Acta Logistica - International Scientific Journal about Logistics
Volume: 3 2016 Issue: 3 Pages: 1-4 ISSN 1339-5629

DOI: 10.22306/al.v3i3.62 *Received: 27 July 2016*
Accepted: 25 Aug. 2016

INVENTORY MANAGEMENT IN DYNAMIC CHANGES IN THE MARKET ENVIRONMENT

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Keywords: logistics, market, stocks, risk, loss
Abstract: In the area of production planning and material resources, manufacturing companies often find themselves in difficult situations. On one hand, pulses in the form of market incentives difficult to estimate come to the enterprise, on the other hand, every production entity tries to plan all production processes as realistically as possible. Therefore, two systems that are diametrically opposed come into conflict. The fundamental problem often arises in the area of inventory management. The production tries to satisfy the highly stochastic demand to the maximum extent, but it tries to manage the resources it uses by deterministic methods. In inventory management, one of the key roles is played by the variability in their consumption. If the majority of planned production orders is based on orders, or if expected consumption can be predicted with high probability, a range of exact logistics tools can be applied in inventory management. With increasing degree of variability in consumption, combined with long delivery times, however, the information value of these methods is significantly reduced. This article analyses the use of the concept of safety stock as a tool for correction of strong changes in the current market environment.

1. Introduction

Methods for inventory management can be generally based on the principles of statistical analysis or simulations. Statistical methods are based on analysis of past consumption and production requirements, on the basis of which they try to predict optimum inventory levels. If the development of future consumption converges with the previous period, conclusions drawn in this way have a high information value. Simulation methods are normally used in situations when there is not enough relevant information, or significantly different future scenarios of development can be expected [1]. A simulation model then allows the evaluation of the consequences of serious situations. In real practice, mainly the statistical methods based on statistical analysis of historical data are applied. Therefore, scheduling and inventory management is often based on the analysis of data that may no longer be current. Conclusions drawn and defined forecasts may therefore have a limited validity. However, in the case of inventory management, we can correct any deviations using the model of safety stock.

2. Stocks in the manufacturing plant

Stocks are perceived as an imminent natural element in the manufacturing and distribution organizations. Stocks mean the part of utility values which have been produced but not yet consumed [2]. Stockholding represents benefits, as well as risks for the manufacturing enterprise. The main advantages of stocks can be classified into the following points:

- Stocks contribute to solving time and capacity disharmony in the production company,
- Stocks promote the production of a wider range of products,
- Stocks contribute to realizing the manufacturing process in the optimum range (good production batches),
- Stocks contribute to minimizing the impact of unpredictable fluctuations and failures,
- Stocks minimize the impact of unexpected supply outages [3].

The negative impact of the inventory can be seen in the fact that they lock up capital, consume more work and resources carry the risk of loss of value, and the risk of becoming unusable and unsaleable [4]. Increasing competition in the markets together with high interest rates for short-term loans may lead to the fact that the capital invested in stocks is missing for financing technical and technological development, it threatens the liquidity of the company and reduces its credibility in negotiations for credits [5].

Stocks are undoubtedly a factor that significantly affects the competitiveness of any company. High levels of inventory causes the allocation of funds in stocks, but they also optimize the adequate flexibility of supply. Both of these effects, however, are antagonistic, and it will always be important to find a compromise. In the case of manufacturing companies, stocks represent one of the financially most voluminous categories. It is one of the reasons why decisions regarding the inventory management system are often of strategic nature.

3. Risks associated with lack of supplies

Lack of supplies for the production can have many causes and it can seriously affect the continuity of the production process. Large fluctuations or higher and unforeseen material consumption will mean the emergence of shortages of raw materials. The same problem can occur when the cycle of the order realization is extended. For the company, these facts may represent a threat for the work flow, a risk of failure to meet delivery deadlines, or even the loss of a customer. One of the ways to avoid these problems is keeping extra – safety stock. In this case, it is necessary to consider the costs of maintaining safety stock and the risks and losses associated with the depletion of stocks. The specific amount of safety stock can be determined either through simulation or statistical methods. Maintaining safety stocks at a level that would prevent inventory shortages in all cases would be unnecessarily costly for the company. Impacts of deficiency that occurs once a year can be much smaller than the cost of maintaining extra supplies year-round. For this reason, it is normal practice that the company decides to maintain safety stock that protects it not in all cases, but, for example, in 80 % of all cases [6]. The percentage of cases when no shortage of supplies occurs is called the level of service. In other words, it is the probability that the size of the demand during the cycle of the order realization will not be greater than the available supply. The greater the level of service, the higher the required safety stock and the associated costs of maintaining inventory, but the lower the possibility of lack of supplies and its impact. One hundred percent service level means that the probability of lack of inventory is zero and all demand will be satisfied [7].

Statistical approaches to determining the level of safety stock may be significantly different. The simplest option is to determine the multiple of the standard deviation of consumption. This principle is quick and easily applicable to virtually all areas where stocks are created. However, the approach to determining safety stock in this way is considerably simplified.

A more relevant approach is based on the evaluation of the probability distribution of demand and the order realization cycle. Within this concept, it is assumed that the variation of both parameters can be described by a normal distribution. It can often be used to describe sales of finished goods of the production enterprises or general goods in commercial enterprises. In this case, it is then possible to calculate the safety stock using the basic statistical characteristics, such as the arithmetic mean and standard deviation. The relationship to calculate the necessary amount of safety stock then has the form of the formula 1:

$$PZ = k\sqrt{\overline{R}\cdot(\sigma_d)^2 + \overline{D}^2\cdot(\sigma_R)^2} \qquad (1)$$

This model of safety stock is based on the assumption that future data on the consumption and the order realization cycle will be similar in nature to the analysed data. If future material consumption is of significantly different character (variability), the information value of this method will also be limited.

