Whether it consists of raw materials or end-products: inventory is unavoidably one of the largest single assets on your balance sheet. In the manufacturing industry, around 37% of total costs consist of inventory costs, while for retailers and wholesalers even more than half of the total costs are caused by inventory (see figure 1). Owning, maintaining, and managing inventory costs a lot of effort and money. However, you need to have enough in stock to deliver customer service: *no inventory, no deal.* This paper discusses an indispensable inventory management figure: the economic order quantity.

Your ordering quantities highly affect inventory height. Since they also influence the number of replenishments, they are an important influencer of your day-to-day supply chain operations as well. Therefore, the determination of the order quantity of your product range should be a deliberate process. You might not be surprised that in practice the order quantity is not determined by your business strategy as it should be, but dictated to you by your suppliers or even worse (and more often the case); nobody knows why that number is there.

Disproportionate order quantities cause very expensive and high average inventory levels, unnecessary risks related to obsolescence and deterioration, and the

**Figure 1: Inventory asset percentage on balance sheet by industry**
need for high storage capacity. On the other hand, order quantities that are too small cause unnecessary warehouse operations and transportation, administrative, and quality control costs that could have been avoided. Ordering the right quantities will lower your operational expenses while boosting your return on inventory investment, thereby resulting into an integral optimisation of your total supply chain costs.

The Economic Order Quantity (EOQ) formula is a well discussed topic in literature and practice. The formula was originally developed by Ford W. Harris in 1913, and updated later on by Wilson (1915) and Camp (1922). The traditional Ford model was restricted in various ways and could not easily be applied in practice since:

1. It required a fixed price (and thus did not take quantity discounts into account);
2. the results were based on known and stable demand (which is, in many cases, a utopia);
3. it only considered ordering and holding costs of replenishment and inventory.

In this whitepaper we explain how to get started with applying economic order quantities in your company. Further, we discuss the issues from the ‘classical’ EOQ and propose the Slimstock solution: ‘EOQ in practice’-model.

Effective reduction of your supply chain costs

The first step in minimizing your supply chain costs is identification of the most important cost factors. Supply chain costs, for companies that operate in an inventory-rich environment, can be roughly categorized by costs related to:

- Inventory carrying
- Transportation
- Warehouse operations
- Lot quantity (production or ordering)
- Order processing & Information
- Place (achieving customer service)

Focus on major costs

The two most important types of supply chain costs are inventory carrying costs and lot quantity costs. The former is often underestimated, due to the fact that a large part is considered as sunk costs. Business managers often state that “We have financed our inventory with own capital” or “It is a given fact we have inventory”. This doesn’t mean you can completely ignore these costs, when you make optimisation decisions. Imagine your company without any inventory: what investments, risks, and expenses would not be there? How much manpower, time, trouble, and effort would you save on a daily basis?

Lot quantity costs are another major type of supply chain costs. They are comprised of all costs a business incurs when they handle certain lot quantities. Many companies don’t realize that handling just one batch/lot involves many different processes. Let’s take a production facility as an example: what does it cost to produce just one batch? You have to select and collect the right raw materials, set up a production line, clean up after production, cope with starting up failures, etc. The same holds for companies that only provide value added logistics and hold inventory: what are the costs of placing/receiving an order for inventory replenishment?

Don’t forget the others!

Although it is important to focus on the two major cost factors, all six types of supply chain costs directly influence one another (see figure 2). In order to avoid you ending up with a suboptimal solution, you should always incorporate all cost types into all inventory management decision making.

When you, for example, optimise for inventory carrying costs, you would lower the ordering quantities (see figure 3). In practice this often negatively affects your transportation and warehousing costs, because this results in many orderliness and probably inefficient use of transportation modes. When aiming for lower production costs by increasing batch order sizes, your inventory and warehousing costs would rapidly increase (see figure 3 at the next page). The one thing that influences all your supply chain costs when replenishing your inventory position, is the order quantity.

Order quantities also drive the utilisation and efficiency of transportation modes, warehouse operations, and production capacity. When ordering the right logistic quantities - like pallet-layers, full pallets, or even truck loads - you can excel in

Figure 2: The relationship between Supply Chain costs and Order Quantity.
operational efficiency. When optimising order quantities, you can significantly improve utilisation of your invested capital in operations and production. Due to a right balance between the number of order lines to be processed and the order size to be handled, labor and handling efficiency will improve.

Underestimation of the capital requirements for inventory management can lead to suboptimal decisions regarding activities like transportation mode selection, network design, and sourcing. In practice, inventory costs are often underestimated since purchase managers only look at the ordering costs and forget about warehousing, transportation, and other inventory-related costs. An unrealistic estimation of capital requirements will inevitably lead to unexpected (financial) setbacks. Inventory investment requirements should therefore be balanced against operating expenses by careful estimation of the cost of capital associated with inventory.

