Optimizing the stock volume under supply delays circumstances

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Abstract: Stock control minimizes the cost of holding stocks whilst ensuring that there are enough materials for production to continue and be able to meet customer demand. Obtaining the correct balance is not easy and there is a need of closely work between stock control, purchasing and marketing departments. Good stock management by a firm will lower costs, improve efficiency and ensure production can meet fluctuations in customer demand. It will give the firm a competitive advantage as more efficient production can feed through to lower prices and also customers should always be satisfied as products will be available on demand. However, poor stock control can lead to problems associated with overstocking or stock-outs. The most frequent situation in stocks management is when the spans of time between purchasing are not equal, running the risk that the delivery time agreed by contract may not always be observed. The solution for this kind of situations is making up a safety stock, but the realistic solution is the one optimizing the costs generated by the safety stock establishment, considering the purchasing delay frequency.

Key words: stock control, safety stock, cost minimization, optimum stock, supply delay

1 Introduction
When we talk about the improvement of a company’s performance, we analyze the optimum and as accurate as possible measurement of efforts and effects, the efficient use of the company’s resources, as well as the identification of the consumption reduction ways, where stocks hold a significant position. Optimizing the stocks implies the management and accounting organization, which are based on the structure and dynamics elements research and also on observing the future evolution trends of the events occurred inside and outside the company. Production stocks management is a complex process ensuring the use of the material resources with the expected efficiency and utility in terms of the storage process. The objective of stock’s management is to establish and maintain the stock’s size under cost minimizing conditions.

2. Problem
The consumption continuity is ensured by the optimum stocks management. By ensuring the equilibrium between the supplier’s delivery potential and the resources demand and by eliminating the uncertainty of the purchasing process this objective can be reached. The consumption ensuring uncertainty may be determined by the following: unawareness of the resource request, delivery potential, and non-compliance with the delivery time. Under all such conditions, the malfunctions are taken over by the safety or the reserve stocks. Even if there may be a balance between the supplier’s delivery potential and the resource demand, the economic activity may not be developed without stocks due to the differences between the production dynamics and the rhythm of purchasing.

Generating great stocks by economic entities may have positive influences in case of a non-favorable influence of the raw material price or of getting some more favorable conditions from the suppliers in order to forward great orders. The influences may also be negative in the following situations: raw material price decrease, raw material processing technology change, qualitatively superior substitutes, and physical and moral degradation losses.
Stocks sizing is the operation settling the optimum need of material current assets for a certain value-expressed period of time for the proper running of the forecast object and volume of the activity.

Managers are directly interested in optimizing the stocks volume and in organizing an efficient management control. The management control is the process ensuring the managers that the resources are acquired and used in an efficient, effective and pertinent manner (Gervais, 2005, p. 20).

The stocks optimum level implies the highest effect, so that every entity may run its business with the lowest production costs and the highest benefits, hence the lowest storage costs.

2.1 Optimum Stock size

For the analytical computation to optimize the stocks levels, one should know the storage process for the following “types of administration” (Bă anu, 2001, p. 107):
- the equal–span constant administration;
- the equal-span variable request administration;
- irregular span variable request administration;
- the two-warehouse administration type (S, s).

The equal-span constant request administration means that the recurrent purchasing for the reinstatement of the current stock shall be carried out in quantitatively equal batches. With this type of administration, one could forecast the running-out phenomenon of the current stock. In such circumstances, the safety stock shall be used in order to avoid the production interruption. This type of administration may be efficiently used by the facilities that have a constant product catalogue, with a time-balanced purchasing volume and traditional relationships with their suppliers.

The equal-span variable request administration requires recurrent purchasing of variable quantities at certain order-releasing calendar moments; the duration of the recurrent purchase is always the same. This type of administration is difficult to carry out and does not exclude the stock shortage phenomenon. That is why it is necessary to have an alarm level of the current stock.

Irregular span variable request administration does not enable one to know the order releasing moments in advance. The re-purchasing is performed in fix batches and the alarm level is considered equal to the safety stocks. This type of administration is efficiently used by non-nominated high-volume production enterprises, by the service suppliers and by the manufacturers of consumer goods upon request.

The two-warehouse administration type means that the spans of time and the requests are variable and the supply batch is regular. The “S, s” administration type name expresses the essence itself of this work procedure, where “s” signifies the re-purchased quantity. Such an administration optimization means that the two “S” and “s” levels should go steady in order to obtain the lowest work effort to comprise and maintain the production stock.

