Abstract:

This is sequel to OM 601 assignment.

The reason for this assignment is to improve overall competitiveness of Hefley Finland by focusing on inventory management.

In this assignment I first clarify why inventories exist, and the types of inventories. Then I examine to which decisions operation managers are involved in inventory management and what tools and methods they have to assist them.
Finally I apply inventory planning and control tools and methods in practice. I evaluate what benefits Hefley Finland would gain from well managed hydraulic hose inventory.

Why inventory exists

All organisations keep inventories in smaller or larger scale. They exist to smooth out gaps in the rate or timing of demand and supply. Only if the supply of products occurred exactly when they are demanded, products would never be stored.

With high inventory level many companies may also cover problems in operations; defective deliveries, poor floor layout, untrained operators, off-standards, re-work, down times, inaccurate quantities etc. Or high stock levels can be consequences of these problems. Either way, these unexposed problems cause costs and prevent smooth output of operations.

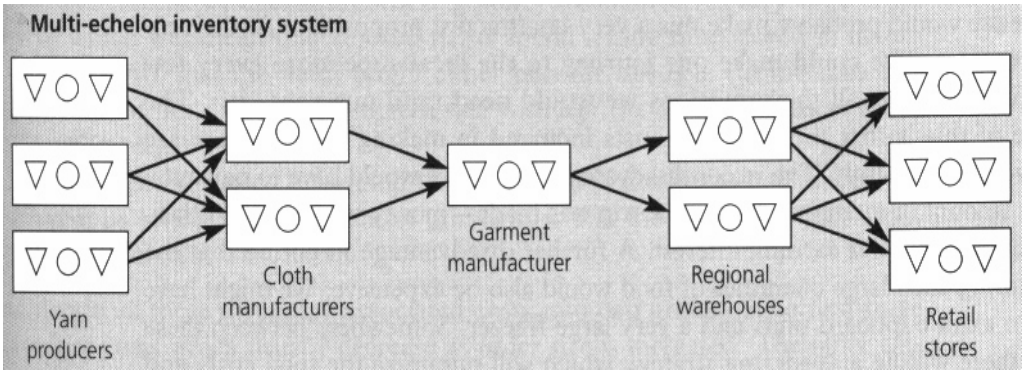
Types of inventory

There are four types of inventory

1) Buffer (also called safety) inventory. Its purpose is to compensate for the uncertainties in supply and demand. It can be finished goods to cover unexpected demand or raw materials to guarantee continuity of process. This type of inventory represents 85 % of Hefley Finland's inventory value.
2) Cycle inventory. It occurs because the one or more stages in the operation are not able to supply all the goods they produce simultaneously. For example at Hefley Finland we produce hydraulic hose assemblies for excavators, and in one excavator there are around 45 different types of assemblies. But the batch size of one hose assembly must be at least same as demand during production cycle of all assemblies. 5% of Hefley Finland's inventory value
3) Anticipation inventory. Its purpose is to compensate for differences in the timing of supply and demand. Mostly it is used when demand fluctuations are significant, but predictable. Value of no account in Hefley Finland
4) Pipeline inventory. It exists because the point of demand and the point of supply are not same. For example when Hefley Finland Business Unit 30 place an order of different types of hoses to Hefley manufacturing plant in England, they collect it, pack it, load it, transport it together with other orders to Hefley Finland's central depot. At central depot they unload it, separate it from other orders, load it again, and transport it to BU 30's warehouse. At final stage it is unloaded and stored. All that time the goods are unavailable. They are said to be "in pipeline". Median of Hefley Finland's pipeline is two weeks, 9,1 % of total inventory value

There are many points where inventories are held between different stages in the operations.

