INVENTORY MANAGEMENT, SERVICE LEVEL AND SAFETY STOCK

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Abstract: *There are many studies that emphasize as a first objective of inventory management to minimize the value invested in inventory because it has a direct impact on return on assets. This approach is not fully correct. The actual objective is to determine the value and the mix of inventory that support a high service level for customers and that maximizing the companies' financial performance. Many companies look at their own demand fluctuations and assume that there are too many variables to predict demand variability. Service level is used in inventory management to measure the performance of inventory policies and represents the probability of not being stock-out and not losing sales. Safety stock is inventory that is carried to prevent stock outs. Safety stock determinations are not intended to eliminate all stock outs, just majority of them. Companies choose to keep safety stock level high as a buffer against demand variability resulting in inefficiencies and high working capital requirements. Safety stock optimization enables companies to achieve savings and increase inventory turns.*
Keywords: *safety stock, service level, standard deviation, stock keeping units (SKU's), service factor.*

1. GENERAL CONSIDERATIONS

The satisfaction of the client is the most valuable assets of an enterprise can record. The measurement of the service level is important due to its connection to the management of stocks because it can affect the relationship with its customers and depending on the nature of the business, it can determine an important impact on profitability.

Even though many companies regard to stocks as being an element of cost, there are companies which regard them as active components that contribute to the leading of a specific market share through a high level of service, offering an availability of products in the quantities that are needed when a request is made from clients.

The most important objectives in improving the management of stocks are:

- Reduce inventory carrying costs and other related;
- Customer retention issue need to improve service level;
- Support growth in new channel;
- Gain market share through superior service and product availability.

According with researches effectuated by the American company Aberdeen Group the truly visionary companies use stocks as a competitive weapon through segmentation of the portfolio of products depending on the medium investment in stocks and the contribution generated. Therefore, these companies are able to attain higher return on assets than other competitors which are active in the same segment of activity and achieves growth of income through the management of stocks, even if the competition is in a sector which is recording stagnation.

Traditional inventory management practices are being made obsolete by increasing global supply chains, more dynamic product life cycles and multi-channel distribution. These are driving the need for companies to adopt new inventory management technology that can reduce inventories while simultaneously increasing customer service level.

2. SERVICE LEVEL AND SAFETY STOCK

In inventory management, service level is the expected probability of not hitting a stock-out during the next replenishment cycle or the probability of not losing sales.

The service level is determined in a company by the level of stocks. Therefore, the safety stock level must be high enough to cover vendor's delivery times, sufficient enough to cover customers' demand, but not so high that your company loses money because of high carrying costs. The main reason is because demand fluctuations and is not enough consistency to predict future variability.

Retailers and producers are trying to record a high level of satisfaction within the client basis which will maximize sales. Although at the same time maintaining a high level of stock is expensive and presents different risks such as: storage, expiration and lowering of prices. The higher level of stocks the higher the risks and costs will be recorded. In the retail sector setting a high level of service is imperative. Companies that set their goals at the level of 95% do this because the level of service is a key factor in assuring the fidelity of the clients.

The service level marks a trade-off between opportunity costs and operation costs. Optimizing the service levels to maximize the returns for the company is usually complex and domain-specific. The analysis is sensitive: reducing the inventory levels results in extra-cash being immediately available while it might take years to observe a lower customer gained through more stock-outs.

Customer sensitivity regarding stock-outs vary from one product to another, the optimum service level being specific to each product individually. In practice in order to lower the complexity the heuristic approach is usually used.

ABC analysis is based on the idea that the more revenue a product generates, the more "important" this product is supposed to be, both for the retailer and for his customers. This assumption offers a convenient way to categorize products to their respective sales volume. Each category is then assigned its own service level as follows:

- items A, top 20% products, classified as "critical few": high service level, e.g. 96-98%;
- items B, next 20-30% products classified as "interclass": medium service level, e.g. 91-95%;
- items C, last 50-60% products classified as "trivial many": lower service level, e.g. 85-90%;

The ABC analysis is used to determine an adequate service level for groups of products, but, in theory, it is possible to find an optimum service level for each individual product. But a more efficient approach to find an optimum service level, based on the business point of view, should be considered in the long-run.

The target service level can be defined as a trade-off between the cost of inventory and the cost of stock-outs. As a consequence, one could get an estimate of these costs and tackle the service level issue through a cost analysis.