The optimum size of the stocks is the one that balances the contradictory relation between the supply-transportation expenses (Ct) varying according to the supplies number and the storage expenses (Cd) varying according to the volume of stocks. For the establishment of the optimum raw material and consumables stocks, a mathematic solution shall be set out between the frequent renewal of the stocks and the stocks renewal on large time spans. If one shall choose a frequent stocks renewal, the transportation – supply expenses would grow, while the maintenance-storage expenses would go down. A stock renewal on larger time spans would lead to the decrease of the transportation–supply expenses and the increase of the maintenance-storage expenses.

In case of equal-span regular demand administration, the Wilson-Whitin model may apply optimizing the stocks volume starting with the stocks leading to the creation of the total cost. This cost shall be minimum, given the operation activity maximization.

The reasoning of the optimum stock determination according to Wilson-Whitin model is (Simon, 1997, 153):

\[
C_{ts} = C_a + C_t + C_d
\]

\[
C_a = S \cdot u
\]

\[
C_t = S/q \cdot a
\]

\[
C_d = [(q \cdot u)/2] \cdot i
\]

\[
C_{ts} = S \cdot u + S/q \cdot a + [(q \cdot u)/2] \cdot i
\]

where: \( C_{ts} \) = stocks incorporation total cost
\( C_a \) = purchasing cost
\( C_t \) = supply-transportation expenses
\( C_d \) = storage expenses
\( a \) = unitary fix cost to prepare a new supply
\( u \) = unitary supply cost
\( i \) = storage cost on stock unit
\( q \) = stock’s optimum size
\( S \) = yearly supply needed

The point where the first derivative of the total cost versus the stock volume equals zero, signifies the minimum total cost.
The stocks optimum size is the following:

\[ q = \sqrt{\frac{2S \cdot a}{u \cdot i}} \]

By knowing the optimum stocks, one can determine the number of purchase-orders (P.No.) and the average span between two purchasing actions \((i_m)\):

\[ P\text{-No.} = \frac{S}{q} \]
\[ i_m = \frac{q \cdot T}{S} \]

\(T\) = number of calendar days for that particular period (\(T_{\text{year}} = 360\) days)

Example:
A wood-processing company purchases raw material (conifer logs) in order to produce timber. The necessary quantity for one year (\(S\)) is \(9\,500\,m^3\), a new order preparation cost (\(a\)) is 1200 lei, the purchasing unit price is 1 000 lei/\(m^3\), and the storage cost is 0.5 lei for one stock unit.
- The optimum purchasing stock is:
  \[ P\text{-No.} = \frac{9500}{213} = 44.49 \]
- The number of purchasing orders:
  \[ i_m = \frac{213.54 \cdot 360}{9500} = 8.09 \text{ days} \]

In order to have the minimum stock incorporation total expenses during one year, it will be necessary for the company to release orders every 8th day, and the quantities that are to be specified in the contracts for each orders shall be 213.54 \(m^3\).

The Wilson – Whitin model may also be extended to the optimization of the in-process product stocks and of the final product stocks. In this case, “\(C_t\)” refers to the supply transportation expenses of the in-process product batches and the release-expenses of a new final product-delivery order, while “\(C_d\)” includes the maintenance expenses of the in-process and of the final product stocks.

The described mathematic model to optimize the stocks volume on a particular purchasing case where the spans of time between supplies are considered regular, the purchasing is rhythmically conducted and stocks are put-up and delivered for consumption step by step until total elimination.

The stocks volume optimization issue shall be approached in relation with the stocks rotation speed. The more accelerated the rotation speed is, the smaller the stocks volume that the economic entity may use to solve out its scheduled economic activities. The stocks rotation speed shall be compared over a certain period of time in order to reach some conclusion and to act upon the stocks level for the benefit of the company. The acceleration of the rotation speed has positive influence on the profit and on the profitableness rate.

The acceleration of the stock rotation speed may be provided by technical, organizational and financial actions that shall be applied during each phase of the operating process: purchasing, production and trading.

During the purchasing phase, decisions and actions are necessary to ensure the elimination of the dead time due to purchasing shortage. The round-the-clock running of the production process requires permanent stocks of raw material and consumables. The purchasing optimization may be achieved by increasing efficiency, by fast adaptation to the market conditions, by suppliers selection according to certain criteria, by concluding the contracts in due time and by the compliance thereto. During this phase it is necessary to reduce the transportation, handling and storage losses. One cause of the rotation speed slowdown during this phase is the extra stocks due to improper contracting or certain product production stoppage.

