OPTIMIZING INVENTORY CAPITAL WHILE MAINTAINING A COMPETITIVE SERVICE LEVEL

The next frontier, multi-echelon planning

GROENEWOUT

CONSULTING, ENGINEERING & OPTIMIZATION IN LOGISTICS NETWORKS

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SUMMARY

Sales & Operations Planning (S&OP) and Integrated Business Planning (IBP) have undeniably made a great contribution to improving the professionalization of inventory management. However, these concepts are focused specifically on the last stock echelon of the end product. The inventory planning of the upstream stock in raw materials and semi-finished products is often regarded simply as a derivative of the end product. This approach creates a bullwhip effect within the supply chain which often results in much too much stock being held upstream.

Therefore, the future development of S&OP and IBP will have to primarily focus on synchronized, integral inventory optimization across all echelons of the supply chain: 'collaborative planning'.

In order to meet the need for multi-echelon inventory planning, TU Eindhoven (TU/e) has developed an innovative inventory planning system called the Synchronized Base Stock (SBS) policy. SBS can be implemented within the existing concepts of S&OP and IBP. The SBS strategy recognizes that there are a number of variances within the supply chain and includes mathematical concepts to take account of them.

In various implementations, it has already been demonstrated that SBS can reduce stock by between 30% and 60% and can even simultaneously raise the service level.

Are you interested in learning more about this new, innovative approach to inventory planning? In collaboration with TU/e, Groenewout can demonstrate the specific benefits for your supply chain in an inventory-focused 'L-Pad game'.

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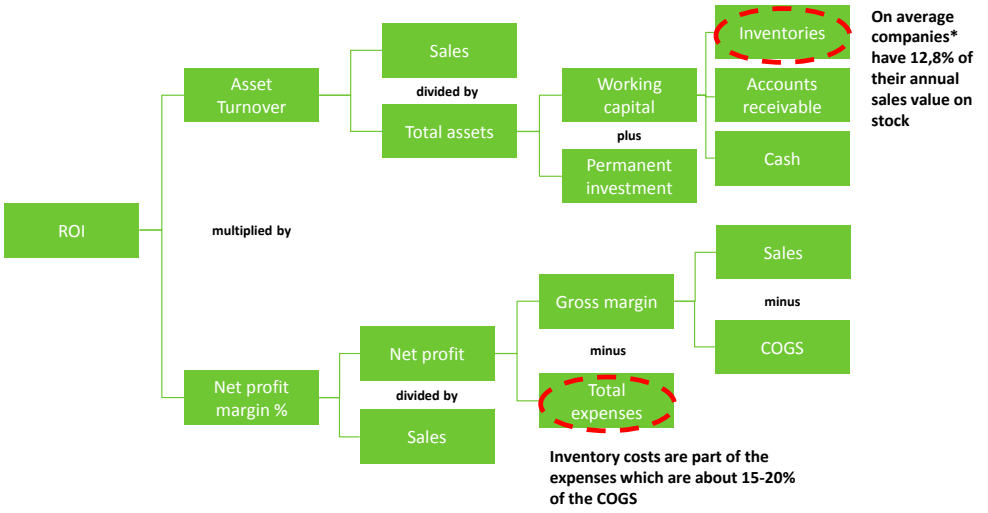
1 INVENTORY, THE ADVANTAGES AND DISADVANTAGES

Inventory is one of the biggest capital investments for most companies. Just think about it for a moment: 1 month's stock equates to an investment of around 10% of your annual revenue. How many projects of that scale have you implemented over the past year? Therefore, it is critically important for a company to correctly determine the necessary inventory levels.

Inventory has a double impact on a company's return on investment (ROI), as illustrated in the DuPont chart below. Firstly, inventory is included on the balance sheet and hence affects the asset turnover. Meanwhile, the inventory costs are included in the total expenses e.g. due to extra storage capacity, meaning that stock has a direct impact on the net profit margin. Since the asset turnover is multiplied by the net profit margin to give the ROI, inventory has a double impact on ROI.

