

The Use of the EOQ Model in Inventory Management in the Supply Chain on the Example of Bahlsen Polska

Waldemar Paluch

Cracow University of Economics, Poland

The article presents the theoretical basis of the EOQ (economic quantity order) model, which allows you to optimize the size of the order so as to minimize the cost of frozen capital. The next part presents the results of implementing the model at Bahlsen Polska, assuming that it does not receive any discounts from suppliers in relation to the size of the order. This assumption can be excluded in the case of the functioning of the disposition system, carried out taking into account large contracts with the supplier. Optimization in this situation does not apply to the quantity in the contract, but only to a single call which is information for the supplier who must deliver a certain amount of goods, and at the same time reduce the balance appearing in the contract.

Keywords: EOQ, supply chain management, maintenance cost, order cost, safety stock.

1. SUPPLY CHAIN MANAGEMENT

In an era of economic crisis, widespread globalization, and thus increasing competition, consumers expect not only high quality, but also low prices and delivery exactly at the time when it is needed. Therefore, companies wanting to stay on the market must focus their activities on searching for areas in which additional savings could be generated, while accelerating processes. At first, almost every enterprise is able to quickly locate areas that can be easily and virtually cost-optimized. However, over time, you need to go deeper into the processes of wastefulness. Supply chain management is one of the least optimized areas in enterprises operating in markets with high demand fluctuations.

Without efficient supply chain management, companies wishing to meet customer requirements face the following problems:

- overloaded warehouses,
- low service level,
- customer demand for short-term promotions,
- availability of materials, raw materials, etc. for the production of the finished product,
- low efficiency of production lines,
- bad relations between departments:

- sales,
- production,
- logistics,
- planning and procurement.

A supply chain is an organized group of at least 3 companies representing the sphere of supply, production and distribution, carrying out logistic and non-logistics processes. The goal of all activities in the chain is to ensure the efficient flow of materials, products and services, starting from the place of origin of the good and ending with the final recipient [4].

Supply chain management according to M. Christopher is the management of relationships with suppliers and customers up and down the chain in order to provide the highest quality to customers and at lower costs from the point of view of the supply chain as a whole [1].

The basis for implementing the concept of supply chain management is building partner relations with contractors and recipients, as well as creating procedures enabling coordinated management. Such action is primarily associated with the need to provide, previously considered

almost secret, information on the demand for our products, sales forecasts, production plans. However, only such full integration with contractors can lead to a reduction in own costs, and thus a reduction in the price of the final product.

An area whose optimization can bring great benefits are stocks in warehouses, both of finished products as well as materials and semi-finished products intended for production. They are nothing more than frozen capital, what's more, they generate an opportunity cost, i.e. the cost of unused opportunities. This area is difficult to optimize because any irresponsible and ill-considered interference in the volume of inventory may result in production stoppage and, consequently, a decrease in the service level and contractual penalties imposed by the customer. That is why it is very important to find the golden mean between the ordered quantity of raw materials and packaging, allowing to meet the needs of production, and the costs related to their purchase and storage.

There are several types of inventory:

- current stocks - permanent and necessary for maintaining production and sales,
- seasonal stocks - occurring only periodically, are related to the seasonality of customer orders,
- buffer stocks (security, reserve) - specifying the quantity that allows continuing production or sale, until the next delivery of materials for production is delivered, or the next batch of final product is produced.

2. MATERIAL INVENTORY CONTROL MODEL (EOQ)

There are many models that allow for efficient management of material inventory, but against them, the stock level model, which sets the moment of ordering, stands out. It is based on the **Economic Order Quantity** Index (EOQ) and buffer stock [1].

Economic Order Quantity (EOQ) - is the amount for which the total amount of order costs and keeping inventory will be minimal. Figure 1 illustrates this situation.

