SENSIBILITY ANALYSIS OF THE PLANNED AVAILABILITY PERIOD AND OF THE IMPACT OF THE COST FACTORS ON TOTAL COSTS

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Abstract: 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 differentiate three basic cost categories, such as the cost elements related to the procurement activity, the costs related to stock holding, and the costs related to stock shortage consequences. From the economic order quantity models we analyze the cost factors of the version with the planned stock shortage. During our analysis, we examine the movement of practical logistics experts within a short time horizon, e.g. the parameters modified during certain orders and the input factors that must be considered as given, and the impact of these factors modified to different extents and in different combination on the different cost factors and on the total cost.
Keywords: *cost factor, economic order quantity, planned availability period, sensibility analysis*

1. The cost categories of stockpile management

It happens often 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.

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 differentiate three basic cost categories:
– Cost elements related to the procurement activity.
– Costs related to stock holding.
– Costs related to stock shortage consequences [1] [2].

These three cost groups can be modified to the detriment of one another [1] [3]. 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 [4]. 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 [5].

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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". This model defines the production quantity optimisation 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. To our analyses we use the probabilistic model with planned shortages.

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 [6]. The main questions of stock management models are the optimum quantity that can be procured on one occasion by most favourable 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 [2] [3] [4] [5] [6] [7] [8]:

- The supply rate can be considered as being infinite, the stock replenishment is immediate, and so the replenishment time is equal zero.
- 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 by 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 [4] [9].

In case of a constant utilization demand with continuous and uniform intensity *[Figure 1 a)]* and a procurement cycle with uniform period intervals, if the opening stock d of period t is smaller than the total utilization demand q due during the period, the stocks before the next period will decrease to zero at a certain t_0 point of time, followed by a stock shortage period with a t_2 length, at the end of which the stocks will be replenished. During period t_2, the continuous demand will lead to a backlog of level s.

Figure 1 b) summarizes in one diagram the arrival of stocks and the development of demands in relation to time, as a cumulated value. The difference of these two shows the relation between the demands satisfied on time and the demands that are rescheduled.
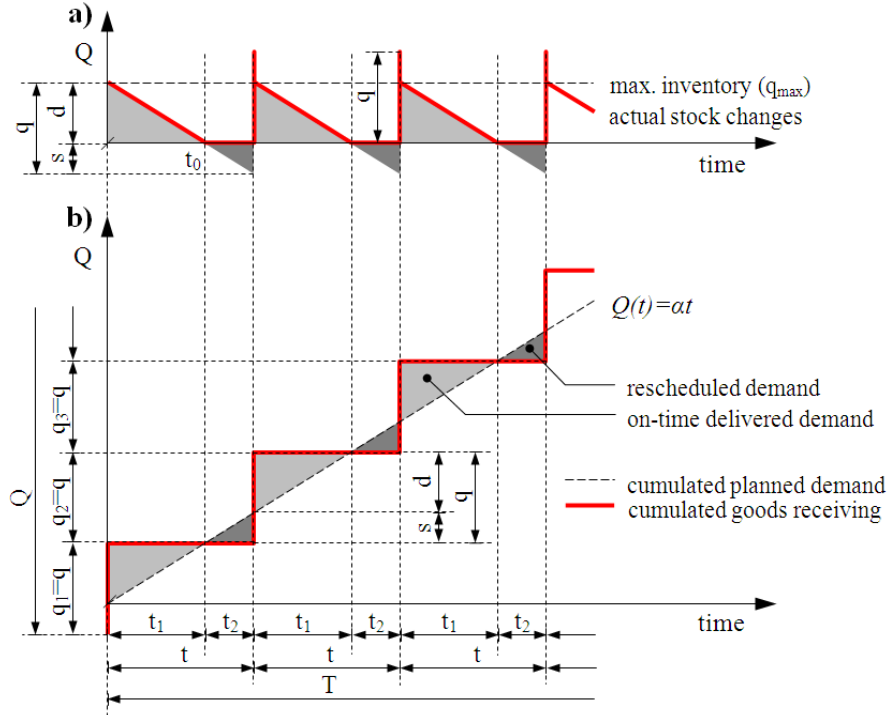
Figure 1 a–b) Optimal stock level in case of regular stock replenishment and a demand with uniform intensity with periods of stock shortage
(Personal editing)

The purchase costs incurring during the whole analyzed period can be defined by multiplying the one-off purchase cost by the frequency of procurements [10]:

$$C_o = \frac{Q}{q} \cdot c_o \qquad (1)$$

where
C_o – total purchase cost for the examined period,
Q – total purchase demand for the examined period,
q – purchase demand for a single period, economic order quantity,
c_o – cost of a single purchase order.