Transportation management is just one example: inventory can be lowered by utilising faster transportation modes that allow for shorter lead times and smaller order quantities. Although this may seem more costly at first - since transportation costs increase – the total inventory and supply chain costs can be lowered, driving improvement in overall financial performance.

Finally, consider the impact of knowing the total cost of inventory on procurement decisions. Many companies aim to lower their purchase-price costs and thus move their production to Asian countries. In practice, production far from the home country often leads to increased investment in inventory, because of higher in-transit and safety-stock inventories. Now it turns out that the source with the lowest purchase-price cost does not always have the lowest total landed costs.

To summarise: in order to minimise your supply chain costs, you should focus on the two major cost types: inventory carrying costs and lot quantity costs. However, also include the other four types of costs into your decision making, since they could rapidly and unexpectedly increase when you forget about them.

Inventory Carrying costs
The cost of carrying inventory can be roughly split up into capital and non-capital associated costs. Capital is tied up in inventory, because inventory is (often) financed upfront by either equity or debt. Capital costs are comprised of the costs paid for financing the asset inventory. The costs that are inevitable when having inventory are called non-capital associated costs.

Non-Capital costs
Costs for warehousing, pilferage, insurances, obsolescence and depreciation of inventory are often underestimated by inventory holding companies. However, in practice these non-capital cost are a major part of the total cost of holding inventory. The following non-capital costs should be considered:

Space and utilities costs
Inventory is often stored and handled in a company’s own warehouse or held by a third party logistics provider. When you consider the total costs of storage and utilities, and take the average inventory stored into account, you will be able to make an accurate estimate of the holding cost rate. This should be between 2 to 5 %.

Administrative costs
Administrative costs are costs related to the administration and management of inventory by employees and systems. Examples are cycle counting, inventory transaction systems, and management software. Administrative costs should rate between 3 and 6 %.

Obsolescence and deterioration costs
In time, inventory loses value or even become unsaleable. Finance often writes this inventory off, depending on multiple factors such as the product’s lifecycle, its outdated-rate, and its trendiness.

Note: All costs can differ per article; therefore make a rough classification between articles by, for example, value-density (price/volume) and demand-rate (fast-, middle-, and slow-moving).
Inventory handling costs
Inventory is linked to various handling operations, like inbound, outbound, and even inventory reallocation. Material and staffing costs related to these operations need to be considered.

Shrinkage and quality-(control) costs
The costs of misplaced, lost, or stolen inventory and the quality control of inventory need to be considered also.

Besides these non-capital costs, there are a few other cost aspects to take into consideration. Examples include overhead (e.g., heating and other utilities), taxes, insurances (for housing, equipment, and inventory), and what about yearly cost of top management time spent on solving inventory problems?

Most investments in inventory are speculative, especially in the wholesale/distribution and retail industries. There is no legally binding contract that your customers will buy your inventory. In cases where inventory is built to order, there is often the probability that a buying customer will change or even cancel the order without fully compensating the selling company for the inventory’s total value. Therefore it is important to also take potential risks into consideration when determining the cost of holding inventory.

Lot quantity costs / Ordering costs
Lot quantity costs are the expenses made for placing/receiving/controlling/producing/etc. a replenishment order for inventory. They are also known as ordering costs and are made up of two components: fixed and variable costs.

The fixed costs, that remain the same for every placed order, include facility costs and maintenance costs of the software that is used for order processing. Variable costs are proportional to the number of purchase orders that are processed. They can include the cost of preparing a purchase requisition, the cost of creating a purchase order, the cost of reviewing inventory levels, the cost involved in receiving and checking items as they are received from the vendor, and the cost incurred in preparing and processing the payments made to the vendor once the invoice has been received.

Since the total variable costs can be made up of so many different cost types, they can significantly increase the total lot quantity costs. The best way to determine your total ordering costs is by determining the amount of time you spend on ordering for a replenishment or preparing a lot quantity for production.

Order costs are often overlooked by businesses managers as they perceive the actions of employees - such as checking inventory and quality checks of incoming materials - as a part of their daily routine. However, when calculating the actual cost of the whole ordering process, they will discover that it actually costs money to have an item or material ordered and in stock at their warehouse. This often comes as a surprise, since they often forget that it costs much more to create ten purchase orders for five items each, than buying fifty items at once from one vendor.

It is possible to make a rough estimate of the cost per order by summing up all staffing- and system costs, and by dividing the total by the total number of order lines (see table 1).

