KEY INSIGHTS

1. The Base Stock Policy as well as review period and lead time reductions can lead to significant savings in inventory level and operating costs.

2. Combining two similar SKUs into one single SKU, while increasing the wastage, can reduce inventory level and operating costs.

3. Increasing inventory of finished products can lead to overall reduction of total inventory.

Introduction

In the Medical Device Industry, which is generally characterized by urgent shipping requirements and long supply lead times, many companies rely on high finished product inventory to meet their customers’ urgent requirements. However, due to the need for sterilization of some of their products that leads to short shelf lives, some companies have to contend with potential product expiration and rework. One example is the company that we worked with for this project, referred to throughout this project as MedCo. MedCo is a large company that offers a broad range of neurosurgery-related medical devices, including a family of four surgical kits that is the subject of our study. Each kit consists of a sterilized and a non-sterilized sub-kit. Figure 1 shows the current supply chain for the kits, which we refer to as the Base Case in this project.
The supply chain entails six stages of activity. The first three stages include inspection, sub-kit assembly and sterilization for the sterilized sub-kits while Stage 4 and Stage 5 are the inspection and sub-kit assembly for the non-sterilized sub-kits. The final stage, Stage 6, is the full kit assembly, in which the sterilized and non-sterilized sub-kits are kitted together to become the final products. Inventories of components are held at Stage 1 and 4, and inventory of finished products is held at Stage 6. MedCo reviews its inventories at Stages 1, 4 and 6, and orders about a month worth of inventories every month. To enable rapid response to requirements, MedCo adopts a Make-To-Stock (MTS) policy and an urgent 1-day shipping policy for the emergency surgical kits. These policies, coupled with long component delivery and kit assembly lead times, invariably result in high inventory level. The purpose of our study was to examine the company’s current supply chain and its inventory management policy, and to propose better inventory management strategies to reduce the inventory level and the operating costs across their supply chain, while maintaining the highest healthcare standards.

Methodology

Strategy Formulations and Analysis, and Sensitivity Analysis

We first assumed that the multi-echelon network comprises a serial and parallel connection of six stages of activities, each of whose inventory level is independent of the other. We then developed a few possible strategies, modeled them into different scenarios, and used mathematical formulae to quantify a pre-defined set of Key Performance Indicators (KPIs) for analysis. The KPIs consist of the inventory level and the relevant operating costs. The results were analyzed and a best strategy was developed from the previous strategies. We also performed a sensitivity analysis to determine the best review period for a few strategies that require a change to the review period. Throughout the analysis, we maintained the same overall performance standard in servicing the customers.

Optimization

We then assumed that the various stages of inventory were dependent and adopted a Strategic Inventory Placement (SIP) method – the Guaranteed Service Level Model - developed by Graves et al. (2000) with some modifications to meet our requirements. The method enabled us to determine the best locations in the supply chain to place the inventories as well as the amount of inventories to place in each location to further minimize the inventory and the operating costs.

Strategies

Various factors affect the inventory level and operating costs. They include: the type of inventory control policy used, the location of the inventory in the supply chain, the point of product differentiation in the supply chain, the product kitting architecture, the review period and lead time. Hence, we identified eight strategies, each varying one or more those factors mentioned above for our analysis. In the following section, we present a brief description of these scenarios, with each of them depicting a strategy.

Brief Description of Scenarios

- **Scenario 0: Base Stock policy** - Apply Base Stock Policy to the whole supply chain with inventory calculations using formulae given by Silver et al. (1998)
- **Scenario 1: Forward Placement of Inventory (a - without partial kits; b - with partial kits)** - Place sterilized sub-kits as well as non-sterilized sub-kits or partial kits’ inventory before the full kit assembly. Partial kits are formed by combining components common to the same set of finished products.
- **Scenario 2: Reduced Review Period and Lead Time** - Reduce review period to 14 days and shorten lead time to 1.5 days for the full kit assembly stage.
- **Scenario 3: Combined Kits** - Combine two of the four full kits that have many components in common into one “super” kit. This is, in effect, applying the concept of Postponement as the Point of Product Differentiation is moved to the customers’ end.
- **Scenario 4: Continuous Review System** - Use Continuous Review System across the whole supply chain.
• **Scenario 5: Combined Strategy 2 and Strategy 3 (Best Case)** - 1) Reduce review period to 14 days and shorten lead time to 1.5 days for the full kit assembly stage; 2) Combine two of the four full kits that have many components in common