DuPont chart: Inventory affects asset efficiency and net profit



Inventory management is not only important in terms of your end products, but also for your semi-finished goods and raw materials. The ultimate aim of a good inventory management system is to achieve the desired level of customer service (delivery reliability) at minimum costs.

2 THE INVENTORY STRATEGY MIX

A wide variety of methods and strategies are available for determining the optimal inventory level, each with their own degree of complexity and relevance. The choice of strategy depends on a number of factors. For example, an electronics manufacturer will manage his stock of expensive and high-value motherboards differently than a manufacturer of engineering consumables like nuts and bolts. Furthermore, a more complex method of inventory management is necessary to achieve the desired service level for customer-critical spare parts with an unpredictable level of demand than for consumables such as printer paper which is in constant, stable demand.

Generally speaking, the following 4 considerations are important when choosing a particular strategy for managing the inventory of a specific product:

1. The value density of the product,
2. How critical the product is for company continuity (both internally and externally),
3. The predictability and variability of demand,
4. The supplier's lead time and delivery reliability.

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2.1 The value density of the product

Inventory costs money. Among other things, these costs comprise the interest on invested capital (cost price of inventory), storage costs, handling costs and the financial risk of certain goods perishing or becoming obsolete.

2.2 How critical the product is for company continuity

Generally, companies strive to keep their stock levels as low as possible in order to reduce costs. However, this one-dimensional approach to cost optimization is not ideal in all situations. In certain business processes, the availability of the goods in a specific place or within a certain lead time is more important than the associated operational costs. This aspect can apply internally – think of critical components for power stations, aircraft maintenance or IT networks, for example. In addition, an item can also be commercially critical (i.e. externally critical), such as for a wholesaler for whom it is critically important to offer a large number of diverse products from stock.

2.3 The predictability and variability of demand

Needless to say, products with a regular or predictable pattern of demand are easier to manage from an inventory perspective. For products with an unpredictable level of demand, the regularity of the demand is reflected in the simplicity of the inventory strategy. However, not all cases of irregular demand are also unpredictable. Examples of this include seasonal products such as ice skates, Christmas items or soft drinks as well as products with trend-related growth, such as can currently be seen within e-commerce. Although the demand is unpredictable, it is nevertheless possible to make reliable forecasts using the right techniques.

In such situations, simple inventory strategies are often sufficient to manage stock efficiently, providing that the strategy allows for regular adjustment of the inventory and order parameters.

2.4 The supplier's lead time and delivery reliability

Key factors within inventory management are the lead times and delivery reliability of the supplier. It is worthwhile to note that in principle it is not necessary to hold more stock of a product than the level of demand for that product during the lead time.

For example, if the supplier can deliver an item within 24 hours, it is not necessary to keep that item in stock at all if the lead time to the client is more than 24 hours.

Now, I can hear you thinking "I prefer to keep a certain amount of stock, because what if the supplier is unreliable? Does the supplier always deliver on his promises…?" We generally regard a supplier as being reliable if he delivers within the time agreed when the order is confirmed. However, from an inventory management perspective this measure of reliability falls short. If a supplier regularly changes his confirmed delivery time, I – the customer – cannot determine how much stock I need to hold because in effect I do not know what the lead time will be next time. Therefore, from an inventory management point of view, to be considered 'reliable' a supplier must not only perform well in terms of 'on time in full' but also in terms of a fixed lead time.

3 SERVICE LEVEL AND ITS IMPACT ON SAFETY STOCK

Companies are often uncertain about which level of stock they should hold in order to guarantee a particular service level. This frequently results in them holding too much inventory of the wrong goods, and there is often no internal agreement about which service level the market expects of them.

Within inventory management, the service level is used as input for calculating the optimal safety stock. There are various ways to define customer service targets when calculating the safety stock, and those different definitions result in different levels of safety stock.