1) Single-stage inventory, i.e. where suppliers deliver goods to one warehouse. Goods are taken into stock and sold. There is only one inventory to manage.
2) Two-stage inventory. Suppliers supply goods to central depot which distribute goods to local distribution points. There are two or more inventories to manage. Hefley Finland has two-stage inventory system.
3) Multi-stage inventory. This type of inventory system is typical for manufacturer. Suppliers supply raw materials and components to input stock and manufacturer transform those to final products through several stages with work-in-progress stocks existing between each stage before reaching to finished goods inventory.
4) Multi-echelon inventory system. (pic1)



(Operations Management. Pitman Publishing)

Pic 1. Multi-echelon inventory system.

Picture 1 shows the relationships of inventories among operations within supply network. Main operation is supplied by first-tier suppliers (cloth manufacturers), which are supplied by second-tier suppliers (yarn producers). The products are distributed to regional warehouses from where they are supplied to retail stores.

Inventory decisions

Operation manager (inventory manager, logistic manager, stock-keeper …) is involved in three major decisions in managing inventory: How much to order (replenishment quantities), when to order (timing) and how to control the stock.

The volume decision:
Operation manager could purchase all at one time or hold no inventory at all and purchase item only when it is needed. Somewhere between these extremes exist an ordering point where the total costs are minimized.
To find out what is this economic order quantity, we need to know costs what are related to inventory;

- Cost of placing the order. Every orders cause costs; clerical tasks, delivery costs, general costs to keep all information concerning orders… These are costs which can easily be underestimated. In Hefley Finland cost of one order is approximately 500 FIM ($93) (calculated).
- Holding costs. Capital tied up in inventory (opportunity costs), storage costs (renting, heating, lighting, warehouse employees, services etc), losses and wastage (obsolescence, write-offs, deteriorate with age, damages etc). These costs are

expressed as a % of stock value. In Hefley Finland: Capital tied up 45% (minimum accepted RONA) + storage costs 7% (calculated) + losses 3% (calculated) = 49,6%

More difficult is to determine the stock-out costs. Raw material shortages in manufacturing what sets stops in production, or causes rescheduling etc, are costs which are somehow computability. But more difficult is to take into account costs caused by dissatisfied customers (loss of goodwill, lost deals etc). If customers take all their businesses elsewhere due continuous stock-outs, these costs can be up to 100% of turnover. Hefley's estimation is 7-8% of turnover.

Order costs usually decrease as order size is increased, and holding costs increase as order size is increased.

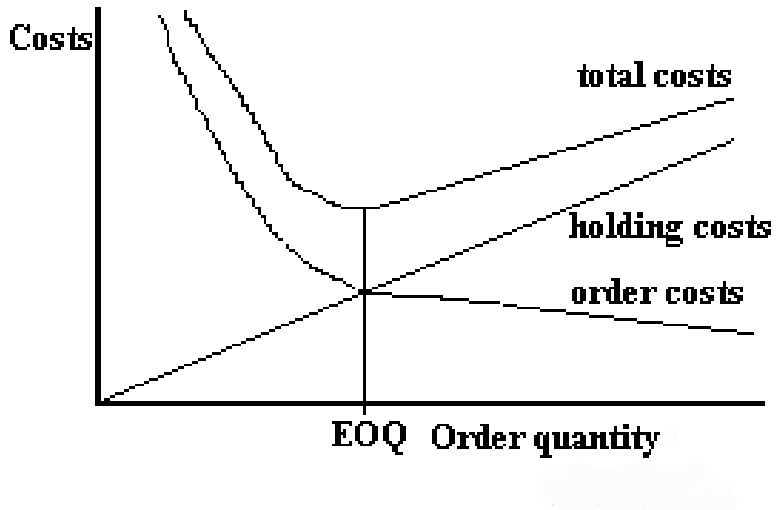
Economic order size

The most common method to find out how much to order, is called economic order quantity (EOQ). This mathematical approach balances between holding and ordering costs, and gives the order level where total costs are minimum.