• **SIP A - Strategic Inventory Placement**
  **Alternative A** – 1) Reduce inventory of components prior to sub-kit assembly; 2) Increase inventory of finished products after full kit assembly

• **SIP B - Strategic Inventory Placement**
  **Alternative B** – 1) Eliminate inventory of components prior to sub-kit assembly; 2) Further increase inventory of finished products after full kit assembly

**Results**

*Comparing Scenarios and Sensitivity Analysis*

We compared these scenarios using the Total Relevant Costs (TRC) and inventory level in each case. Figure 2 ranks all the scenarios based on the TRC, which includes the safety stock (SS), cycle stock (CS) and pipeline (PL) holding costs, the stock-out costs and the ordering costs across all stages of the supply chain.

Our analysis revealed the following results:

• Managing the inventory using the Base Stock Policy (Scenario 0) reduced the TRC by about 30% relative to that of the Base Case.

• Although using partial kits instead of sub-kits offered marginal cost savings, Scenario 1 did not lower TRC further from Scenario 0 because of the extra costs incurred from forward placing the inventory.

• While reducing review period and lead time for the final assembly stage (Scenario 2) reduced costs by 12% compared to that of Scenario 0, combining the two SKUs with common components (Scenario 3) offered only smaller savings. The benefits of risk pooling the demand uncertainties were minimal in the latter case because of the large difference between the average demands and variations in demand of the two kits that were combined.

• The lower holding costs achieved by continuously reviewing the inventory (Scenario 4) were offset by a corresponding increase in the ordering costs. Hence, even this strategy reduced the TRC only marginally relative to that of Scenario 0. However, the added complexities of implementing Scenario 4 made Scenario 3 a better candidate for inclusion in the Best Case (Scenario 5).

• The Best Case, which combined Scenario 2 and 3, lowered TRC by about 40% over the Base Case and 15% over Scenario 0 and offered relatively easier implementation than the other strategies.

To determine the range of review periods that lead to lowest overall costs in Scenario 2 and 5, we did a sensitivity analysis of the TRC and the inventory level using different review periods for the full kit assembly stage. Although the review period of 11 days gave the lowest TRC, we chose to review every fortnight because the results remained close to optimal and provided a more practical time bucket.

*Optimization*

We observed that optimizing the supply chain further reduced the TRC on average by about 10% over its
non-optimized counterpart. While optimized Scenario 0 reduced TRC by about 35%, optimized Scenario 5 reduced TRC by about 45% relative to that of the Base Case. We also noted that although eliminating the component inventory (SIP-B) further increased the stock of finished products, it lowered the TRC more than just reducing the component inventory (SIP-A).

Figure 3 ranks the strategies based on total inventory level across the supply chain.

Figure 3: Comparison of Strategies based on Inventory Level (in 000s of $)

Comparing the strategies based on inventory level gave overall results similar to those given by comparing strategies based on TRC. In both cases, optimizing Scenario 5 offered the best results. However, this analysis showed that Scenario 0 optimized using SIP B ranks even higher than the Best Case (Scenario 5), closely followed by Scenario 0 optimized using SIP A. Based on these observations we inferred that there are significant benefits associated with reducing component inventory while increasing the stock of finished products in the supply chain.

Management Insights

Our research shows that there is a tremendous potential for enhancing MedCo’s supply chain for the emergency medical kits. The key insights are:

- First cut is easy to achieve. Managing inventory using the Base Stock Policy gives significant cost savings.

- Postponement drives costs down. With changes to the kitting process, product differentiation can be postponed until consumer use. This induces some marginal wastage but the overall savings offset this small increase in costs.

- There is no great advantage in reviewing inventory continuously since the order cycles increase inordinately. However, there is ample benefit in reducing lead times and review periods since the inventory level in the network goes down.

- Strategic inventory placement leads to significant cost savings, especially so for inventory level. However, when making decisions on the amount of inventory of components and finished products, MedCo should weigh the decisions against the potential risk of suppliers not delivering on time, especially those overseas suppliers. In this supply chain, costs associated with value-add are low compared to material costs. Therefore, it is recommended to stock more of finished product inventory and maintain as low component inventory as possible, considering the risks involved.

- Following a spiral or a phased approach to improve the network is recommended since the potential benefits and relative ease of implementation vary widely across different strategies.