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INVENTORIES MANAGEMENT IN DISTRIBUTION LOGISTICS

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ABSTRACT: Companies being confronted, regarding inventories management, in distribution channels, with two contradictory, opposite tendencies: reduction of operational and inventories holding costs and, on the other side, realizing of a high service for customers, it is necessary the reengineering of logistics chain. Only structural changes in supply chain are not enough for efficient inventories management, being necessary also instruments for inventories management, which consider the maximum level of inventories for different service levels and yearly total costs of storage for different items, referring the clients' service quality and the connected storage levels.

1. INTRODUCTION

Inventory management is strongly related by the financial, technical and commercial considerations. Extension of inventory management problems to a distribution network is a strategic problem, which consists in finding the locations for distribution centers and their dimensions and also the volume of carried inventories within these distribution centers.

It is important for distributors to find optimization models for inventories, these being the most important part of working capital. Variables that have to be taken in consideration are: volatile demand, prices and supply costs which are modifying and, not at last, lead times that have a variable character.

2. INVENTORY MANAGEMENT, ESSENTIAL COMPONENT IN LOGISTICS OF FREIGHT DISTRIBUTION

The companies are being confronted, in what is concerning the inventory management in their supply chains, with two opposite tendencies: one side, with reduction of operational costs and carrying inventories, tendency that follows up to maintain low stock levels, and, on the other side, realization of a high customer service, available where and when the customer desire. To realize that, is necessary the reengineering of supply chain.

But the structural changes in supply chain are not enough for an efficient inventory management, being necessary also inventory management tools that take in consideration the maximal level of stocks for different service levels and the annual total costs for a certain item related with the quality of customer service and associated storage levels.

For distribution companies a problem arising is the conflict between keeping low inventory level to minimize associated costs and the requirements of customers and the need to insure for them products at the right time and place. But also it could differentiate some special situations function of product types, their costs and not less important, the situation when customer service requirements are high.

There are two types of inventory at every stage in the supply chain: cycle stock and safety stock. Cycle stock is the material need to cover average demand during the inventory lead time period. Safety stock is the material you keep "just in cases" to cover the variability in demand and in lead time itself during the inventory lead-time period. The more time and uncertainty that exist in the supply chain, the more inventory will be required to compensate.

How much inventory it is carrying depends on how frequently it is placed the order, how long it takes to get the order filled and how much uncertainty it has to deal with. These variables are also tied together, so that increases in one tend to lead to increases in the others.

Whether in the past, the logistical systems had focused on stored freights, on warehoused inventories, as results of electronic technologies by last generation, which manage the information flows, by connecting logistics is focused, more and more, on the management of in transit inventories [1].

In inventory management problems, it is important to determine the number of needed distribution centers or storage spaces. Also, these suppose determination the inventory dimension at each of these points. Treating independently these problems, it determines a sub optimization degree.

For a distribution center, to take the decision of order quantity in conditions of incertitude of customers' needs, must to take in account a series of costs involved in inventory management: storage costs, out-of-stock costs, purchasing cost.

An important problem is that the demand of every distribution centers is determined by customers requests assigned to retailers, outlets. The demands of clients are independently and it is no correlation between them, related to requested quantities and the moment of demand formulation.

For this reason could be efficient to estimate the demand with some probability, necessary to grow the obtained profit. The demand could be deterministic, random, but statistical stable (is not known with precision, but respectively a statistical rule, randomness) and statistical instable (unknown demand).

Whether the demand is approximated to be stable, the problem consists in establishing the optimal order, obtained by derivation of supply costs function that includes purchasing costs, ordering costs and freight storage costs on considered period, as well as the cost of tied up capital in carrying inventories. The ordering cost includes all the generated costs starting with laying down the order, sending it to supplier, transport and handling costs of orders. Warehousing cost is determined by the receiving costs, transport, handling within the warehouse, storage costs, associated costs with capital immobilized in stocks, amortization costs of storage spaces and other facilities, remuneration expenditures and a series of other indirect costs generated by the storage.

$$C_a = c_l \frac{Q}{q} + c_s \frac{q}{2} + Q \cdot p \Rightarrow \frac{\partial C_a}{\partial q} = -c_l \frac{Q}{q^2} + c_s \frac{1}{2} \Rightarrow q^* = \sqrt{\frac{2Q \cdot c_l}{c_s}} \quad (1)$$

where Q represents the needful quantity to supply;

q – optimal order;

c_l – ordering costs on a order;

c_s – storage costs on a unit of product;

p – purchasing price of the product [2].

Economic order quantity, usually, could be determined with well known Wilson formula. The formula is specific for supply of a single product type. But Wilson model is a simplified mathematical model, taken in account a uniform consumption, being applicable to durable and imperishable products. It is a method applicable especially in industrial companies.

Wilson model doesn't correspond to inventory management for distribution centers, because that takes in consideration the hypothesis of instantaneous supply (the period between ordering and freight input in warehouse is nil).