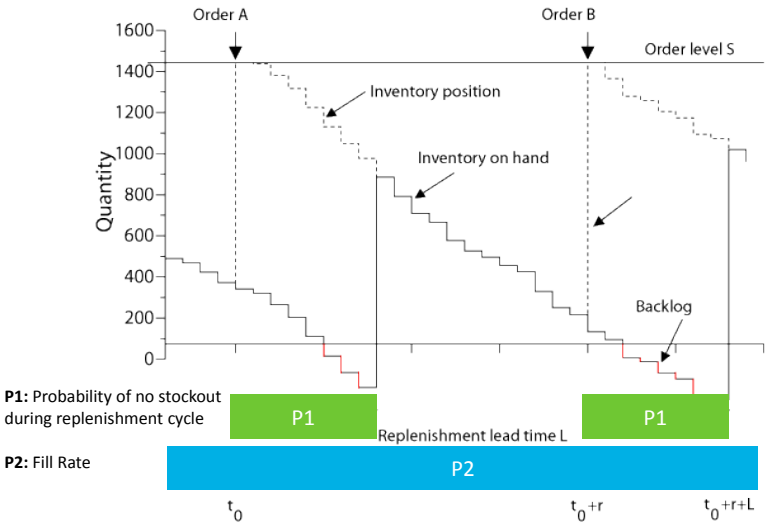
- Percentage of order cycles without stockout (P1)
- Percentage of the number of products that can be supplied immediately (P2)
- Percentage of the time during which net stock is positive (P3)
- The average time between two stockout occasions (TBS)

3.1 P1 calculation – order cycle

The P1 service criterion is widely used to determine the safety stock levels. One important advantage of this method is that it is relatively easy to implement. This approach establishes the safety stock in such a way that a desired percentage of the order cycles suffer no stockouts. By 'order cycle', we mean the period between two replenishments. A service level of 95 percent for the P1 criterion means that, on average, five stockouts occur per hundred replenishments.

3.2 P2 calculation – fill rate

Calculating the safety stock based on the percentage of products that can be supplied immediately from stock is a method that is more closely aligned with the conventional definition of the service level. This is also known as the 'fill-rate service level' (P2). The difference between the P1 and P2 service criteria is visualized below.



As can be seen in the illustration above, the P1 method looks purely at whether there is a stockout situation at the moment of replenishment, whereas the P2 method also considers the size of the associated back order. This makes the definition of a 95% service level within P1 significantly stricter than the same service level within P2.

Example:

> *Every week, a batch of product A is produced. In weeks 3, 15, 24 and 49 there is a shortage of stock, resulting in failure to fulfill sales orders. In that case, the P1 service level is 100% - (4/52) ≈ 92.3%.*
>
> *The average total sales volume for product A is 1,000 units per week. The back order for each of the 4 weeks in which a stockout occurred comprises 50 units. In that case, the P2 service level is 100% - ((4x50) / (52x1,000))≈ 99.6%*

In other words, in the case of a 95 percent P1 service level it is necessary to hold a higher level of safety stock than for a 95 percent P2 service level. Therefore, especially in situations with (very) high sales volumes, P1 will also lead to substantially higher stock levels and hence higher inventory costs, including a lot of dead stock. As a result, in particular in the case of significant sales volumes, it is advisable to work with the P2 service criteria unless there are explicit reasons not to do so – such as in the case of business-critical products.

3.3 P3 calculation – ready rate

Service criterion P3, the ready rate, is defined as the percentage of time during which the available stock is positive. In this case this means the 'available-to-promise' stock rather than the physical stock.

This service criterion can be defined as the equivalent of the probability of no stockouts at a chosen moment. For example, if the ready rate is 95% then the available stock over a period of 100 days is 0 or 'negative' for 5 of those days.

This service definition is applied particularly for products that are highly business critical, such as spare parts.