Let S = Purchasing cost
D = Annual usage
I = Holding cost as percentage of stock value
C = Unit purchasing cost
Q = Economic order quantity (= EOQ)

Therefore: Unit purchasing cost = S / Q
Annual purchasing cost = S x D / Q
Average quantity held per year = Q / 2
Annual carrying cost = I x C x Q / 2

Total costs = annual purchasing costs + annual carrying costs.



Pic. 2 Economic Order Quantity

Total costs are at minimum when holding costs = order costs

i.e. S x D / Q = I x C x Q / 2

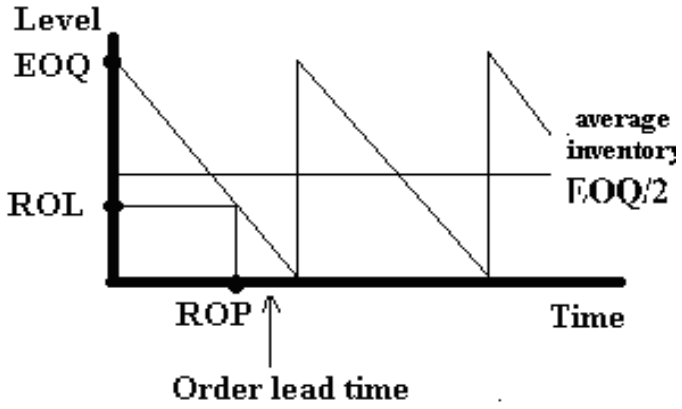
From which Q (EOQ) = $\sqrt{(2SD/IC)}$

This application of the economic order quantity gives considerable financial benefits, although it has some drawbacks:

- Cost of stock-out not considered
- Reasonable stable demand is necessary
- Costs assumed fixed
- May not agree with minimum order sizes

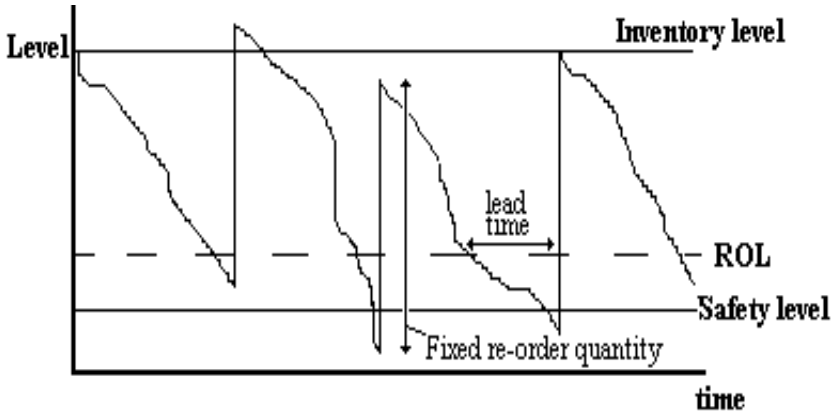
The timing decision

Now when we know how much to order, it is easy to calculate when to order. Re-order point (ROP) is the point at which stock will be empty minus the order lead time. Re-order level (ROL) can be derived with same way.



Pic 3. Re-order point (ROP) and re-order level (ROL)

However, this assumes that demand and order lead time are firm. In real life they are likely to vary.



Pic 4. Cope with uncertain demand and order lead time

Many stock systems need to cope with uncertainties. But rather than guarantee 100% stock availability, inventory managers normally agree a inventory service level, which mediates the cost of stock-out with the cost of the safety stock. Inventory service level is expressed as (%) probability of stock availability to meet demand.
Assumed that demand and order lead time are normally distributed, safety stock can be calculated:

$$\text{Safety stock} = \sqrt{(L_{mean} \times D_{var} + D_{mean} \times 2 \times L_{var})}$$

where L_{mean} = mean lead time
D_{var} = variance of demand
D_{mean} = mean demand (in the lead time)
L_{var} = variance of lead time

Today most of inventories are managed by computerized systems, which update stock records, generate orders and inventory reports and calculations. More and more inventory managers are exempted from time-consuming calculations and they able to focus attention on strategic issues : what should be a inventory's service level (95%, 99% or 99,9%), are there items which need exceptional order levels or more detailed control etc.