The holding costs can be defined with the area of sections due to the t_1 period of the saw tooth diagram [10]:

$$C_h = \frac{1}{2} \cdot d \cdot t_1 \cdot \frac{Q}{q} \cdot c_h = \frac{1}{2} \cdot d^2 \cdot \frac{T}{q} \cdot c_h = \frac{d^2}{2 \cdot q} \cdot v \cdot r \qquad (2)$$

where
C_h – total holding cost for the examined period,
d – the portion of the demand covered by stock within one single period,
t_1 – period, during the demand is performed without delay at the time of its occurrence,
c_h – holding cost per time unit,

T – the length of the complete period,
v – purchasing price per unit,
r – annual holding cost rate.

During the quantification of the stock shortage costs, we have to start from the relation that the continuous demand increases the level of the backlog, which can be expressed with the area of sections due to period t_2 of the saw tooth diagram [2] [10]:

$$C_s = \frac{1}{2} \cdot (q - d) \cdot t_2 \cdot \frac{Q}{q} \cdot c_s = \frac{(q - d)^2}{2 \cdot q} \cdot T \cdot c_s = \frac{s^2}{2 \cdot q} \cdot T \cdot c_s \qquad (3)$$

where
C_s – the shortage cost during the whole analyzed period,
t_2 – period, during the demands due must be rescheduled for a later date,
c_s – shortage cost per time unit.

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 favourable the purchase costs are per unit, and at the same time, the holding costs are linearly increasing [11] [12].

   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 is defining the minimum of the function of total costs [2] [3] [4] [5] [6] [9] [10]:

$$C(q; d) = Q \cdot v + C_o + C_h + C_s = \frac{Q}{q} \cdot c_o + \frac{d^2}{2 \cdot q} \cdot T \cdot c_h + \frac{(q - d)^2}{2 \cdot q} \cdot T \cdot c_s \ \to \ min \quad (4)$$

where
C – total cost of inventory management for the examined period.

The optimal order quantity can be defined by solving the system of previous equations, where the form of partial derivatives according to q and d of the function of total costs is set equal to zero [2] [4] [6] [10] [13] [14] [15]:

$$q = d \cdot \frac{c_h + c_s}{c_s} = \sqrt{\frac{2 \cdot Q}{T} \cdot \frac{c_o}{c_h}} \cdot \sqrt{\frac{c_h + c_s}{c_s}} \qquad (5)$$

The on-time delivered quantity can be calculated as followed:

$$d = \sqrt{\frac{2 \cdot Q}{T} \cdot \frac{c_o}{c_h}} \cdot \sqrt{\frac{c_s}{c_h + c_s}} \qquad (6)$$

The optimal amount to be backordered [4]:

$$s = q - d = q \cdot \frac{c_h}{c_h + c_s} = \sqrt{\frac{2 \cdot Q}{T} \cdot \frac{c_o}{c_s}} \cdot \sqrt{\frac{c_h}{c_h + c_s}} \qquad (7)$$

The minimum total cost incurring during the whole period together with the money spent on purchased stocks:

$$C = \sqrt{2 \cdot Q \cdot T \cdot c_o \cdot c_h \cdot \frac{c_s}{c_h + c_s}} + Q \cdot v \qquad (8)$$

3. The representation of cost factors of demands satisfied on time and demands with rescheduled satisfaction in case of an optimal order quantity

Among the deterministic models, it is expedient to further analyse the approach closer to practical life, thus when a planned level of stock shortage is allowed by considering a certain aspect of economic efficiency, and the backlog accumulated during the period of stock shortage is completed at the start of the next stockpiling period as one item.

In this case we must calculate with a period with a length t_1, during which the demand is performed without delay at the time of its occurrence, and with a period with a length t_2, during which the demands due – because of a drop to zero of stocks in time t_1/t – must be rescheduled for a later date. Among the conditions we can mention that the demand is permanent and has a consistent intensity, and both parties are committed to satisfy the demand, thus the client will not change to another supplier. This, of course, has a price on the side of the supplier, which is defined in the specific cost factor c_s Similarly, the holding of stocks for the immediate satisfaction of the demands has a specific cost c_h as well, which has an effect in opposite direction as the consequences of the lack of demand. The costs c_h and c_s set a price to the ratio of the satisfaction of demands on time and of their rescheduling.

For logistics managers, order values *Q, c_o, c_h, c_s and T* can be regarded in practice as fixed, they do not have an impact on those factors within a short time horizon or at all, or they can be influenced only to a small extent. What can be changed is the selection of the length of periods t_1/t_2, the frequency of procurements and the quantity per orders. The target is the definition of optimum values for variable factors.

As the initial step of the analysis, we must present the rate of period t_1/t attributed to the optimum order quantity and the related cost levels *(Figure 2)*.

The horizontal axis shows the period of demand satisfaction without delay within the whole period, thus the relation of periods t_1/t. Regarding the horizontal axis, the diagram has a lower and an upper boundary, which results from the relation *$0 \leq t_1/t \leq 1$*. Obviously, in case the value *$t_1/t = 0$,* we must calculate with a delay during the whole period, thus the planned demand is completely rescheduled, while in case the value *$t_1/t = 1$*, the performance will be on time during the whole period. The vertical axis shows the value of calculable costs in case of the different availability levels, values t_1/t.