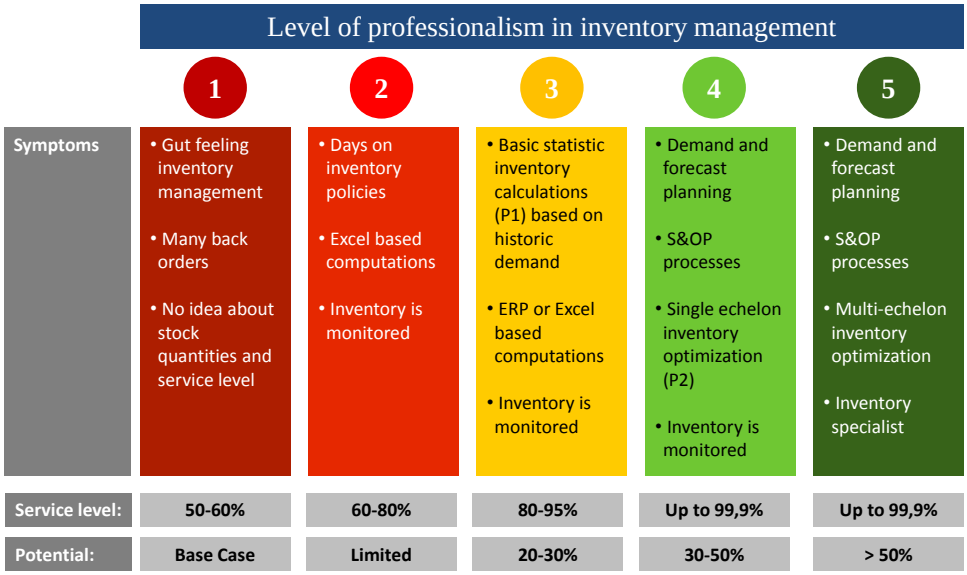
3.4 TBS - Time Between Stockout Occasions

Time Between Stockout Occasions (TBS) is a customer service variant of the P3 calculation. The time during which the stock is positive as defined in P3 does not provide any information about the exact frequency and duration of the stockouts over time, i.e. the length of time between two stockouts.

Adjusting the stock calculation based on the right service level definition will ensure the optimal composition of the inventory. Selecting the right technique enables us to provide the same level of customer service with less stock.

4 FIVE PHASES OF INVENTORY MANAGEMENT PROFESSIONALIZATION

Over the years, many inventory management methods and techniques have been developed, including the service criteria outlined above and the associated calculations to determine the optimal levels of safety stock. These different methods and techniques involve varying degrees of complexity and produce varying results. We have classified these methods and techniques based on 5 different levels of professionalism in inventory management below.

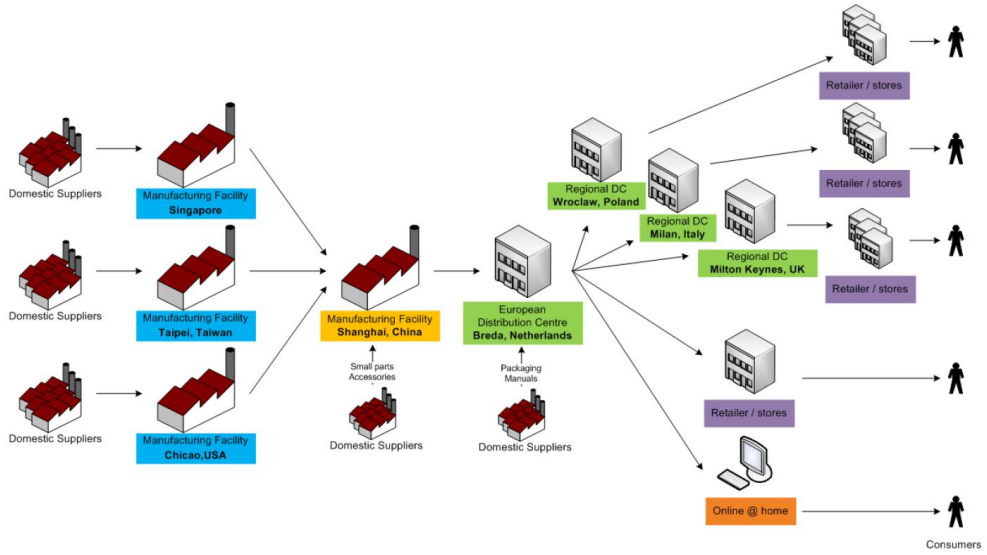


The majority of companies are currently in the third phase of professionalism in inventory management. In MRP algorithms, the operational inventory planning is prepared within the ERP system based on fixed stock parameters.

