a large steel company warehouse is run only on the generation of requirement or the requirement of the materials. The process of study the existing system of inventory management is as follows:

- Procedure adopted for procuring the materials by the study of existing system of a large steel company warehouse.
- Observations from the whole study of inventory management system of a large steel company warehouse.
- Two echelon method classification is done for prioritization of materials to select the items to reduce the costs related with it.

Generally, in the a large steel company warehouse the procedure are followed in system when the material are going to be end stage in the warehouse and other is when required by the retailer. These requirement are based on fulfill the need of the retailer which require multiple types of products by the warehouse.

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3.1 Two Echelon inventory management using the particular stations

Two echelon inventory management method using the two stations, one warehouse and other is retailer in supply chain management system. It is a process when retailer placed an order to warehouse and demanding quantity of material which is denoted by Q_2, when retailer place an order at the average inventory level and then consumption of inventory reach at the safety stock, demand an order to warehouse by using the EOQ method, when retailer placed an order of Q_2 quantity that day the warehouse replenish inventory level, and this process have constant time or no lead time. The retailer have Q_2 inventory and sometime after Inventory consumption are the slop of the curve are decrease at the time of safety (average inventory) level then retailer place an order then two types of cost are vary in system one is ordering cost (loading, unloading and information flow charges etc.) and other is holding cost that are types of security cost, charge of holding item unit per year etc.

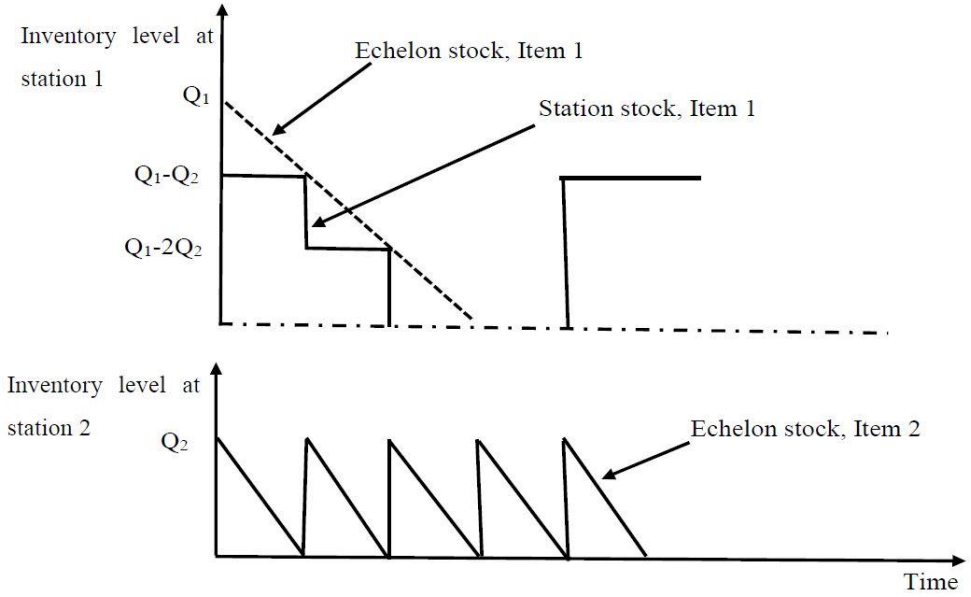

Figure 3: Inventory level at station 1 and station 2

That the total cost is

$$C_2 = \frac{dk_2}{Q_2} + \frac{Q_2 h_2}{2} = \text{Rs. } 63228.16 \quad (1)$$

Where, d- demand
Q_2 – quantity of product at station 2
k_2 – order cost at station 2
h_2 – holding cost at station 2
Now calculate order quantity at station 2, Q_2 is

$$Q_2^* = \sqrt{\frac{2dk_2}{h_2}} = 126.45 \text{ (fractional value)} \quad (2)$$

So Q_2 = 126 items, Quantity are calculate in integer numbers
Where
Demand (d) = 2221 per year
Order cost (k_2) = 1800 per order at station 2
Unit cost of item (C) = 5000 rupees per unit
Interest rate (i) = 10% per unit
Holding cost of item at station 2 (h_2) = C * i
h_2 = 5000 * 10% = 500 per unit per year
Minimum cost at station 2,

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$$C_2 = \sqrt{2dk_2h_2} = \text{Rs. } 63228.16$$

Number of times place an order

$$n^* = \sqrt{\frac{k_1h_2}{k_2h_1}} = \sqrt{\frac{3000*500}{1800*400}} = 1.44, \text{ n* is an fractional value}$$

There are a condition applied to find the value of n, n is an integer number

Applying condition if $\frac{n^*}{[n^*]} \geq \frac{[n^*]+1}{n^*}$, then the value of n = $[n^*] + 1$

Evaluate the value of n, $\frac{1.44}{1} \geq \frac{2}{1.44}$, then the value of n = 2