As an auxiliary line, the stock holding and stock shortage costs quantified to the optimum order quantity can be drawn to the coordinate system. During the interpretation, it must be noted that the actual cost level reflects the value corresponding to the optimum state, which can be interpreted only in the optimum point t_1/t. However, during the representation, independently of the t_1/t ratio, we represent it over the whole width of the diagram. This is necessary for the indication of the situation (height) of the costs in relation to the vertical coordinate axis and the axial intersections.
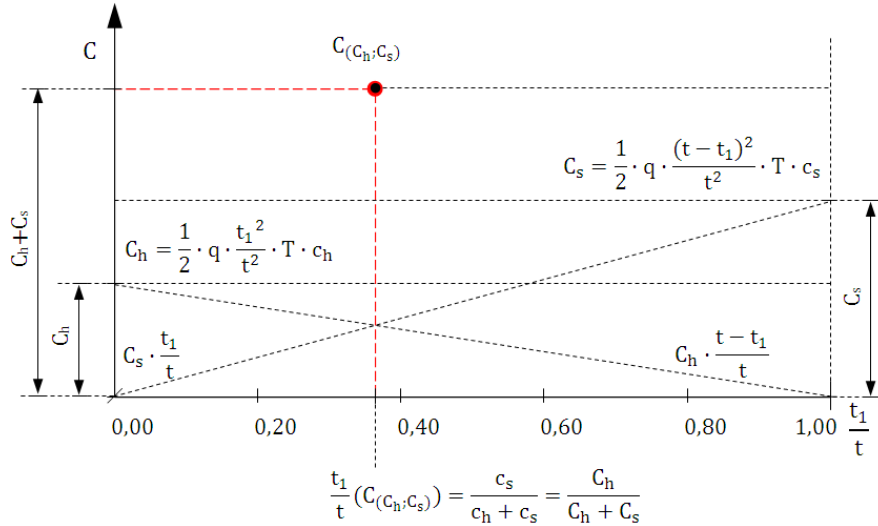
Figure 2. The t_1/t rate attributable to the optimum order quantity and the cost levels
(Personal editing)

Also as an auxiliary line, the indicated slope of the actual cost functions can be drawn, thus the inclined lines drawn to the optimum t_1/t level line.

The illustrated slope of stock holding C_h:

$$C_h \cdot \frac{t - t_1}{t} = \frac{1}{2} \cdot q \cdot \frac{t_1^2}{t^2} \cdot T \cdot c_h \cdot \frac{t - t_1}{t} \qquad (9)$$

The illustrated slope of stock shortage C_s:

$$C_s \cdot \frac{t_1}{t} = \frac{1}{2} \cdot q \cdot \frac{(t - t_1)^2}{t^2} \cdot T \cdot c_s \cdot \frac{t_1}{t} \qquad (10)$$

The optimum t_1/t ratio is defined by the point, where these two lines of opposite sign and with given slopes intersect, that is:

$$C_h \cdot \frac{t - t_1}{t} = C_s \cdot \frac{t_1}{t} \qquad (11)$$

By replacing relations (9) and (10), we get the following equation:

$$\frac{1}{2} \cdot q \cdot \frac{t_1^2}{t^2} \cdot T \cdot c_h \cdot \frac{t - t_1}{t} = \frac{1}{2} \cdot q \cdot \frac{(t - t_1)^2}{t^2} \cdot T \cdot c_s \cdot \frac{t_1}{t} \qquad (12)$$

Simplifying both equations, the place of the optimum t_1/t point can be given with the specific cost factors, and with the relations of stock holding and stock shortage costs:

$$\frac{t_1}{t} = \frac{c_s}{c_h + c_s} = \frac{C_h}{C_h + C_s} \qquad (13)$$

By knowing the optimum cost and period defined by the horizontal and vertical axes, we can illustrate the punctual situation of the minimum total cost assigned to the optimum order quantity.

The deduction of the above-mentioned relation is necessary to illustrate the characteristics of the optimum state. The following sections describe the deviations from the optimum state.

4. Sensibility analysis of the planned availability period and of the impact of the cost factors on the total costs

During the first analysis, the *q* economic order quantity is defined beside values *Q, c_o, c_h, c_s and T* that have been defined earlier. In case we modify the t_1/t ratio by a *q* value, thus we deviate from the optimum value in both directions, a cost level can be given for every t_1/t point, and the full curves of stock holding and stock shortage can be drawn up.