A number of pioneers, in particular in the automotive, FMCG and electronics industries, have progressed to phase 4. They have implemented tactical planning processes such as Sales & Operations Planning (S&OP) or Integrated Business Planning (IBP). Such concepts balance the often-conflicting interests of the commercial and operational departments (Sales wants flexibility, Production wants efficiency) at management level.

Phases 1 to 4 all utilize a sequential, single-echelon approach in which the demand and the necessary safety stock is calculated individually for each echelon within the supply chain. The disadvantage of this approach is that, because each link within the supply chain holds safety stock, the variance and hence the amount of stock increases upstream. The literature calls this phenomenon the 'bullwhip effect'. The bullwhip effect occurs within almost all industries and results in unnecessarily high costs.

Phase 5 marks the transition to multi-echelon inventory management which takes a holistic approach to all the inventory echelons in the supply chain, including consideration of the impact of the stock at a particular level or echelon on other echelons.



For example, if a product is sold through a sales point served by one of the distribution centers, the distribution center represents one echelon in the chain and the sales point is a different echelon.

The level of stock required at the sales points is largely dependent on the service levels achieved by the distribution center.

Higher levels of inventory upstream in the supply chain mean that the sales points need to hold less safety stock, and vice versa. The aim of multi-echelon inventory management is to continuously optimize and update the levels of safety stock integrally across all these echelons.

Phases 3, 4 and 5 of the professionalization of inventory management within companies will be covered in more detail in the next chapter.

5 PHASES 3 & 4 – MRP WITH P1 AND P2 SAFETY STOCK

MRP is a proven technique which many companies have been using since the 1970s to help them prepare realistic plans. MRP I actually takes care of two things: a Bill-of-Material explosion and lead-time offsetting. In principle, MRP always starts with a sales forecast from the commercial departments. MRP I uses parts lists to break down the expected demand for end products into requirements for semi-finished goods and ultimately raw materials. In addition, MRP I determines precisely when each of these must be available. Based on the necessary manufacturing resources, MRP II then calculates a detailed production schedule from the perspective of production-line capacity and labor.

Therefore, the overwhelming majority of IT systems also utilize these MRP concepts. However, there are a number of clear disadvantages to MRP:

- The MRP planning mechanism is based on a forecast of the demand, average delivery times (for raw materials) and production times (for machinery). On top of that, it also often works with fixed order- and batch sizes. In practice, this results in a bullwhip effect. As a result, minor variances in the demand upstream in the supply chain can create major fluctuations in the MRP production recommendations.

- It is not possible to include the practical limitations facing production in an MRP model. For example: if the production sequence progresses from light to dark in order to minimize changeover times, or the fact that if you manufacture product A you must also manufacture product B.

- MRP takes a lot of time to calculate an optimal solution. This is not so much the case for a single, simple supply chain, but it does apply to multi-stock/multi-point supply chains. Such supply chains demand a lot of computational power to be able to factor in all the variables successfully. This variant results in an explosion of the number of variables and the relationships between them, producing such long computational times as to be unworkable. Scenario analysis is no longer possible simply because it involves too many man-hours and it takes too long to calculate the results of so many different scenarios.

- If the demand for end products changes, MRP recalculates the entire plan without taking the old plan into account. This creates a very jittery picture.

Furthermore, MRP works with a similar planning methodology for the whole supply chain. However, in order to maximize the benefits of the inventory system it is necessary to focus on the areas of the supply chain where it will have the most effect. With this in mind, we can make a number of observations.

- The majority of the invested inventory capital is downstream in the supply chain. Various studies have shown that upstream stock of raw materials and semi-finished goods generally accounts for less than 10% of the total inventory value.

- Holding a 'high' level of inventory mainly pays off at the end of the supply chain. This enables you to offer customers short lead times.

- Moving the customer-order decoupling point further upstream creates extra inventory flexibility which decreases the need to hold a high safety stock of end products. Stock shortages or surpluses will then affect the core product rather than the end product.

- To achieve manufacturing efficiency and inventory reduction, the focus should be directed at the start of the supply chain, i.e. where the stock has not yet been made customer-specific.

