Inventory and Holding costs
A white paper approach for managers

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0. Introduction

In essence inventory control is very easy. It should provide answers for two simple questions: “when to order?” and “how much to order?” The answers to these questions are again simply trade-offs. The “when to order” problem is a trade-off between inventory holding costs and out-of-stock costs. The “how much to order” problem is a trade-off between inventory holding costs and ordering costs. So if we know the cost components, fairly easy calculations give us the answers to the two questions. And there is abundant literature available to answer these questions in all kind of environments, assuming that these costs are known. But this is theory: from the moment Harris came up with his famous Economic Ordering Quantity formula in 1913 [Harris 1913], a debate is going on how to determine inventory holding costs and ordering costs. Less debate is going on regarding out-of-stock costs because it seems to be impossible to give a simple solution for this problem.

A common number in literature for the holding costs seems to be 25% per annum of the purchasing or cost price of the product. It is not clear why we use this number but maybe because of the statement of Harris in 1913: “It will be assumed here that a charge of ten per cent on stock is a fair one to cover both interest and depreciation. It is probable that double this would be fairer in many instances”. However in literature is often mentioned that the holding costs, observed in industry, range from 5 – 45%, which indeed gives an average of 25%. So although we know that inventory holding costs can vary a lot, many industries seem to use the average percentage; as if they just don’t know. This observation of “not-knowing” seems also to hold for the ordering costs (and in production environments for set-up costs). Although one might debate the use of the Economic Order Quantity in certain situations it is strange that many companies seem to be unaware of the costs, needed to answer the two basic questions of inventory control. So in this paper we present a way to calculate both inventory holding costs and ordering costs. We will do this in the next two chapters of this paper. In the third chapter we show a new approach to use these costs in order to calculate batch sizes. In this paper we restrict ourselves to warehouse environments or situations where we buy from suppliers.

1. Inventory holding costs

Again, when looking at the inventory holding costs from a theoretical point of view, it should not be too difficult to determine these costs. It is quite easy to determine the costs components out of which these holding costs consist. We divide these in three categories:

1 Cost of Capital (to finance inventory)
2 Costs of storage and handling the inventory
3 Cost or risk (insurance, pilferage, obsolescence etc)

We will look into these categories more closely in the next paragraphs and show how these costs can and should be calculated.
1.1 Cost of capital

The question: “how much does capital cost?” is another cause for debate. Some companies use the rate, banks are charging then for lending money. We even came across companies who claimed: “it’s my own money so its costs nothing”. If, however, we have to deal with shareholders, the picture will be slightly different (to say the least). They demand a certain return on their investment which will be definitely higher than the current interest rate. So money tied up in inventory should yield a similar result. One could argue that ROI (Return on Investment) or RO(N)A (Return On (Net) Assets) would be better rates to use. Or maybe opportunity costs although they might be difficult to define. Nowadays the WACC (Weighted Average Cost of Capital) seems to be often used because it reflects the way a company is financed. The definition of the WACC as given by \[2\] is

\[
WACC = \frac{E}{V} \times R_E + \frac{D}{V} \times R_D \times (1 - T_C)
\]

In which

\begin{align*}
E & = \text{Market value of firm’s of equity} \\
R_E & = \text{Cost of Equity} \\
D & = \text{Market value of firm’s debt} \\
R_D & = \text{Cost of Debt} \\
V & = E+D \\
T_C & = \text{Corporate tax rate}
\end{align*}

This is nor the context nor are we the financial specialist to argue which base should be used for the cost of capital. However, within a company, those responsible for inventories should know which costs of capital are used and how it was determined.

1.2 Cost of warehousing and handling

The second category comprises all the costs related to the handling and storage of the inventory. In case the warehousing-activity is outsourced these costs are more or less transparent because the provider will charge us per pallet or per sq meter or other variable. Although these costs are not exactly related to the value of the inventory because of different value-densities of the products stored, it will give us a fair estimate (see also \[vd Berg, 2007\]). In this case we consider the storage costs as being variable.