Whether the demand is variable at equal intervals it is necessary to take in account also the out of stock costs, determined by the lack of products, as well as the costs of carrying stocks in larger quantities than the products demand. For this situation it has to determine the statistical distribution of demand, the cumulative probabilities of this and to compare them with the unavailability factor with a view to determine the optimal level of order.

The cases of out-of-stock represent an important problem and many times are extremely hairpin situations. As indicators are possible to take in consideration the number of annual items necessary and unavailable when are required, number of cases of out-of-stock, the costs generated by the lack of products. Whether for some products, lack of them from stock don't have a significant impact on supply chain management, in case of pharmaceutical products, for example, these situations could determine effects that are difficult to neglect.

Determination of optimal order it is possible to be realized also using graphical representation of costs variation function of order quantity. Using the more frequently freight delivery and consolidated load units, the company saves up inventory carrying costs against the purchasing more transport services (fig. 1.).

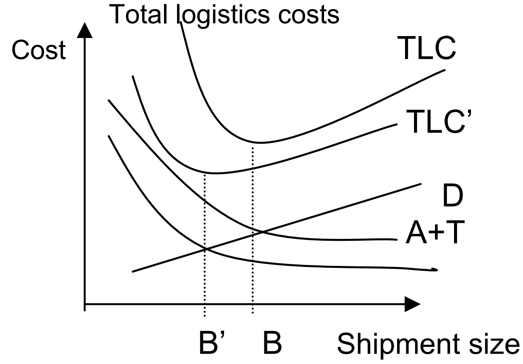


Fig. 1. Variation of total logistics costs function of shipment size

where B represents the shipment size obtained in point where total logistics costs TLC are at minimum level;

TLC – total logistics costs.

When it takes place a reduction of transport costs, the effect is a decreasing of total logistics costs at TLC' value and of optimal order size at value B', that determines also a reduction of inventory carrying costs.

The costs of freight storage are proportional with stock level s(t).

$$C_{st} = c_{st} \cdot \frac{1}{t_1 - t_0} \int_{t_0}^{t_1} s(t)dt \quad (2)$$

where c_{st} represent storage unit costs in $t_1 - t_0$ period of time;

s(t) – stock level.

In time distribution of stored freights depends of warehouse type. Whether for finished goods warehouses within the enterprises, their distribution is a normal type one, in case of commercial warehouses the distribution is uniform [3].

Average stock level $\bar{s}$ and average standard deviation σ(s) are, in this case:

$$\bar{s} = \frac{1}{n}\sum_{i=1}^{n} s(i) \tag{3}$$

$$\sigma(s) = \pm 0{,}29(s_{\max} - s_{\min}) \tag{4}$$

where s_{max} represents the maximal level of stored freights;

s_{min} – minimum level of the same stock.

The type of inventory management for freights distribution through warehouses or distribution centers is, as general rule, that specific for variable demand at unequal periods of time, without knowing the moments of ordering, determining them by extrapolation. Another variant possible to adopt by the distributors is the S,s inventory model.

In the case of distribution centers, those need the supply with a large range of products at variable periods of time, due to the diversity and variability of freight demand. The problem can be extent taking in account the case of supplying with many products types, calculating economic order quantity for a group of products q_{egr} and, on this basis, the quantities from each product type that compose the delivery order [5]:

$$q_{egr} = \sqrt{\frac{2c_l Q}{\bar{p} \cdot c_p}} \tag{5}$$

where c_l represents the cost of ordering;

Q – total quantity necessary to supply on the entire period;

$\bar{p}$ - average cost of products purchase;

c_p – inventory carrying cost, as percentage from the average purchase cost of products.

$$\frac{q_{egr}}{Q} = \frac{q_{e1}}{Q_1} = \dots = \frac{q_{en}}{Qn} \tag{6}$$

where q_{e1} ... q_{en} represent the optimal order quantities for each type of product;

Q_1 ... Q_n – total quantities needful to be supply from each product.

To protect themselves against the lack of stock during the re-supply period, the distribution centers use the safety stock, the replenishment period being considered the period of time between the ordering and the receiving the order. Safety stock represents the maintained stock as reserve to insure a desired customer service level. The level of safety stock SS depends on the standard deviation σ of the demand during the replenishment period (fig.2.):

