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Evaluation of Stock Management Strategies Reliability at Dependent Demand

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Abstract

In the article there is a suggested methodical approach that allows calculating the safety stock quantity at the dependent demand in view of supply chains reliability requirements; the variants for different inventory management strategies at the dependent demand are examined; results of total costs calculation in view of the reliability are given.

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Keywords: supply chains reliability, inventory management, dependent demand, perfect order

1. Introduction

The publications analysis has allowed to reveal the opinions of several authors about features of stocks management at dependent demand. "Dependent demand" means the demand for one item is related to the demand for another item. The dependent technique used in a production environment is called material requirements planning (MRP) (Heizer and Render, 2011). Originally popularized by Joseph Orlicky, MRP deals specifically with supplying materials and component parts whose demand depends upon the demand for a specific end product (Coyle *et al.*, 2003). The purpose of MRP is to avoid carrying items in inventory (Ballou, 1999).

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Effective use of dependent inventory models requires that the operations manager know what is to be made and when; materials and parts required to make the product; what is in stock; what is on order; how long it takes to get various components (Heizer and Render, 2011).

Protection against uncertainty in the requirements and supplies that are part of material requirements planning can be achieved with the aid of safety stock and safety time (Jonsson, 2008). It seems wise to include "some" safety time into the lead-time offset of uncritical operations that is the direct predecessor of a critical operation (Stadtler and Kilger, 2008).

The minimum projected on-hand inventory should not fall below the safety stock level (Wisner *et al.*, 2012). The safety stock is also a planning parameter that can be chosen arbitrarily (Axsäter, 2006). A fixed on hand-inventory level can be maintained that is determined by practical experience or some other means. Although this method is approximate, it is probably the best that can be done (Ballou, 1999).

The usual policy is to use safety stock for end items and purchased items to protect against fluctuating customer orders and unreliable suppliers of components but to avoid using it as much as possible for intermediate items (Krajewski *et al.*, 2013). If the firm does not exceed 99% record accuracy, then material requirements planning will not work (Heizer and Render, 2011).

Summarizing the sources where parameters calculation examples of different planning strategies of inventory quantity at the dependent demand are given, the following can be stated:

1. Planned periods duration, for which the calculation is executed, fluctuates from 6 to 12 weeks.
2. Minimal and maximal stock quantities in each planned period cover the wide range of values, for example, from 20 to 100 products (Axsäter, 2006), from 0 to 50 products (Leenders and Fearon, 1997).
3. To choose the best strategy using the economic criteria the two costs types are used: for the order implementation and for stock holding.
4. Safety stock quantity is mentioned in two works (Axsäter, 2006; Lysons and Gillingham, 2003), but there are no instructions for their determining method.
5. The number of stock quantity strategies and their periodicity planning fluctuates from one to six; the most often indicated strategies are LFL, EOQ and LTC, but there are not any instructions for the most appropriate strategy.

Thus, in spite of having several strategies (lot-for-lot – LFL; least total cost – LTC; least unit cost – LUC; part-period balancing – PPB, Silver-Meal algorithm, Groff's method etc.) for dependent demand management, all of them are intended to calculate the current stock parameters. Other indexes, for example, probabilistic evaluation of safety stock, deficit, functioning reliability of all stock management system practically are not considered. This problem becomes even more vexed at supplying the component parts (items, details etc.) that cannot be made at this enterprise.

2. Inventory management strategies clarification at dependent demand in view of safety stocks

The inventory management strategies at the dependant demand can be symbolically divided into two main groups. The first one is the empirical strategies based on grouping without considering the stock holding costs. Three strategies belong to them: LFL, FOQ and POQ. When we say 'grouping', we mean the union of demands in a unit of some consecutive periods. So, when we use the LFL strategy, we consider single (independent supplies) according to the demands in every period; the FOQ strategy stipulates supply quantity constancy during the whole planned period (at the same time, supply periodicity varies); the POQ strategy stipulates a variable supply quantity at fixed periodicity.