Then the quantity of station 1, condition are applied

$$Q_1 = nQ_2$$

The quantity is $Q_1 = 2 * 126$

So the value of $Q_1 = 252$ items

Now calculate the cost of station 1, get it

$$C_1 = \frac{dk_1}{nQ_2} + \frac{(n-1)Q_2}{2}h_1 = \text{Rs. } 51640.47$$

Where, order cost (k_1) = 3000 order cost at station 1

Holding cost $(h_1) = C * i$

Where, C = 5000 rupees per unit and i = 8% per unit

So $h_1 = 5000 * 8\%$

$h_1 = 400$ per unit per year

Total cost of system $C = C_1 + C_2$

So, total cost of particular two stations, get it

C = Rs. 51640

3.2 Two Echelon system are in simultaneously optimization

A supply chain consists of two-echelon network to procure products, and transport the products to retailer through a distribution system. For example in the supply chain, a warehouse can store an inventory (first echelon), then carry them to distribution centers (second echelon). Such a system is called two echelon inventory system. A supply chain management system uses the inventory in one echelon to replenish the inventory at the next echelon, thus the two-echelon inventory system is one of the important topics we care about to manage the inventories in a supply chain. To remains the competitive market, one of the key intentions of a supply chain is to minimize the total cost allied with two-echelon inventory system.

Now calculate the simultaneous method between stations in a supply chain system, when two stations are dependent each other than station 2 is a retailer and other is warehouse.

The total cost is

$$C = \frac{d}{Q_2}\left(k_2 + \frac{k_1}{n}\right) + \frac{Q_2}{2}(e_2 + ne_1) \quad (4)$$

Where, $e_1 = h_1$ and $e_2 = h_2 - h_1$

Where e_1 and e_2 are the inventory holding costs at station 1 and station 2.

Order quantity at station 2, get it

$$Q_2^* = \sqrt{\frac{2d\left(k_2 + \frac{k_1}{n}\right)}{(ne_1 + e_2)}} \quad (5)$$

Put the value of Q_2 in equation, get it

Minimum cost is $$C_{min.} = \sqrt{2d\left(k_2 + \frac{k_1}{n}\right)(ne_1 + e_2)}$$

Differentiate with respect to n, get it

$$n^* = \sqrt{\frac{k_1e_2}{k_2e_1}}$$

Calculative values are:

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Where demand (d) = 2221

Order cost (k_1) = 3000 order cost at station 1

Order cost (k_2) = 1800 per order at station 2

Inventory holding cost at station 1 (e_1) = h_1 = 400 per unit per year

Inventory holding cost at station 1 (e_2) = h_2 - h_1

e_2 = 500 – 400 = 100 per unit per year

Put the value in above equation

$$n^* = \sqrt{\frac{3000 * 100}{1800 * 400}} = 0.64, \text{ n* is an fractional value}$$

There are a condition applied to find the value of n, n is an integer number

Applying the condition, if n* < 1, then n = 1

Now calculate the value of Q_2^*, put the value in equation (5), get it

$$Q_2^* = \sqrt{\frac{2 * 2221\left(1800 + \frac{3000}{1}\right)}{(400 + 100)}} = 206.50, \text{ where } Q_2^* \text{ is a fractional value}$$

So Q_2 = 206 items, Quantity are calculate in integer numbers

Then the quantity of station 1, station 1 quantity are the multiple quantity of station 2, when station 2 are place an order at n = 1 time then condition are applied

$$Q_1 = nQ_2 = 206$$

There at station 2 place an order only one time.

Now calculate the total minimum cost of stations, get it

$$C_{min.} = \sqrt{2d\left(k_2 + \frac{k_1}{n}\right)(ne_1 + e_2)} = 103{,}251.15$$

Now find out the total minimum cost of the simultaneous two echelon system.

4 RESULTS

Comparing the total costs of particularly system and simultaneous system in two echelon system by which help we find the optimum cost and quantity in system.

Table 2: Analysis of separate and simultaneous echelon inventory

	Separate optimization	**Simultaneous optimization**
Q_2	126	206
n^*	1.44	.64
N	2	1
Q_1	252	206
C_{Total}	114,868.63	103,251.15

The two echelon method which calculated at a large steel company warehouse, it is a iron and steel industry we comprises the result if we take the particular stations in system then the retailer have low level inventory and 2 times demand required in a year and get the total cost of the system is comparison to high then the simultaneous optimization system if taking the simultaneous system then in this system the number of inventory is required more, but the demand at the year is only one time then its holding cost are increased but the overall cost of the system are decreases.

5. CONCLUSIONS

The inventory management is calculated on the basis of past one year demand data, in which the inventory ordering material and consumption of inventory are analyzed. Form the comparative data exhibited in Table 2, it can be seen that a two echelon system with simultaneous stations achieves 10.11% as compared to that with separate stations. Therefore it can be concluded that simultaneous stations are having better cost efficiency as compared to separate system. The logic may be extended further to multi echelon supply chain management Apart from cost considerations, the simultaneous system can also be used in other systems in according to place value of customer demand.

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