Generally speaking, the cost of inventory is numerous and sometimes not easy to isolate in terms of accounting, but can be identified: cost of working capital, cost of storage space and cost of routine manipulations. On the top of these costs can be added for certain products cost of obsolescence, the cost of inventory gone bad and destroyed.

The cost of stock-outs is an altogether different and more complex matter. The most obvious cost of stock-outs is the lost sales, but this factor, however important it may be, is far from being the only one, nor the most significant.

Extensive studies have shown that stock-outs are a huge risk in terms of client satisfaction and can cause, in the long run, a serious erosion of the client database.

All efforts within a company to improve the service level consist of an assortment of sub goals that are monitored and that must be part of a process of continuous improvement. For a company to meet the requirements of the service level that wants to provide, it focus on the following individual goals: readiness to deliver, delivery time, delivery flexibility, reliability and quality.

Readiness to deliver is the ability to satisfy a requirement on time. Readiness to deliver can be measured in different ways, depending on company's focus.

If company wants to measure readiness to deliver according to the number of units sold, the formula is:

$$\text{Service level} = \frac{\text{the number of quatities delivered in time}}{\text{the total quantity of the demand}}$$

Table 1 contains additional formulas for calculating service level.

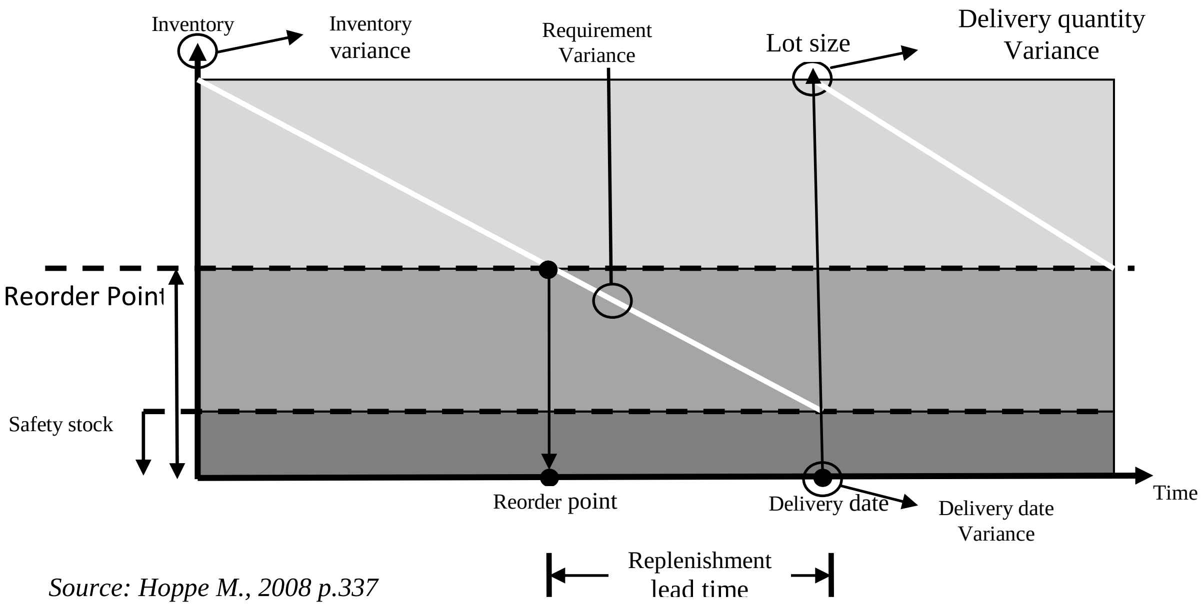
Table 1 Options for calculating the service level

Criterion	Formula for service level
Stock out	the number of quantities delivered / the total quantity of the demand
Frequency of stock outs	the number of order delivered / the total quantity of customer sales orders
Frequency of stock outs	the number of order item delivered / the total quantity of order items
Loss of sales	the value of quantities delivered on time / the value of the total quantity of the demand
Stock out period	the number of days with stockout / the total number of days

Source: Hoppe M., 2008 p.339

Safety stock is defined as inventory that is carried to prevent stock out and back order situations. Safety stock protects against various deviations, such as delivery date variances (when the replenishment lead time varies), requirement variances (when the forecast is inaccurate) delivery quantity variances (when the vendor does not deliver enough materials or the quality of delivered materials is poor) and inventory variances (when inventory recognizes a deviation between the plan and actual inventory). Figure 1 summarizes these deviations and shows the relationships among them.