Figure 3 shows the development of the costs of stock holding and stock shortage in case we deviate in one direction from the optimum t_1/t point by leaving the input factor unmodified.
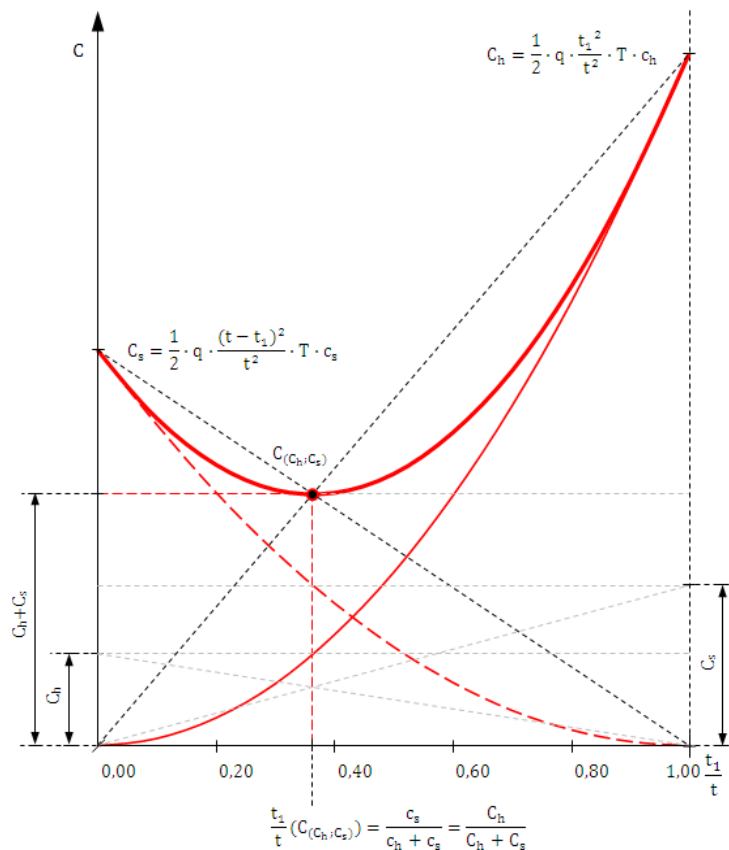

Figure 3. The impact of the modification of the availability t_1/t ratio on the costs in case of fixed q quantity
(Personal editing)

This shift describes a case that can be frequently observed in practice, since there are influencing parameters that justify the deviation from the optimum periods. One such a case can be when the calculation results in a fractioned day for the availability time belonging to the most favourable cost level, but the organization must think in terms of full days, so that rounding is necessary in one direction, which will result in a shift from the optimum t_1/t ratio. The legitimacy of the model is justified by the fact that in case of certain products, clients and suppliers, the calculation of the optimal value can result in different values, but during the daily operation, it is necessary to consolidate these data to a certain extent, which will result again in a deviation from the optimum.

By connecting the axis intersections diagonally with the origin, the intersection of the two opposing lines will coincide, in case of horizontal and vertical coordinates as well, with the optimal cost level and period values shown in *Figure 2*.

Figure 4 shows the positive quarters of the four diagrams rotated together by their common axis, showing the mechanism of the possible modification in the level of performance on time.
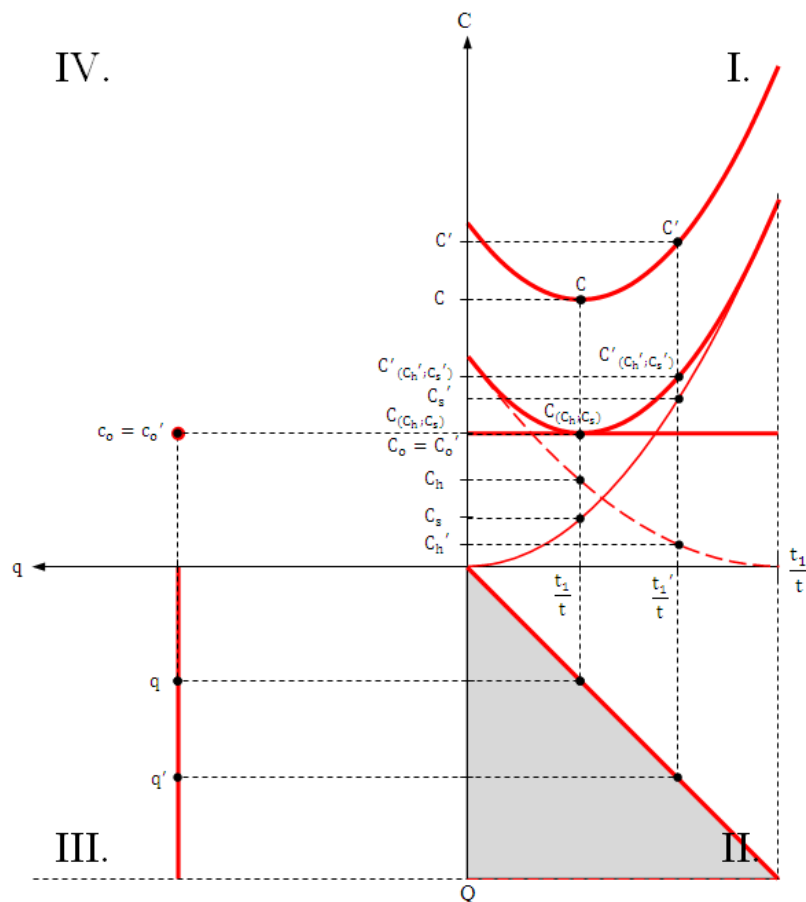