The economic size of the order is determined by the formula:

$$EOQ = \sqrt{\frac{2 \times P \times K_t}{K_u}}$$

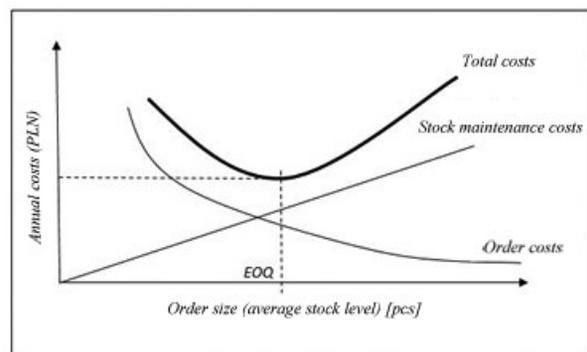
where:

P - the volume of demand for a given range of materials in time (in the year, month week)

K_t - The cost of creating an inventory of material assortment converted per unit during this time period (order cost per order)

K_u - the cost of keeping a unit of a given range of materials in stock for a specified period of time

Fig. 1. Relation of maintenance costs and material inventory creation



Source: Own study

The formula for the economic size of the order shows the relation of inventory creation costs, i.e. the order, to the costs of maintaining this inventory.

Maintenance costs - are the costs incurred by the entity as a result of maintaining inventories. These costs mainly include:

- ✓ costs of lost benefits of investing in inventories (they are most often assumed at the level of interest on a bond or savings account in a bank),
- ✓ increase in insurance costs,
- ✓ increase in storage costs,
- ✓ increase in material costs due to inventory handling,
- ✓ costs of aging and deterioration of supplies.

It should be emphasized that maintenance costs should include only those items that change with a change in inventory levels (e.g. warehouse employees' salaries are not usually relevant).

Order costs - they are the total costs related to order preparation, receipt of delivery and payment of amounts due. Please note that procurement costs that are common to all inventory decisions are not decision costs and are not material in their

considerations. Only incremental order costs are relevant.

Capturing the costs that generate inventory is often a big problem. Even if it does not require storage in specially designated rooms, with appropriate conditions prevailing in them, or special protection, it is never "free". The minimum cost of keeping inventories is the capital frozen in them, which in the worst case could earn interest on the savings account at the bank. Depending on the source of this capital, it may be low (e.g. trade credit), or high (e.g. inventory financed with equity).

The EOQ model is based on the existence of two types of inventory: rotational and security (buffer). In standard production, the first of the stocks is consumed, its depletion is a signal to place an order with the supplier for the quantity specified by the discussed model. However, the safety margin is used up until delivery. Figure 2 shows the process of controlling the inventory of a given material used for production [3, 6].

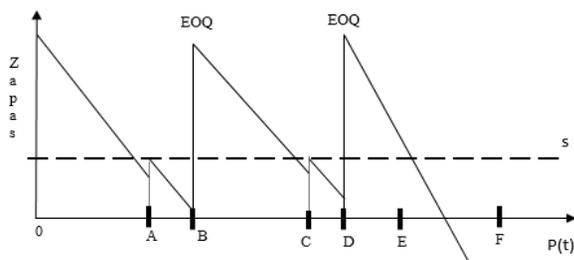


Fig. 2. The process of controlling the inventory of a given material used for production.

Source: Own study

where:

- EOQ - economic order volume
- P (t) - material demand over time
- s - buffer stock

The ordinate shows the amount of inventory, the abscissa represents the consumption over time. The "s" line is the buffer stock volume. Subsequent episodes [0-A], [B-C] show the consumption of rotary stock for current production, up to the intersection of the "s" line, which is the moment of starting the consumption of buffer stock and at the same time a signal to place an order in the amount specified by EOQ. Section [AB] shows the consumption of buffer stock, at this time the supplier must complete the shipment, which takes place in point B. It is important that the safety stock and the moment of ordering are designated so that the supplier is able to deliver the material

before it runs out of production, and the plant will be forced to stand up. This situation was presented on the section [D-E-F], where there was not enough buffer. Their task is to prevent material deficiencies. It is determined on the basis of the formula [5, 6]:

$$s = y \times L + k \times \sigma \times \sqrt{L},$$

where:

- s - buffer stock
- y - average level of demand in the adopted period
- L - average lead time
- k - customer service level factor
- σ - average forecast error

In order to calculate the buffer stock level it is necessary to determine the average level of demand (y) in the assumed period; average delivery time (L); average forecast error (σ), which in the normal distribution is 1. It depends on us whether we include one, two or even three σ in the calculation of the safety margin. In addition, the customer service level factor (k) is necessary for calculations, which is determined using normal distribution tables, of course, we assume here that demand is characterized by such a distribution. On the basis of the standardized normal distribution cumulative distribution factor k is calculated then depending on the adopted service level, e.g. k = 1 for 84.1% probability of satisfying customer demand [6, 7].

3. THE ANALYSIS OF THE USE OF THE EOQ MODEL AT BAHLSSEN POLSKA

Bahlsen Polska is an international family company operating in the food industry, producing cakes. Its basic brands include: HIT, Krakuski and Leibniz. As in many companies operating on similar markets, with similar specifics, one of the basic problems in supply chain management is the accumulation of inventories, and thus the freezing of large capital in inventories. This is related to the specifics of the food industry, namely:

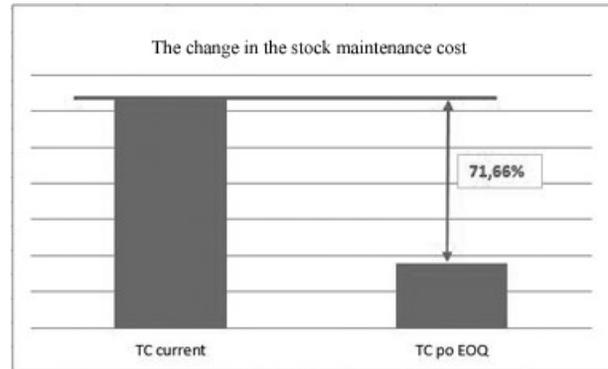
- large number of non-standard packaging,
- seasonality of many articles,
- rapidly changing consumer tastes,
- large fluctuation in demand,
- sudden promotional campaigns.

All these factors make managing inventory of packaging and raw materials used for production very difficult, because the level at which they are maintained should allow to secure production while minimizing their quantity. It should also be noted that high seasonality of production and significant changes in demand affect the increase in the burden of the supplier due to insufficient production capacity, and therefore the deadlines for orders are often extended.

Another group of factors, very important from the point of view of the volume of inventory, is related to the impact of supply on the inventory management process. These include the following:

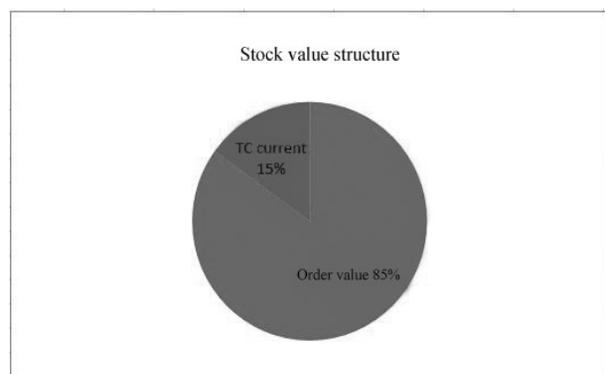
- minimum production batches at the supplier,
- the need to combine supplies in order to fully use the means of transport,
- specific storage times at the supplier, after which the material must be delivered to the factory sending the order,
- often long lead time, i.e. the time between placing an order and delivering it to the plant,
- expiry / use dates, after which the raw material / material can no longer be used,
- non-standard pallet sizes or very large quantities on pallets.