The second group is the economic strategies which use optimization algorithms of supply consignment forming considering supply costs (or starting-up and adjustment works) and stock holding. The three most wide-spread strategies – LUC, LTC and Silver-Meal algorithm – are similar according to the employing procedure: the search and determination of the local groupings indexes in a form of supply units during the planned period according to the costs minimum criteria.

In this way, the dependency for the unit costs evaluation in view of safety stocks (LUC strategy) is recorded in the following way:

$$C_u(k)=\left[C_{or}+C_h\sum_{i=1}^{k}(i-1)N_i+C_hQ_{ss}(k)\right]/\sum_{i=1}^{k}N_i\rightarrow\min, \quad (1)$$

where $C_u(k)$ is the unit costs which includes k of consecutive periods supplies in a volume of N_i, k = 1, 2, …; C_{or} is the costs for the order and starting-up and adjustment works; C_h is the costs for the product unit holding during the time unit, for example, during a week; N_i is a planned requirement (supply) in i-th period; $Q_{ss}(k)$ is safety stock for k-*th* periods.

If in formula (1) we exchange $\sum_{i=1}^{k}N_i$ for k, we will get the main estimated dependency for the Silver-Meal algorithm.

The distinction of the LTC strategy from the examined above ones lies in the fact that the choice criteria of the estimated k periods quantity and, accordingly, the total volume of a supply unit $\sum_{i=1}^{k}N_i$ is formed as a difference of order costs and holding costs

$$\Delta_k=\left|C_{or}-\left[(C_h\sum_{i=1}^{k}(i-1)N_i+C_hQ_{ss}(k)\right]\right|\rightarrow\min. \quad (2)$$

According to the (2) dependency, at $\Delta_k\rightarrow\min$ the quantity $\sum_{i=1}^{k}N_i$ is regarded as a supply for k periods.

We have to emphasize that the EOQ model which allows to define the indexes of the inventory management of dependent demand in view of the whole planned period duration must be attributed to the economic strategies.

3. Approbation of worked out methodical approach

Some calculations for the number of strategies have been carried out to approbate the worked out methodical approach.

Initial data about the planned items need is shown in Table 1.

Table 1. Planned need for stocks during the planned period.

Week	1	2	3	4	5	6	7	8
Planned need, N_i, un.	50	70	80	60	40	75	45	60

Apart from the need, the following has been accounted in the calculations:

- Costs for order C_{or} are 1200 c.u.
- Holding costs for product unit per week C_h – 2 c.u./week.
- Probability of supply quantity accuracy p_1 = 0.97.
- Probability of supply quality accuracy p_2 = 0.98.
- Probability of deficit absence P_Q = 0,95 (quantile $x_{0,95}$ = 1.645).

In Table 2 there are the calculation results for the following strategies: LFL, POQ, EOQ, LTC, LUC.

The analysis of obtained results allows making the following conclusions.

Total costs calculated on the basis of the empiric strategies (LFL, POQ) are significantly larger than the same costs calculated on the basis of the economic strategies (EOQ, LTC, LUC).

Table 2. Total costs and reliability indexes calculation results for different inventory management strategies (dependent demand).

Strategy	Total costs, c.u.		Probabilities	
	Without considering the safety stock	Considering the safety stock	Without considering the safety stock	Considering the safety stock
LFL	9600	9693	0,663	0,980
POQ	5330	5486	0,814	0,990
EOQ	4293	4464	0,903	0,995
LTC	3870	4167	0,903	0,995
LUC	3910	4190	0,903	0,995

The best strategy in view of total costs minimum criterion is LTC strategy: this conclusion coincides with the results of (Chase *et al.*, 1998) and (Leenders and Fearon, 1997) works.

There is a stable relationship between the safety stock holding costs and supply reliability indexes: the supply reliability probability increase requires the safety stock costs increase.

The suggested methodical approach belongs to the stage of dependent demand stocks planning. When it is fulfilled in practice, the planned quantity of safety stocks will differ from actual values of stocks consumption (due to the probabilistic patterns used for their calculations). Therefore, at the beginning of every new consignment (that lasts one or several weeks) it is necessary to check and correct the planned values considering the rests of previous period (probably, using the prediction methods), i.e., actually, here we are speaking about the use of situational approach to manage stocks at dependent demand.

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