Figure 4. The relation between the availability time, the order quantity and the three cost factors in case of a fixed quantity q
(Personal editing)

The first quarter reflects the costs assignable to the different levels of performance on time. The fixed input factors q, Q, c_o, c_h, c_s and T can be found among the initial conditions. The second quarter contains the extent of the planned demand and the demand that has been met on time. The third quarter shows the possible modification of the order quantity in relation to the satisfied demand. The fourth quarter shows the purchase cost in relation to the order quantity. The punctual illustration reflects that the purchase costs can be considered as given, since quantity q can take up only one fixed value, and the input factors of cost C_o are fixed.

The diagram has boundaries on the bottom and on the right side, indicated by the dotted lines. The right boundary results from relation $0 \leq t_1/t \leq 1$, while the lower boundary results from the relation of satisfied and planned demands.

It is important to mention the fixedness of order quantity q, which is reflected by the line parallel to the vertical axis in the third quarter. In case we deviate in any direction from the optimal availability level t_1/t assigned to the lowest amount total costs, the costs of stock holding and stock shortage will change to a different extent and in different directions. Since purchase cost C_o remains unchanged due to fixed factors Q, q and c_o, the development of total costs will result from the modification of stock holding costs C_h in relation to the modification of stock shortage costs C_s.

The first quarter of *Figure 4* shows that the deviation in any direction and to any extent of the availability time from the optimal ratio leads to the increase of the total cost function.

The deviation of the stock holding costs from the optimal point t_1/t by a rate of $1+z$ changes as follows:

$$\frac{C_h{'}}{C_h} = \frac{\frac{1}{2} \cdot q \cdot \frac{(t_1 \cdot (1+z))^2}{t^2} \cdot T \cdot c_h}{\frac{1}{2} \cdot q \cdot \frac{t_1{}^2}{t^2} \cdot T \cdot c_h} = (1+z)^2 \tag{14}$$

Similarly, the extent of stock shortage modification can be defined as:

$$\frac{C_s{'}}{C_s} = \frac{\frac{1}{2} \cdot q \cdot \frac{(t - t_1 \cdot (1+z))^2}{t^2} \cdot T \cdot c_s}{\frac{1}{2} \cdot q \cdot \frac{(t - t_1)^2}{t^2} \cdot T \cdot c_s} = \frac{(t - t_1 \cdot (1+z))^2}{(t - t_1)^2} \tag{15}$$

In case of a deviation from point t_1/t by a rate of $1+z$ and a fixed quantity q, the total costs of stock holding and stock shortage will change according to the following relation:

$$\frac{C_{(C_h;C_s)}{'}}{C_{(C_h;C_s)}} = \frac{C_h{'}}{C_h} + \frac{C_s{'}}{C_s} = (1+z)^2 \cdot C_h + \frac{(t - t_1 \cdot (1+z))^2}{(t - t_1)^2} \cdot C_s \tag{16}$$

In case stock holding and stock shortage, as specific cost factors, and the one-off purchase cost change to the same extent $1+z$, the diagram showing the cost function will change by an extent $1+z$ along the vertical axis by keeping the original proportions. Consequently, point t_1/t of the optimal cost level and quantity q remain unchanged, only the level of costs will change to an extent $1+z$. *Figure 5* shows a proportionate cost increase, which is a characteristic inflation effect. The price and wage increases following inflation can cause some extent of deviation and distortion in the proportionate increase of certain cost factors

in relation to each other, thus a perfectly proportionate change is rarely imaginable in practice, and at the same time, the impact of the changes can be seen on the diagram.