If however, you own a warehouse it becomes more complicated. Because you only want to include costs which directly relate to the amount of inventory you are holding. If you own a warehouse which can take 5000 pallets, it doesn’t matter for the storage costs if you use only 1 pallet place or 3000 pallet places. The same holds for equipment like forklift trucks etc. Unless you are able to rent free space to others, storage space will be probably fixed costs.
Also the costs for employees working in a warehouse can be considered fixed, unless you work with part-timers who can be hired and laid-off at will. But somehow this interacts with the number of orders received. We will look into this in paragraph 2.4 and paragraph 3. So it seems that in case of an own warehouse we might as well use the capacity. We come back to this in paragraph 3.

1.3 Cost of risk

These costs comprise everything connected to the risks of holding inventory; the main component being obsolescence. This component is very much product- or product family related. Even in the same company or in the same product family costs regarding obsolescence can vary widely. It can depend on the product-life cycle (product with a short product-life cycle are prone to higher risk of obsolescence) or stage in the product-life cycle (products in the phase-out stage will have higher risks). We think it might be wise to allocate different risk-costs to different products.

1.4 Summary on inventory holding costs

Looking at the different categories, described above, it is clear that there is not one general percentage for inventory holding costs. Because it depends on variables which are different for different companies. The cost of capital depends on the way a company is financed, the storage costs depend on whether a company owns a warehouse or outsourced this activity. The cost of obsolescence is related to the product or the product-life cycle. For this reason it is obvious that one finds in practice a wide range for the inventory holding costs. However, every company should be able to calculate an appropriate percentage.

2 Ordering costs

When ordering from a supplier we also have to deal with costs but unless the inventory holding costs almost no reliable data exist nor has substantial research been done in this matter. And it seems to be difficult to find a consistent cost for placing an order or an order-line. Although figures as few euro per order-line or between 50 – 100 euro per order are mentioned, these data are anecdotal. Ordering costs can be divided in four categories:

1 Costs to place an order
2 Costs to transport the products
3 Costs to receive the order
4 Costs to store the order

2.1 Costs to place an order

The most important components of costs are the costs of the purchase department. It will cost a purchaser or buyer a certain amount of time to place an order or order-line. The time however will not be dependent of the number of products bought per order-line. So the
number of buyers and or purchasers defines the maximum number of orders or order-lines that can be placed. The costs for the purchase department are most often fixed because they consist of wages. Because these costs are fixed one should not incorporate these in the ordering costs; one might as well use this capacity! The same holds for the costs for software. The only variable costs in this category would probably be neglectable (postage, etc).

2.2 Cost to transport the orders

If the supplier would pay for the transport, this would be simple. However the supplier will sometimes only pay for transport if a certain amount of products (or money) is ordered or if a FTL is ordered. Or the buyer should pay for transport in which case the buyer wants to order in FTL. In these cases it becomes more complicated to assign transport costs to a certain order. And the order-strategy will become different. One can apply the so-called joint-replenishment strategy (JRS) of which we give a small example. Suppose we have to order product A from supplier S. We have to pay for transport because only ordering A doesn’t qualify for free transport. So it might be interesting to see if there are other products, from the same supplier, almost due for ordering. Maybe these products could be ordered at the same time as product A. This strategy will increase inventory holding costs but decrease transportation costs. The same holds for a situation in which we want to transport in FTL. This strategy is easy to understand but it is not easy to calculate the exact order-sizes or order-times.

2.3 Costs to receive the order

These costs are analogue to the costs of placing an order. There will be employees for all the administrative things and checks to receive an order. Probably many of these things will take an amount of time irrespectively of the order-size. So, analogue to the purchasing department the number of people at the receiving end (or maybe quality department) limit the number of orders and/or orderliness to be received. There will probably not be many important variable costs in this category to be included.