Purchasing costs and Price Discounts
Besides inventory carrying costs and lot quantity costs, there is a third cost aspect that has a major impact on the total supply chain costs: purchasing costs. In practice, there is often a relation between the order quantity and the buying price: higher quantities lead to larger price discounts. In order to determine the order quantity for which the total supply chain costs are lowest, all order quantities in relation to all price discounts (and sometimes additional charges) should be considered. Note that the highest price discounts do not automatically imply the lowest total costs. This is for example shown in Figure 4 below, where the third price discount range (150 pieces) leads to the lowest total cost, instead of the highest price discount range (300 pieces).

A rule-of-thumb: if you add one month forecast to your order quantity, you should at least have an additional price discount of 2 percent.
‘EOQ in practice’-model

Why the Economic Order Quantity formula is popular despite its unrealistic assumptions, is shown by sensitivity analysis. This analysis provides clear insights into the practical use of a method. The exact answer is, however, not always applicable in practice and can evoke the increase of other supply chain costs. Therefore it is important to know how variations in the main components of the formula can affect the outcomes of the model. Slimstock has acknowledged this fact and created the ‘EOQ in practice’-model.

Cost sensitivity and practicality

What is the effect of applying a different order quantity than the EOQ? This is shown in figure 4 below. For an increase of 5% in total cost, you can apply an order quantity that is 30% more or less than the EOQ. It can be clearly seen that the EOQ is relatively cost insensitive near the optimum order quantity. When ordering more than the optimum quantity, costs increase less than when you order less than the EOQ.

Logistic units

Now we have established that the outcome of the EOQ formula is relatively cost insensitive near its optimum, we can use this information when optimising for other relevant supply chain costs. Warehouse operations and transportation can be optimised by applying logistic units, like pallet-layer(s), full pallets, or even truck loads. Finding the right logistic unit near the EOQ will enhance all supply chain costs.

Seasonality

When the demand for an article follows a significant seasonal pattern, the traditional EOQ method will not always provide the optimal solution. Near and in the high season, orders will be placed more frequently when applying a fixed order quantity. This leads to more inbound operations related to warehousing and transportation, and can be disruptive for the outbound operations of your organisation. On the other hand, near and during the low season, the inventory position can become very high. Leading to unnecessary high inventory costs and even sometimes difficulties in warehousing operations.

When managing seasonal articles, it is recommended to apply the Economic Order Interval (EOI), also called POQ (Periodic Order Quantity) in literature. This method ensures that order quantities are adjusted to the changes in demand due to seasonality. In the calculation of the EOI, the optimal cycle length is determined by dividing the EOQ by the total seasonal demand:

\[
\text{EOI} = \frac{\text{EOQ}}{D}
\]

Figure 5: Total cost sensitivity EOQ

Figure 6: Total cost sensitivity by demand
From theory to practice in 7 easy steps

This paper provides you with the basic knowledge you need for the optimisation of your order quantities. Now you have read the theory, it’s time to put it into practice!

1. Identify your main supply chain costs.

2. Determine the various specific costs per article group (start with 9 groups maximum).

3. Take the numbers and methods from this paper to make a quick scan of your costs. You can use figure 1 to benchmark your organisation’s outcomes.

4. Calculate the EOQ for every article, despite the product life cycle phase and specific demand characteristics.

5. Compare the outcomes of the formula with your current order quantities and see which ones differ the most from the EOQ.

6. Make a root-cause analysis in order to specify business rules: where can you apply the EOQ directly, and where do you need additional business rules?

7. Apply the EOQ and recalculate it frequently, especially if there are any changes in costs and demand.

The EOQ can be a useful tool for the assessment of the current order quantities of your main suppliers. Find and analyse the biggest differences between your current and the optimal order quantities in order to make quick wins. You can use this information to review your supplier agreements (see figure 6).

If you are willing to put effort into the optimisation of your order quantities, your risks and capital requirements will decrease, whilst you will be able to work more efficiently and most importantly, save a lot of unnecessary costs.

### Literature


Published by Slimstock, market leader in inventory optimisation.

Founded in 1993, Slimstock has become the market leader in inventory optimisation in Europe, with more than 500 customers. Our complete software package, Slim4, contains forecasting, demand planning and inventory management, helping you to get the right inventory to the right place at the right time.

**Practical solutions & expertise**

Beside software solutions, we also offer project based support and professional services, including coaching, analysis, and interim professional support. We showcase our knowledge and experience at international events, and we also offer our own (university of applied sciences) qualifications and training programs.

**The Results for your Business**

We can offer assistance to help reduce your inventory while at the same time increasing the service level. So turnover increases, while costs decrease. The return on a Slim4 investment starts within one year of introduction, and we can offer a guarantee on these results.

For more information about Slimstock go to www.slimstock.com.

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**Figure 7: Supplier MOQ versus EOQ analysis**

![Figure 7: Supplier MOQ versus EOQ analysis](image-url)