During the production phase, the stocks volume depends mainly on the costs and on the duration of the manufacturing cycle. Any way of reduction is also a way of accelerating the stocks rotation speed. This objective may be attained by the due organization of the production, by settling some rational manufacturing flows and by choosing the best manufacturing technologies.

During the trading phase, the products dispatching and the fast receiving of their value lead to re-making the liquidities. The company’s general liquidities shall be determined by comparing the total current assets to the total short-lived assets. The immediate sale of the final products occurs when they match the market’s requirements in terms of volume, structure and quality. The acceleration of the rotation speed during the trading phase may be achieved by reducing the reimbursement period, by rhythmically procuring the products and by reducing the selection and packaging time.

3. Analysis of costs incurred for safety stocks

The most frequent stock management circumstance is when the spans of time between procurements are irregular running the risk that the delivery time agreed in the contract may not always
be complied with. Thus, purchasing delays may occur. In such cases, the contradictory relation between profitableness and risk becomes questionable, requiring safety stocks. These are the quantities of material goods accumulated in the economic entity’s storeroom deemed to ensure the production continuity, when the current stock has run out and its supply is delayed due to the supplier’s malfunction or to transportation, or to the consumption increase over the forecast limit during that administrative period.

A prudent risk approaching policy shall ensure a safety stock creation that would cover the current stock breakage in case of supply delays. This policy is recommended whenever the stock breakage generated costs or whenever the costs caused by the operations stoppage are very high. For a wood processing company, the quantity of necessary raw materials for one year (S) is 9 500 mc and the supply delays take one to four days. Under these conditions, the safety stock (Ss) must be:

\[ S_s = \frac{9500}{360} \cdot 4 = 106 \text{ m}^3 \]

This policy records high storage costs of the safety stock.

An aggressive, risk neglecting policy shall lead to the determination of an average safety stock as an arithmetic mean of the safety stocks for each supply delay, including the non-delayed situation. Based on the above-mentioned data, the average safety stock (Sms) is:

\[ S_{ms} = \frac{9500}{360} \cdot \frac{0 + 1 + 2 + 3 + 4}{5} = 53 \text{ m}^3 \]

Shall the supply delays be up to 2.5 day, the economic entity shall cover the safety stock storage expenses, and if the delays take more than 2.5 days, occasional costs may occur due to stock shortage.

A more realistic policy (Stancu, 2002, p. 126) would optimize the costs generated by each one of the above-mentioned policies. Two stages are run in order to enforce this policy:

- determining the costs generated by each level of the safety stock, in all possible cases of supply delays;
- determining a consequences pattern derived from each level of the safety stock on stocks management based on the supply delays frequency (statistically registered).

For the analyzed economic entity, a stock breakage cost of 1 200 lei is admitted for the first day of supply delay, of 1 300 lei in the second day and for the following days. The necessary quantity of raw material for one year is 9 500 \text{ m}^3 and statistically there were recorded delays up to 4 days.

The unit purchasing price is 1 000 lei/\text{ m}^3, and the storage cost is 0.5 lei for one stock unit. Based on these data, the safety stock-generated costs shall be calculated and they are shown in table 1.

### Table 1: The safety stock generated costs

<table>
<thead>
<tr>
<th>Days of delay</th>
<th>Safety stock volumes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1 day</td>
<td>1200 lei</td>
</tr>
<tr>
<td>2 days</td>
<td>2500 lei</td>
</tr>
<tr>
<td>3 days</td>
<td>3800 lei</td>
</tr>
<tr>
<td>4 days</td>
<td>5100 lei</td>
</tr>
<tr>
<td>0</td>
<td>36,111 lei</td>
</tr>
<tr>
<td>1 day</td>
<td>36,111 lei</td>
</tr>
<tr>
<td>2 days</td>
<td>36,111 lei</td>
</tr>
<tr>
<td>3 days</td>
<td>36,111 lei</td>
</tr>
<tr>
<td>4 days</td>
<td>36,111 lei</td>
</tr>
<tr>
<td>0</td>
<td>109,722 lei</td>
</tr>
<tr>
<td>1 day</td>
<td>109,722 lei</td>
</tr>
<tr>
<td>2 days</td>
<td>109,722 lei</td>
</tr>
<tr>
<td>3 days</td>
<td>109,722 lei</td>
</tr>
<tr>
<td>4 days</td>
<td>147,222 lei</td>
</tr>
</tbody>
</table>

A safety stock calculated for one day of supply delay must be of \[ \frac{9500}{360} = 26 \text{ m}^2 \]. When there are no supply delays, this safety stock is useless, generating an additional cost of:

\[ 26 \cdot 0.5 \cdot \frac{1000}{360} = 36,111 \text{ lei} \].