ABC analysis

ABC analysis (a.k.a. Pareto or 80/20 rule) can be used to classify items. Items are ranked according to importance to the organisation into three groups, ABC. Criteria for classifying each item can be:

- annual usage and value. Class A items are those 20% of items which account for 80% of the total stock value(or 10/70). Class B 30% of items and 10% of value (or 20/20), and class C 50% / 10% (or rest 70% of items).
- Consequence of stock out. High priority is given to items which would cause delays or disruptions to other operations if they run out of stock.
- High obsolescence or deterioration risk. Some items may need special monitoring if they loose their value due to obsolescence or deterioration.
- Uncertainty of supply etc.

With ABC analysis inventory managers identify A items to which focus control , and put less control to B and C items. Tight control over A items can have great impact over the cost of inventory.
More detailed control system might include multiple criteria by classifying on A, B and C for more than one basis. For example A annual usage x value rated but C consequence of stock out rated item may need less monitoring than C usage x value but A consequence of stock out rated item.
Or in assembly line, where A and C items (annual usage times value) are fitted together, a C item out of stock delay production as much as missing A item.

Measuring inventories

We can measure inventory's monetary level by taking the number of each item and multiply it by its value and summing all.
But to get the whole picture of the inventory, it is important to know which items are just "shelf warmers" and which are "fast movers".

There are two ways to calculate those:

1. Stock cover: This calculation shows how long time the inventory would last (days, weeks, months), if not replenished.

   Stock cover = stock/demand X 12 months

2. Stock turn: This method calculates how often the inventory is used up in year.

   Stock turn = Demand / stock.

To calculate the average stock cover/turn for the total inventory, the individual item measures can be weighted by their demand levels as proportion of total demand..

Conclusion

In Hefley Finland value of inventories is 35 million FIM, and turn-over 185 million FIM. Our stock/sales ratio is 0,19 what is " B+" compared to our competitors (median 0.28. source: Statistics Finland). But the stock/sales ratio is clearly " flattered " by our high gross margin.
By calculating stock covers or stock turns, real "stumbling-blocks" stand out more clearly; too high stock level with lots of slow movers (= stock cover over 6 months). Our average stock cover is 4,5 months and average stock turn 2,64. Slow movers proportion is 27%. of total stock value (Hefley database).

Present Hefley hydraulic hose inventory value (9,6 million FIM) is extreme high compared with inventory value (1,5 million FIM) proposed by EOQ (appendix 1).
If all inventories can be reduced with same ratio, totally 30 million FIM could be released from inventories. (Hydraulic hose inventory stand for as a median inventory within Hefley's inventories).

At 99% confidence level stock value (1.495 million FIM) is only 85 000 FIM higher than at 95% confidence level (1.410 million FIM) (appendix 1). Therefore I recommend 99% confidence level to be taken in use.

Based on EOQ, average stock turn 20.2 (at 99%) would be 7.5 times higher than present (2,64). (appendix 1)

In ABC analyse, 22% of items (34/154) present 70% of total inventory value. (appendix 2).
Stock cover, based on EOQ, is very short for A items, varying between 1 to 2. weeks. For B items its varying between 2 to 3, and C 4 to 33 weeks. (appendix 1)

For A items EOQ suggests to replenish the inventory frequently with small quantities. Today A items are ordered only few times per year. And due to this, order sizes are high. If demand decrease , our possibilities to react are considerably lower. Today we have lots of items in stock which demand have decreased or even stop. (Hefley database). If order quantities are based on EOQ, changes in demand do not cause "insurmountable" problems to inventory levels.

I strongly recommend EOQ to be taken in use..