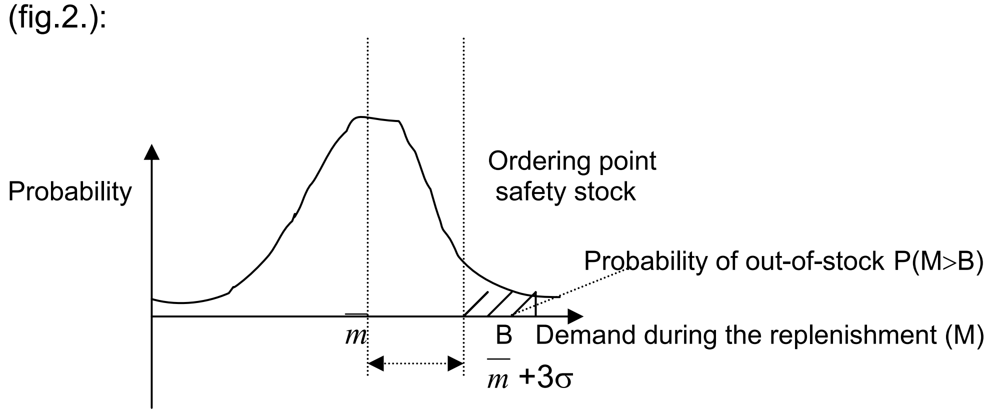


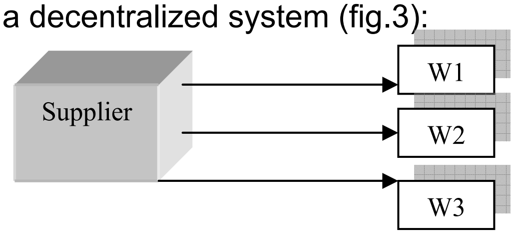
Fig. 2. Demand during the replenishment (M) (after [4])

The safety stock represents:

$$C_{ss} = h \times SS_i \tag{7}$$

where h represents the unit cost of inventory carrying;
SS_i – total safety stock at warehouse i.

In a decentralized system (fig.3):



w_1, w_2, w_3 – distribution centers

Fig. 3. Case of decentralized supply system

Safety stock at each distribution center is given by the relation:

$$SS_i = 3\sigma_i \sqrt{t} \tag{8}$$

where t represents the transport time (days) ;
σ_i – standard deviation of demand at distribution center i.

Total safety stock: $$SS = 3\sum_{i=1}^{3} \sigma_i \sqrt{t} \tag{9}$$

In a centralized system (fig.4), where demands are concentrated in a single point, the three distribution centers are approaching as a single distribution center. Using the consolidation of the flows, the variance of total demand is: $\sigma_1^2 + \sigma_2^2 + \sigma_3^2$. In this case the average standard deviation for grouped demands represents:

$$\sigma_g = \sqrt{\sum_{i=1}^{3} \sigma_i^2} \tag{10}$$

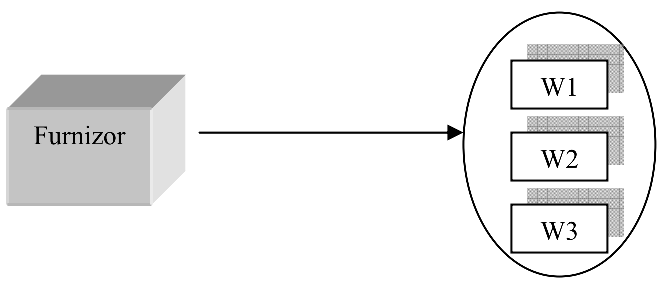


Fig. 4. Centralized case of replenishment

Total safety stock in centralized system is given by the relation:

$$SS = 3\sqrt{\sum_{i=1}^{3} \sigma_i^2}\sqrt{t} \tag{11}$$

The out-of-stock cost is difficult enough to quantify because intervene a series of unknown elements, generated by the stocks shortage. The simplest case is when lost sale determine a cost corresponding to lost additional value for the lost sales. Another situation that can appear is when with additional costs it is possible to make the delivery without some delay, which reduced the venues, but the situation is solved for customers. When are established contractual penalties, this generates additional costs. But the most important situation is when, because of such a case, the client is lost and the image of company is deteriorated. If the demand is lost, the cost on period p is proportional with the number of articles. If the request is deferred, the delivery delay intervenes in cost assessment.

For some companies a stock/out probability of five percent or larger may be acceptable. For others one percent or even smaller may be desirable if there are severe consequences for a stock-out. Since the arrival of part demands and the length of the lead time are both random, determining the appropriate stock-up-to level is a simple calculation.

When is speaking about the pharmaceutical products for a hospital or blood reserves this could determine special situations which need a special treatment. The out-of-stock of inventory is impossible situation in this case. Even a small rate of stock loss undetected by the information system can lead to inventory inaccuracy that disrupts the replenishment process and creates severe out-of-stock.

Many retailers use an automatic replenishment system which tracks the number of products in the store and place an order to the supplier in a timely fashion with minimal human intervention. Information regarding what products are where and quantity must be provided accurately to effectively coordinate the movement of goods.

The reduction in inventory levels relative to sales could be realized by use of just-in-time or quick response replenishment, the centralization of inventory, the application of new IT systems and the development of supply chain management.

3. CONCLUSIONS

Companies are in a continuous change of the manner of supply chain management. Direct interaction with supply chains partners offers the possibility for companies to reduce the inventory levels, to obtain reduced trade-off costs, as well as a short time reaction to market changes and requirements.

In today economic environment companies cannot afford to carry excessive level of inventory. The inventory decisions are the results of inventory strategy which is different for different products type, for example, differentiated by costs; high-cost products and inexpensive parts.

More and more, the communication between logistics chain actors becomes indispensable. For this reason, adopting an efficient communication in distribution network considerably reduce the sources of errors in order processing.

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