2.4 Costs to store an order

Again, the assumptions of the previous paragraphs will hold. The majority of the costs in this category (handling costs) will be fixed.

2.5 Summary of ordering costs.

Looking at he costs involved in placing an order we see that most of the costs are fixed and o not vary with the number of orders (or order lines) placed. Only transport costs can have an influence which however can not be easily allocated to a certain order. We did see that although many costs are fixed they do act as a (maximum) limit for the orders to be placed, received or stored. This leads to a preliminary conclusion, that we should order in as small quantities as possible, because this will reduce the inventory holding costs.
3 Inventory holding costs, ordering costs and the EOQ in practice

When we look at the results of the two previous paragraphs we can conclude that the variable inventory holding costs consist mainly of costs of capital and costs of obsolescence. The variable ordering costs can be even zero, in cases where transport is paid by the supplier. When using the EOQ formula (or any other lot sizing method for that matter), it yields that order sizes in these situations will be very low. In these cases other issues become prevalent or limiting. We talked already about minimum order quantities (in money or pieces) prescribed by the supplier or FTL. They constitute the lower limit for the number of orders placed. On the other hand, the purchasing department and the receiving part of the company have a certain upper limit regarding the number of orders or order-lines that can be processed. There are several possibilities to deal with this problem. The first possibility is to treat this problem as a joint-replenishment-problem as mentioned in paragraph 2.3. The second possibility is to use the so-called Lagrange-multiplier approach. In this approach one calculates the batch sizes under a certain constraint being the maximum number of orders placed or a maximum storage place or other constraint. Also this method is in many cases not very easy to understand, although sometimes practical solutions exist. For both the JR- and the Lagrange multiplier approach we refer to the literature. For the order costs one uses a certain average costs to calculate the batch sizes. We propose a third possibility which comprises some of the concepts of the previous approaches, but seen from a practical point of view. We call it the capacity-oriented method, which will be discussed in the next paragraph.

3.1 The capacity-oriented method

The problem with the JPR-alike methods is to allocate the (transport-costs). But why should we not consider the transport costs also fixed, just like the costs of the purchasing department? Let us for simplicity reason assume that all products are delivered by one supplier (the ultimate single-source). We only want to be supplied in FTL. When looking at all the products we can calculate the total volume ordered and also the number of FTL required. So we can calculate the total order/transport costs, being the total costs for the total of FTL’s needed. These costs are independent from the number of orders or order-lines so we can consider them fixed! On the other hand we know the maximum number of orders or order-lines we can process. So how to divide this amount of orders over the products in order to minimize the total inventory holding costs? This is quite similar to the problem defining a production cycle in (semi-) process industry. In this paper I will give a first practical solution without trying to find an optimal solution. Basis is the ABC analysis in which we distinguish between fast- and slow movers, looking at usage. Fast movers will have to be ordered frequently, probably once a week. In doing so the batch-size stock of A-products will be about 0.5 week. Safety-stock depends on uncertainties in demand and supply during lead time. This batch-size for A-products will form the basis of the ordering pattern. If one should order more because of minimum order quantities due to volume (money, FTL etc) one can use the B- and or C- items. C-items should be ordered once in the 3 or 4 months, B-items can be ordered every month. In this way one can devise a continuous replenishment cycle, using safety stocks to cover for uncertainties. With
this method one might even order “express-orders” in small quantities without extra (transport) costs.

4. Summary

In this paper we looked at the cost components involved in determining inventory holding costs and ordering costs. We concluded that the cost of capital and the risk of obsolescence are the main drivers for the inventory holding costs. For ordering costs we concluded that only transport costs should be included. Many other holding costs and ordering costs are fixed and should not be included in the determination of order sizes. We showed a practical way to determine batch sizes in cases where it might be sensible to order several orders at once. We introduced a capacity-oriented approach to determine when and how much to order.

Literature

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