Figure 1: Reason for safety stock



Source: Hoppe M., 2008 p.337

Based on the consumption behavior of a product, the literature distinguishes between two variants to determine the safety stock. The safety stock can be calculated either based on historical distribution of demand or on the basis of a future distribution of the demand (forecast error).

The formula for the standard method is as follows:

*Safety stock = safety factor * average replenishment lead time*

The formula assumes that the demand is distributed normally during the replenishment lead time.

The safety factor indicates how many standard deviations correspond to a specific service level. If the stock issues are distributed normally, it can be determined the safety factor from the distribution function of the standard normal distribution.

According to the ultraconservative method the safety stock is as follows:

*Safety stock = maximum daily consumption * maximum replenishment lead time in days*

This method leads to surplus stocks, because it is always based on maximum. It should be used for critical materials or for that SKU's that consumption cannot be predicted.

According with Percentage method the safety stock be calculated as follows:

*Safety stock = average consumption * average replenishment lead time *safety factor*

The safety factor is between 20% and 40% and is chosen on instinct without considering specific criteria. This method depends on the knowledge and experience of the stock controller and by the company's acceptance of this factor.

In practice, the following rules of thumb are used to determine the safety stock:

*Safety stock = average period consumption * replenishment lead time in days*

Or:

Safety stock = 10-20% of the average stock level.

3. STATISTICAL MODEL FOR CALCULATING SAFETY STOCK

In general the initial value of the safety stock must be verified and calculated with the help of an informatics stem which a set time periods to have a safety stock adjustment if the demand will record some changes.

Considering that the safety stock is used for offering a certain level of protection and represented by the deviation of demand, there can be used statistical functions.
Statistical theory can be used to produce decisions for achieving a specific service level. To specify a desired service level, management should be informed in advance of the cost implications of various policies. Should be emphasized that the additional inventory required to improve service level becomes progressively greater in moving to very high levels of service.

It has been suggested that service level and safety stock can be much more effectively controlled through the use of standard deviation.

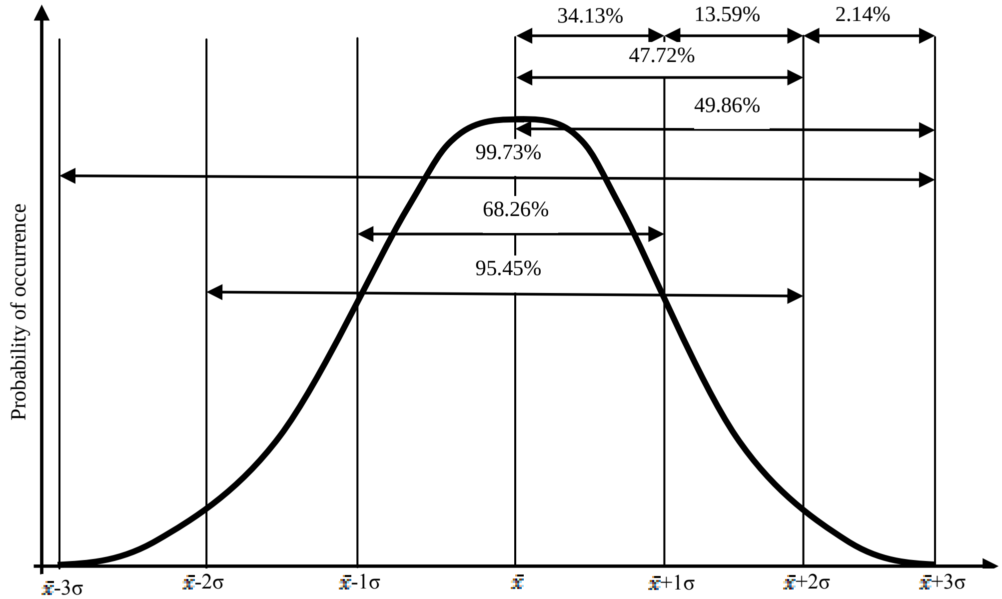
The normal distribution describes a set of data where most values are close to the mean (average) value, fewer values exist at extreme distances from the mean value and the total number of values occurring above the average values is close to the total number of values occurring below the average value.

$$Standard\ deviation\ (\sigma) = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

Where: x_i =demand in period "i"; $\bar{x}$ =average demand.