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6 PHASE 5 – THE NEXT FRONTIER, MULTI-ECHELON PLANNING

S&OP and IBP have undeniably made a great contribution to improving the professionalization of inventory management. However, these concepts are focused specifically on the last stock echelon of the end product. The inventory planning of the upstream stock in raw materials and semi-finished products is often regarded simply as a derivative of the end product. Therefore, the future development of S&OP and IBP will have to primarily focus on synchronized, integral inventory optimization across all echelons of the supply chain: 'collaborative planning'. This approach prevents the traditional bullwhip effect within the supply chain which often results in much too much stock being held upstream.

6.1 Synchronized Base Stock Policy

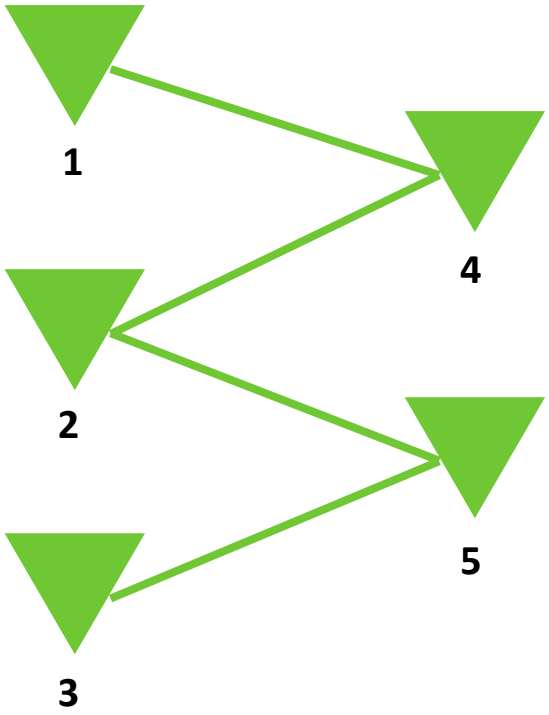
In order to meet the need for multi-echelon inventory planning, TU Eindhoven (TU/e) has developed an innovative inventory planning system called the Synchronized Base Stock (SBS) policy. SBS can be implemented within the existing concepts of S&OP and IBP.

The SBS strategy recognizes that there are a number of variances within the supply chain and includes mathematical concepts to take account of them. Whereas MRP holds safety stock or buffer stock in all areas/echelons of the supply chain, SBS reveals where and which (buffer) stock is surplus to requirements or even dead. The dead stock can be removed from the system without any problems and may mean that the company can temporarily reduce its sourcing activities while still being able to maintain its customer service levels.

Unlike MRP, SBS works with so-called Echelon Inventory Positions (EIP). The EIP principle entails the inventory from assemblies and sub-assemblies in the chain for a particular end product being added together. The aim of SBS is to maximize the service level in the most upstream echelon with as low an EIP as possible.

Once the optimal EIP has been determined, it is kept constant by SBS inventory planning. The figure below shows an example of a supply chain with two end products: end product 4 and end product 5. End product 4 comprises two components: 1 and 2. End product 5 also comprises two components: 2 and 3. If 50 units are sold of end product 4 and 25 units of end product 5, the following orders are released based on the EIP principle:

- Component 1: 50 units
- Component 2: 50+25=75 units
- Component 3: 25 units



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Whereas MRP is based on a forecast, SBS manages the supply chain based on the current demand, with the safety stock in the various echelons compensating for the fluctuations in demand. As a result, SBS is more responsive and the number of orders released remains more stable. Research has shown that the use of SBS results in a higher service level and lower stock levels compared with MRP and Advance Planning systems.

6.2 The first practical applications of SBS are a success

In various implementations, it has already been demonstrated that SBS can reduce stock by between 30% and 60% and can even simultaneously raise the service level.

If you are interested in learning more about this new, innovative approach to inventory planning, Groenewout – in collaboration with TU/e – can demonstrate the specific benefits for your supply chain in an inventory-focused 'serious game'.

7 ABOUT THE AUTHORS

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