For reasons of clarity, *Figure 5* shows quarter number one and two twice, the first showing the state before the change, the other the state after.
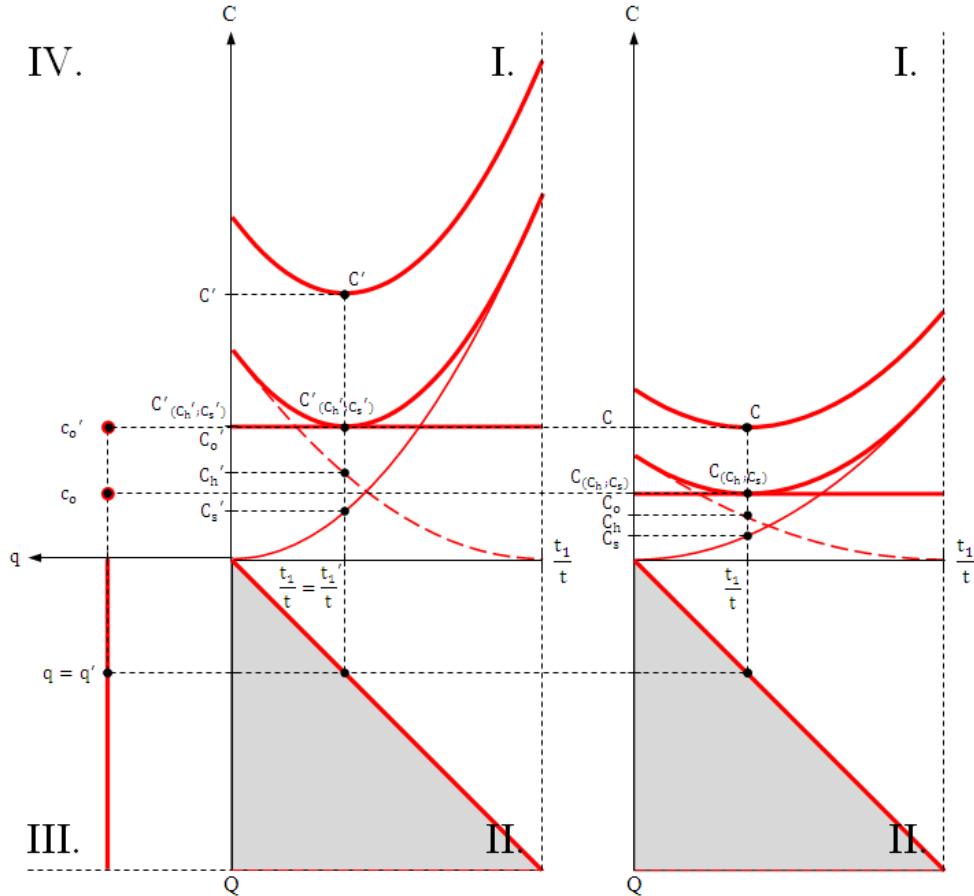

Figure 5. The impact of the proportionate increase of the specific cost factors and the one-off ordering cost on the total cost
(Personal editing)

The relation shown in a formula:

$$c_o' = c_o \cdot (1 + z) \quad \text{and} \quad c_h' = c_h \cdot (1 + z) \quad \text{and} \quad c_s' = c_s \cdot (1 + z) \tag{17}$$

where

c_o' – one-off purchase price after the change,
c_h' – specific cost after the change for the stock holding time unit,
c_s' – specific cost after the change for the stock shortage time unit.

The modification of the total cost function can be derived from the change of the different costs:

$$C' = C_o \cdot (1 + z) + C_h \cdot (1 + z) + C_s \cdot (1 + z) = C \cdot (1 + z) \tag{18}$$

where

C' – modified total costs related to stock management during the whole period.

It is a frequent phenomenon in practice that the specific costs and the one-off ordering cost is given in for a short time horizon and the only space for logistics managers is the modification of the availability time or the selection of order frequency. In case the fixedness of quantity q is lifted, different stock holding and stock shortage costs arise due to the different order quantity. *Figure 6* models the mechanism on the costs by fixed factors Q, T, c_o, c_h *and* c_s and in relation to the changes of quantity q.
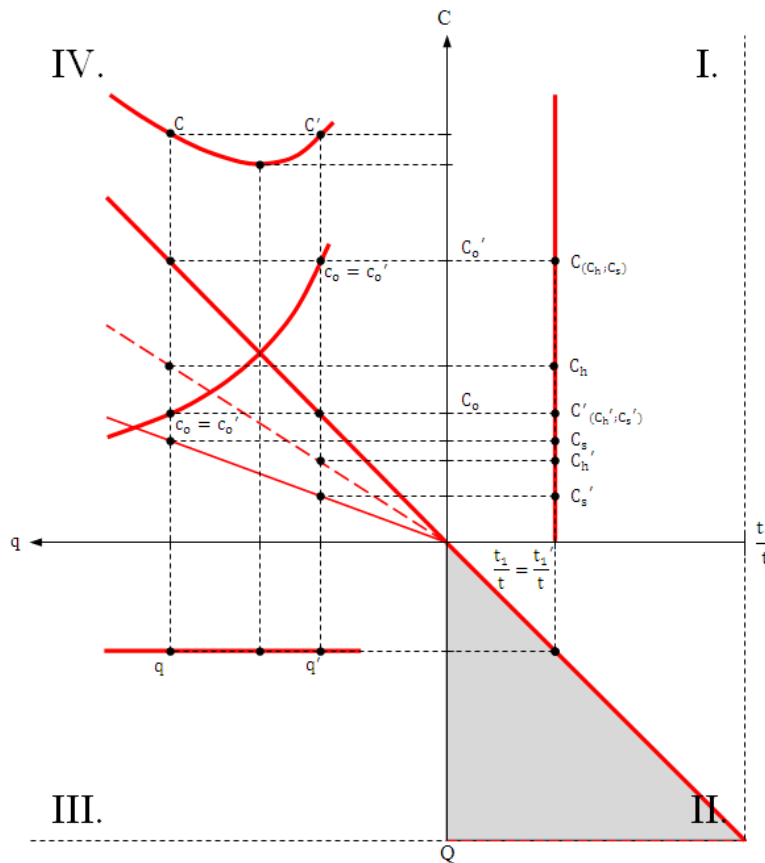

Figure 6. Modification of costs as a function of changing order quantity, in case of fixed specific cost factors and one-off order cost
(Personal editing)

Since the specific costs cannot change, the ratio between them can be considered as given as well. Consequently, the t_l/t ration is fixed as well, thus stock holding C_h and stock

shortage C_s, and their total cost can only change vertically. The level of purchase cost C_o is determined by the order quantity, since the other factors can be considered as constant.