In case of one day of supply delay, there is no additional cost, because the safety stock was consumed and covered the stock shortage. In case of two days of supply delay, the company shall cover an stock breakage cost of 1 200 lei. The cost for three days of delay is 1 200 lei + 1 300 lei = 2 500 lei and for four days of delay, the cost is 1 200 lei + 2 \cdot 1 300 lei = 3 800 lei.

A safety stock calculated for two days of supply delay shall be of \[ \frac{9500}{360} \cdot 2 = 53 \text{ m}^3 \]. When there are no supply delays, this safety stock generates an additional cost of \[ 53 \cdot 0.5 \cdot \frac{1000}{360} = 73,611 \text{ lei} \].

In case of one day of supply delay, the same safety stock will determine an additional cost of 36,111 lei. For two days of supply delay there is no additional cost because the safety stock is consumed. If there are three days of delays, the stock breakage cost will be of 1 200 lei. The same type of cost will be of 2 500 lei for a four-day delay of the supply.

Following the same methodology as presented above, the safety stocks were calculated for three and four days of delay. The additional stocks generated either by these stocks either by the stock breakage, are presented in table no. 1.

The consequences pattern determined by each level of the safety stock (table 2) shall be determined based on the statistically recorded occurrence frequency of the supply delays. For the analyzed economic entity, these frequencies are:

- 0.1 when there are no supply delays;
- 0.2 for one-day supply delays;
- 0.4 for two-day supply delays;
- 0.2 for three-day supply delays;
- 0.1 for four-day supply delays.
Our case study for wood storage process came to the conclusion that every different operation stage has a stock sequence with different sizes and different values on measurement unit. In the process of stock size optimization we propose the use of a non-equal span variable demand administration. The reason for this choice is that most of the production processes are based on the customers’ orders and consequently, the re-purchasing quantities of the raw material should be made according to the forecast production plan on irregular spans of time. The problem that may occur is the delay in supply, in which case keeping a safety stock with a minimum cost is needed, considering the negative relation between profitability and risk.

By analyzing the data in the above table, one could conclude that the 106 m³ safety stock determines the lowest total cost of 73,332 lei, thus this being the most favorable decision.

4. Conclusions
Nowadays the managers need an efficient tool in their decision-making process. This is the reason why they must access an important volume of relevant information, which is provided by the accounting and stock management. The accent of this tool should be on knowing the methods and the resources, on the stock movements follow-up, on checking the dynamic path and the structure and, most of all, on predicting the future trends of the inside and outside company’s environment. For optimizing the stock size under uncertainty a knowledge base is needed and that implies the aggregation of accounting, financial, administration and risk management. The stocks volume can be optimized using all the factors that raise the stock rotation speed and taking into consideration the company’s needs of consumption.

Table 2: Pattern of the consequences determined by each level of the safety stock

<table>
<thead>
<tr>
<th>Days of delay</th>
<th>Frequency</th>
<th>Safety stock volumes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 0,1</td>
<td>0 3.611 lei 7,361 lei 10,972 lei 14,722 lei</td>
</tr>
<tr>
<td></td>
<td>1 day 0,2</td>
<td>240 lei 0 7,222 lei 14,722 lei 21,944 lei</td>
</tr>
<tr>
<td></td>
<td>2 days 0,4</td>
<td>1000 lei 480 lei 7,222 lei 14,444 lei 29,444 lei</td>
</tr>
<tr>
<td></td>
<td>3 days 0,2</td>
<td>760 lei 500 lei 240 lei 0 7,222 lei</td>
</tr>
<tr>
<td></td>
<td>4 days 0,2</td>
<td>510 lei 380 lei 250 lei 120 lei 0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1</td>
<td>2510 lei 1363,611 lei 504,583 lei 106,138 lei 73,332 lei</td>
</tr>
</tbody>
</table>

References