For a normal distribution 68.26% of the data falls under one standard deviation of the mean ($\bar{x} \pm \boldsymbol{\sigma}$) 95.45% of the data falls under two standard deviation of the mean ($\bar{x} \pm 2\boldsymbol{\sigma}$) and 99.73% of the data falls under three standard deviation of the mean.($\bar{x} \pm 3\boldsymbol{\sigma}$).

Figure 2: Normal distribution according with Gauss



Source: Hoppe M., 2008 p.373

The service factor is used as a multiplier with the standard deviation to calculate a specific quantity to meet the specific service level.

In the Table 2 bellow it is presented a service factor used to convert service level percentage to service factor (with the help of function NORMSINV from Excel).

Table 2: Relationship between desired service level and service factor

Desired service level	Service factor
50%	0,0
60%	0,3
70%	0,5
80%	0,8
85%	1,0
90%	1,3
93%	1,5
95%	1,6
97%	1,9
98%	2,1
99%	2,3
99,90%	3,1

Source: author's computation

As illustrated the relation between service level and service factor is non-linear: higher service level require higher service factor and higher safety stock level.

If the desired service level is 98% and the inventory reached reorder point, during the lead time, the company expects to fill all customers' orders during the lead time 98% of the time. For 2% of orders the company will expects to run out of stock. In this way the company will forecast the frequency of the stocks-out. In the other words, the company has an estimate of how frequently will run out of stocks, but no estimate of the quantity or size of unfilled orders.

Rather than using a fixed service factor for all products, the company can set different service factor for groups of products based on strategic importance, profit margin or contribution of sales. The products with greater value for the business will have more safety stock.

If it is assumed a deterministic replenishment time and a stochastic or random consumption the safety stock calculation can be done with the equation:

$$\text{Safety stock} = Z * \sqrt{\frac{LT}{T}} * \sigma_D$$

Where:
Z = service factor (Z- score);
σ_D = standard deviation of demand;
LT = total lead time;
T = time used for calculating standard deviation of demand.

If the lead time, order cycle time and forecast period were all the same and if the forecast was the same for each period and equal to the mean of the actual demand for those period, this formula would work great.

Since the situation is highly unlikely to occur it must be added factors to the formula to compensate for these variations.

When variability in lead time is primary concern, the safety stock equation becomes:

$$\text{Safety stock} = Z * \sigma_{LT} * D_{avg}$$

Where:
Z = service factor (Z- score)
σ_{LT} = standard deviation of lead time;
D_{avg} = average demand.

When both demand variability and lead time variability are present, statistical calculations can be combined to give a lower total safety stock than the sum of the two individual calculations.

$$\text{Safety stock} = Z * \sqrt{\left(\frac{LT}{T} * \sigma_D^2\right) + \left(\sigma_{LT} * D_{avg}\right)^2}$$

The safety stock is service factor times the square root of the sum of the individual variability's squares.

But when demand and lead time variability are not independent of each other, this equation can’t be used. In these cases, safety stock is the sum of the two individual calculations:

$$\textbf{Safety stock} = \left(Z * \sqrt{\frac{LT}{T}} * \sigma_D \right) + (Z * \sigma_{LT} * D_{avg})$$

With the recognition of what factors dominate the equation, it becomes easier to focus improvement efforts. If a reduction in safety stock desired, it is far more productive to reduce demand variability than lead time variability. If a high level of customer service is not required, safety stock can be lowered to a more appropriate level.

Once safety stock has been established, inventory level should be monitored on an ongoing basis to determine if the inventory profile is as expected. If not, before any adjustments are made, perform a root cause analysis to see if any special causes are responsible for the deviations from expected results.

CONCLUSIONS

Determining appropriate inventory level is one of the most important and most challenging tasks faced by operations management. If the company carry too much inventory, it ties up money in working capital; if the company doesn’t carry enough inventory, it faces stock outs and reduced service level.

There must be a balance between inventory costs and customer service. One key challenge is calculating the safety stock level to achieve the desired customer service levels

Unfortunately, rules based approaches tend to be a „one size fits” all approach to inventory management. This means that the rule will deliver the right amount of inventory for some items, too much inventory for other items and too little inventory to meet service levels for other items.

The most accurate and effective method for calculating safety stock is a statistical approach for setting and meeting target service level while maintaining minimal inventory levels to keep operational costs low. It is very important to test the model prior to final implementation to ensure it is working correctly and to determine impact on inventory levels.

For the statistical model calculation it is not easy task to gather all the data that is needed. Each SKU needs to have its own re-order point calculations and its own safety stock calculation. This can become confusing if attempted without a system to support the calculations.

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