In such conditions, it becomes very important to find the "golden mean" between the costs of maintaining inventory and ensuring continuity of production. The EOQ model comes in handy, which allows you to calculate the size of the order, allowing you to optimize storage costs. Graph 1 shows the change in the total cost of maintaining inventory before and after the economic size of the order is applied. The model would reduce the cost of frozen capital (TC - Total costs) by about 71%¹.



Graph 1. Change in inventory maintenance cost

Chart 2, in turn, presents the structure of the inventory value, i.e. the ratio between the amount on the order (understood as what we pay the supplier, i.e. the invoice price), and the cost of maintaining the material, which accounts for about 15% of the total cost of the order.



Graph 2. Structure of inventory value.

An important element of the discussed model, that should be kept in mind, is the safety margin, the calculation of which can, however, be very problematic. The reason is the parameter appearing in the formula, i.e. σ - mean forecast error, understood as standard deviation. The higher the seasonality of the product, the more sudden promotional campaigns the greater the fluctuation in demand, and thus the standard deviation. This can lead to a situation where the safety stock, which should be maintained at a certain level, would be too high and would ultimately increase the stock. Therefore, the use of a safety stock is not always possible and recommended. Therefore, when using the EOQ model, use common sense above all.

¹ The calculations did not take into account the discounts for the large volume of orders that could be obtained from suppliers

4. SUMMARY

The model presented above allows you to estimate the amount of material that should be ordered to minimize all costs associated with inventory handling and capital freezing. The basis is having reliable data on the costs of creating and maintaining inventory. However, the EOQ model has drawbacks regarding the assumption of wear linearity and the difficulty of adjusting the size of the safety stock due to large fluctuations in demand. Another problem related to calculating the economic size of an order is determining the costs that a single order generates, especially if a given supplier provides us with several different materials in one delivery. It should also be taken into account that by reducing the quantities we order, we generate a higher cost of transport, because the car that will carry us goods may be incomplete. Suppliers often do not agree to such a loss, which is why when buying a larger quantity they offer a lower price, which should also be taken into account when making business decisions regarding the quantities ordered from the supplier. It may turn out that buying according to the discount offer is more profitable for the company than according to the calculated EOQ. Supplier's production minima are another obstacle to reducing ordered quantities, he may simply not be able to make a smaller batch for us [2].

Therefore, the EOQ model should be treated as a starting point on which to base our process of striving to reduce our supply chain. It shows a certain way, as well as data on the size of orders, which with the current system would save capital, and also pay attention to the costs generated by the inventory. EOQ can also be helpful in negotiations with suppliers, because at the beginning we will know what order sizes will interest us.

REFERENCES

- [1] Christopher M., *Logistyka i zarządzanie łańcuchem dostaw*, PCDL, Warszawa 2000.
- [2] Krawczyk S., *Zarządzanie procesami logistycznymi*, Polskie Wydawnictwo Ekonomiczne, Warszawa 2001.
- [3] Krzyżaniak S., *Podstawy zarządzania zapasami w przykładach*, Instytut Logistyki i Magazynowania, Poznań 2002.
- [4] Lysons K., *Zakupy zaopatrzeniowe*, Polskie Wydawnictwo Ekonomiczne, Warszawa 2004.
- [5] Saryusz-Wolski Z., *Sterowanie zapasami w przedsiębiorstwie*, Polskie Wydawnictwo Ekonomiczne, Warszawa 2000.
- [6] Saryusz-Wolski Z., *Strategia zarządzania zaopatrzeniem*, Placet, Warszawa 1998.
- [7] Skowronek Cz., Saryusz-Wolski Z., *Logistyka w przedsiębiorstwie*, Polskie Wydawnictwo Ekonomiczne, Warszawa 1999.

Waldemar Paluch
Cracow University of Economics, Poland
waldemar.p87@gmail.com