4. Determining the appropriate level of safety stock

Determining the safety stock level can be demonstrated on the stock item, for which we have available data on the consumption and delivery time. The data are displayed in the context of Table 1 and they are based on the real needs of the company in the area of forming the material. In the case of consumption, the data are provided for thirty days.

Table 1 Input data about the particular stock item

Day	Consumption (Pieces)	Delivery (days)
1.	0	5
2.	3	4
3.	2	6
4.	1	8
5.	1	7
6.	2	
7.	5	
8.	3	
9.	2	
10.	2	
11.	4	
12.	2	
13.	2	
14.	4	
15.	2	
16.	3	
17.	2	
18.	4	
19.	4	
20.	4	
21.	3	
22.	2	
23.	4	
24.	1	
25.	2	

26.	4	
27.	3	
28.	2	
29.	4	
30.	6	
Average	2.70	6.00
σ	1.39	1.10

For the time of delivery, the data are provided for the duration of the last five orders (delivery cycles). Based on these data, we can perform a calculation of the possible level of safety stock based on Formula 1. For both monitored parameters of the stocks (consumption, time of delivery), we will determine the arithmetic mean and the standard deviation. The results are shown is Table 1 again.

These values are then substituted to Formula 1 and the required amount of safety stock is calculated. It will be determined for the service level 85, 90, 95, 99 %. This allows us to choose an appropriate strategy for inventory management later, where it is possible to use any level of safety level. However, it is necessary to be aware of the fact that the level of service is essentially the level of the risk that the company is willing to undergo. Therefore, in the case of service level of 85 %, the company accepts a 15% risk of a shortage of supplies. Each level corresponds to a specific value of the hedge ratio which is based on Gaussian curve. The determined values of safety stock then have the following values:

$$PZ = k\sqrt{\overline{R}\cdot(\sigma_d)^2 + \overline{D}^2\cdot(\sigma_R)^2}$$

$$PZ(99\%) = 2{,}326\sqrt{6\cdot 1{,}39^2 + 2{,}70^2\cdot 1{,}10^2} = \underline{\underline{10{,}51}}$$

$$PZ(95\%) = 1{,}645\sqrt{6\cdot 1{,}39^2 + 2{,}70^2\cdot 1{,}10^2} = \underline{\underline{7{,}41}}$$

$$PZ(90\%) = 1{,}282\sqrt{6\cdot 1{,}39^2 + 2{,}70^2\cdot 1{,}10^2} = \underline{\underline{5{,}78}}$$

$$PZ(85\%) = 1{,}036\sqrt{6\cdot 1{,}39^2 + 2{,}70^2\cdot 1{,}10^2} = \underline{\underline{4{,}67}}$$

Due to the fact that the given stock is registered in pieces, the determined values can be rounded to whole numbers. For rounding, we can apply the normal rules of statistical rounding. Thus the estimated value of safety stock represents an amount below which the supply should never fall. If we display everything graphically in a simplified form, the determined general level of safety stock is shown in Figure 1; it is marked with the abbreviation PZ. The symbol Q1...n represents a specific amount of a regular order. This diagram is based on the concept of Harris-Wilson model of stock consumption.

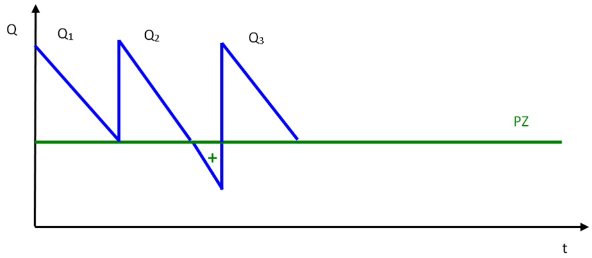

Figure 1 Graphical representation of safety stock

In the event of an unexpected high consumption, it will be the covered from safety stock. In the event of drawing of stocks, there is no production interruption or threat to the continuity. For analysing the stock for which the amount of the safety stock was determined, we can recommend the use of values determined mainly for the service level of 90 % and 95 %. This is mainly due to relatively low variability in the consumption of the reserves and simultaneously low fluctuations in supply. Here, however, we must also take into account the extent of the potential damage resulting from lack of stock. In the event that it is the case of a stock item, the lack of which can mean high costs, it is necessary to take advantage of higher levels of safety.

5. Conclusion

Inventory management is carried out in the current market conditions in the large variability. Safety stock protects manufacturing enterprises against lost output and threat to the production continuity. Correctly set safety stocks then simultaneously reduce the costs associated with capital locked up in inventories. In the case of the applied model, it should be noted that the effectiveness of the identified safety levels is also influenced by the nature of future consumption. If this is significantly different from the analysed data, the quality of the detected levels of safety stock will not be sufficient. Generally, it is important to note that in the case of safety stock, the current market trends have to be continuously monitored and their amount continually optimized. The current dynamic market environment will also bring big changes in the requirements on stocks that may be rather different in the short term. Therefore, it will always be necessary to compare the determined values with the current market developments.

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Review process
Single-blind peer reviewed process by two reviewers.