Due to the decrease of the one-off order quantity, the demand of the whole period can be satisfied only with more frequent procurement, which causes a lower average stock level, thus the cost levels of stock holding and of stock shortage drop as well.

The diagram also shows that the minimum value of the total cost is where the purchase cost corresponds to the total cost of stock holding and stock shortage, which can be replaced in a weighted way according to following formula, simplifying the practical use of the model and the quantification of the optimal points:

$$c_{(c_h;c_s)} = \frac{c_h \cdot c_s}{c_h + c_s} \tag{19}$$

The fourth quarter of the resulting diagram is the representation of the relations of the planned basic model with stock shortage. Due to its placing in the fourth quarter, it is illustrated as a reflection of the basic model.

The model shown in *Figure 7* shows a change during which, by fixed factors *q, Q, T, c_h* *and c_s*, it is only the one-off purchase cost c_o that changes, showing a decrease to an extent of *1+z* in a favourable direction. This describes a phenomenon occurring in practice, e.g. a decrease of costs as a result of a more favourable tariff scheme renewed within a transport tender.

The relation shown in a formula:

$$c_o{}' = c_o \cdot (1 + z) \ \text{ and } \ c_h{}' = c_h \ \text{ and } \ c_s{}' = c_s \tag{20}$$

The modification of the total cost function in case of quantity *q* can be derived from the change of the different costs:

$$C' = C_o \cdot (1 + z) + C_h + C_s = C_o{}' + C_h + C_s \tag{21}$$

The relation shows that the purchase cost changing to an extent of *1+z* cannot be made equal with the sum of unchanging stock holding costs and stock shortage costs, which is a condition of a balanced optimal state:

$$C_o{}' \neq C_h + C_s \tag{22}$$

Accordingly, the resulting total cost level cannot be an optimal state due to the fact that, if the purchase cost would become more favourable, so that by a more frequent procurement, it would provide the possibility to achieve a lower stock level, lower stock holding costs and stock shortage costs, but this would require the lifting of the fixedness of quantity *q*.

By using the modified one-off purchase cost and the fixed specific stock holding and stock shortage costs, the modified optimal order quantity can be given with formula number (5):

$$q' = \sqrt{\frac{2 \cdot Q}{T} \cdot \frac{c_o \cdot (1 + z)}{c_h}} \cdot \sqrt{\frac{c_2 + c_s}{c_s}} = \sqrt{\frac{2 \cdot Q}{T} \cdot \frac{c_o}{c_h}} \cdot \sqrt{\frac{c_h + c_s}{c_s}} \cdot \sqrt{(1 + z)} \tag{23}$$
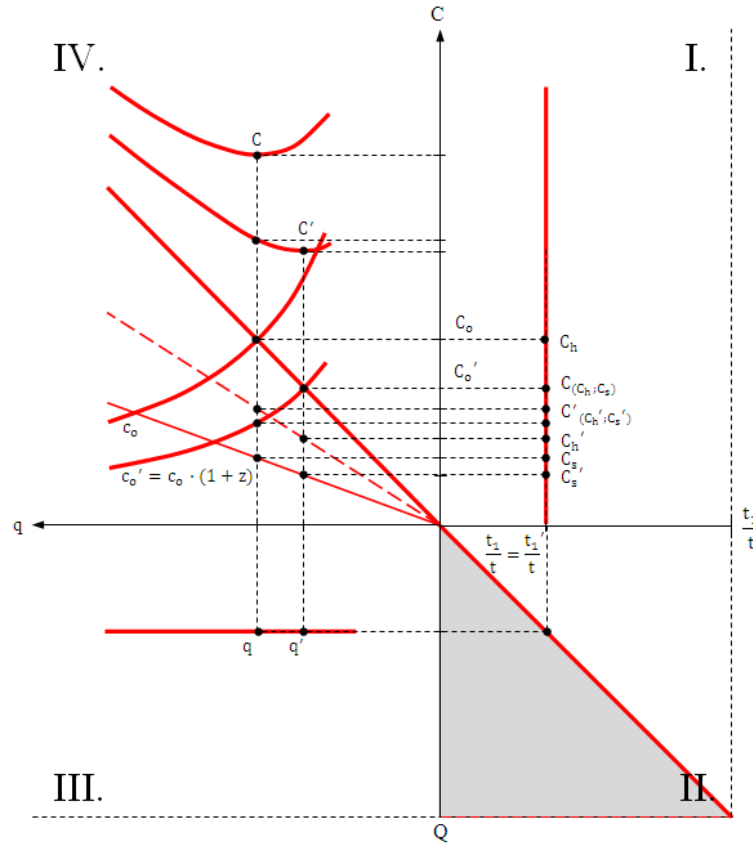
Figure 7. Modification of costs in case of a fixed order quantity, fixed specific cost factors and the modification of the one-off order cost
(Personal editing)

By simplifying the formula, we can define the impact of the modification of the one-off purchase cost by *1+z* on the optimal order quantity:

$$q' = q \cdot \sqrt{(1 + z)} \tag{24}$$

where

q' – purchase demand of a single period, order quantity following the modification.

The change in the total cost level, in case of a fixed quantity *q*, can be defined with the following relation:

$$\frac{C'_{(C_o';C_h;C_s)}}{C} = \frac{C_o \cdot (1 + z) + C_h + C_s}{C_o + C_h + C_s} = 1 + \frac{z}{2} \tag{25}$$

In case of lifting the fixedness of quantity *q*, the costs of stock holding and stock shortage change too, thus the optimal total cost level can be defined as follows:

$$C' = C_o \cdot \sqrt{1 + z} + C_h \cdot \sqrt{1 + z} + C_s \cdot \sqrt{1 + z} = C \cdot \sqrt{1 + z} \tag{26}$$

In case the fixedness of quantity q cannot be lifted, e.g. the frequency of transports cannot be modified due to the constraint of scheduled services, the extent of deviation from the optimal total cost is described by the following relation:

$$\frac{C'_{(C_o';C_h;C_s)}}{C'} = \frac{C \cdot \left(1 + \frac{z}{2}\right)}{C \cdot \sqrt{1 + z}} = \frac{\left(1 + \frac{z}{2}\right)}{\sqrt{1 + z}} \tag{27}$$

A version occurring in practice is the selection of the order quantity at different levels. In case we modify the order quantity q by an extent of $1+z$ from the optimal value, with fixed factors Q, T, c_o, c_h and c_s the modification of costs can be defined with the next relations.

The modification of the purchase cost:

$$C_o' = \frac{C_o}{(1 + z)} \tag{28}$$

The modification of the stock holding cost:

$$C_h' = C_h \cdot (1 + z) \tag{29}$$

The modification of the stock shortage cost:

$$C_s' = C_s \cdot (1 + z) \tag{30}$$

The modification of the total cost function can be derived by replacing formulae number (28) (29) and (30):

$$\frac{C'}{C} = \frac{\frac{C_o}{(1 + z)} + C_h \cdot (1 + z) + C_s \cdot (1 + z)}{C_o + C_h + C_s} = 1 + \frac{z^2}{2 \cdot (1 + z)} \tag{31}$$

The extent of the modification of the total cost can be illustrated in the function of the deviation from the optimal order quantity *(Figure 8)*.
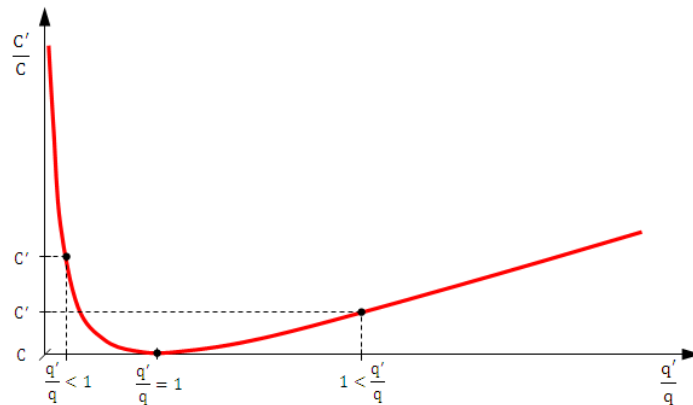

Figure 8. The modification of the total cost as a function of the deviation from
the optimal level of the order quantity
(Personal editing)

From value z^2 in the numerator results that in case of any $0 \leq (1+z)$, the value of deviation will be positive, resulting from value $+1$, the relation will show a higher value compared to the original cost level, meaning that a decrease of costs cannot be achieved by deviating in any direction from the optimal order quantity q.

5. Summary

During the realization of a cost-effective stockpile management, it is essential to define the impact of certain parameters on the total cost. By assuming a deterministic operational environment, we must examine the model close to practical life, when planned level of stock shortage is allowed by considering a certain aspect of economic efficiency, thus the backlog accumulated is completed at the start of the next stockpiling period. In this case, the subject of examination can be the relation between the total cost and the frequency of procurement, the quantity per orders and the one-off purchase cost. The aim of the analysis is the definition of the optimal value of modifiable parameters and the realization of a cost-effective stockpile management.

Acknowledgements

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