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Effect of the Safety Stock on the Probability of Occurrence of the Stock Shortage

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Abstract

The objective of the logistics management is to guarantee the stock level required for the adequate handling of production at the lowest possible level of costs and risks. By using the economic order quantity model, we can define the optimal order quantity, along which our stock management can be guaranteed by the most favourable cost level. The theoretical approach of the model assumes a deterministic operational environment. In practice, however, there are several unpredictable factors influencing the operation of the production company. The aim of our analyses is to present the relations between the stock level and the risk of shortages. As a result of the research, the introduction of the safety stock is the solution to cover the effects of the uncertain factors in the supply chain. The avoidance of stock shortages would be possible only with the management of an infinite stock level due to the stochastic factors, but it is not feasible in practice. We need to quantify a service level, which determines the accepted probability of the shortage occurrence.

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1. The cost categories of stockpile management

It often happens in practical logistics that the actual utilization demand cannot be satisfied immediately. The continuity of service, in some cases, is broken by a disturbance in a stage of the supply chain, which causes a significant confusion for both the customer and the supplier. In other cases, the reason is a planned stock management strategy that can be led back to a certain aspect of economic efficiency.

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The classical stockpile management approaches the optimization of the stock level from the side of expenses, meaning that the optimal stock level is represented by the stock derived from the lowest total costs. Among the costs of the stockpile management system, we can differentiate three basic cost categories:

- Cost elements related to the procurement activity
- Costs related to stock holding
- Costs related to stock shortage consequences.

These three cost groups can be modified to the detriment of one another. The holding costs increase linearly with the increase of the lot size, while the costs related to procurement decrease with the increase of the order quantity. Similarly, the holding costs are in trade-off relation with the costs of stock shortage. The task is the definition of the optimum of the total costs function that fulfils the cost-minimizing target, and the quantification of the derivable order quantity and of the order period [1].

2. The determination of the economic order quantity in case of planned shortage

The first scientific model about an optimal lot size determination was published by Harris in 1913 in the article "how many parts to make at once" [2]. This model defines the production quantity optimization with not acceptable stock-out periods and assumes deterministic conditions. Several extensions of the basic Economic Order Quantity model are defined since that, describing the real operational processes more and more in details, and gives answers to the practical issues. In case of deterministic inputs the model is extended with the analyze of the deterioration of goods [3], the quantity discounts [4], limited supplier capacity, the dynamic version of the economic lot size [5] etc., and several researches are also done in the direction of stochastic factors such as demand fluctuation, lead time variation, fraction of the defective items [6] or shortages – using a probability density function, etc.

As in the practice the demands are only in exceptional cases predictable with full certainty and the decision between the higher inventory level and risk of stock out situation presents often strategic importance we use the probabilistic model with planned shortages to our analyzes.

As an initial condition we define that the unsatisfied demand due to stock shortage can be rescheduled by a defined cost level, and it will be fully performed at a later date. The main questions of stock management models are the optimum quantity that can be procured on one occasion by most favorable total costs, and the optimal scheduling of procurement. The balance between the stock level and the costs can be defined with the economic order quantity with planned shortage model, the initial conditions of which are as follows [1, 7]:

- The supply rate can be considered as being infinite
- The ordered quantity arrives as one item; the frequency of supplies is scheduled for identical periods
- The demand is known and pre-definable with absolute certainty
- Both the customer and the supplier want to satisfy the demand. The demand is continuous and the utilization has a consistent intensity, thus the demand rate is constant. Accordingly, within a supply period, the stock level shows a strictly monotonous descending linear function in relation to time
- Stock shortage is accepted at a certain cost
- The ordering costs are independent from the order quantity
- The holding costs per unit are constant and they change linearly with the stock quantity
- The purchase price per unit does not depend on quantity, thus the purchase price does not influence the stock management policy to be chosen
- By assuming an infinite time horizon, the costs are independent of the time factor [8, 9].

The basic model of the economic order quantity starts from the relation that the purchase cost and the stock level change according to the order quantity, and the holding cost changes as well. Accordingly, the more rarely orders are made, the more favorable the purchase costs are per unit, and at the same time, the holding costs are linearly increasing [10, 11]. The function of total costs can be defined as the sum of these three costs and the value of the purchased parts. The objective function defines the minimum of the function of total costs [1, 7–9]: