Inventory Strategies for Patented and Off Patent Products for a Pharmaceutical Supply Chain

By Prashanth Krishnamurthy and Amit Prasad
Thesis Advisor: Dr. Jarrod Goentzel

Summary: This project assesses the inventory strategies for patented and off-patent products in a pharmaceutical supply chain with a focus on service level, forecast accuracy, lead times and supply reliability. The safety stock equation used in the current distribution model is examined and a revised model with a new safety stock equation is proposed. Sensitivity analysis then evaluates the impact of variations in input parameters on the safety stock. The study shows that there is a significant difference in inventories between the proposed model and practice, demonstrating an opportunity to reduce working capital.

KEY INSIGHTS

1. The inventory levels for both patent and off patent products are higher than the levels recommended by the planning tool, demonstrating a gap between theory and practice.

2. The safety stock equation in the planning tool did not incorporate the combined variability in demand and supply correctly.

3. Supply reliability should be measured for all SKUs. Safety stock is highly sensitive to variation in supply reliability and hence should be accounted for both under patent and off patent products.

Introduction

Large pharmaceutical companies, such as our sponsor, have high inventory levels to service their downstream supply chain partners. A high level of inventory implies a significant amount of working capital investment. With products going off patent, the profitability of some pharmaceutical companies has declined. This has led to increased focus on opportunities to reduce the working capital investment to improve the bottom line. Our research addresses the key question that our sponsor company is facing: What is the right amount of finished goods inventory to be held by pharmaceuticals in their distribution centers?

We focus our efforts by studying a patented drug and an off patent drug in the North American region. These product lines have different demand patterns, service level requirements, profit margins, and supply chain networks. We explore the inventory planning aspect – especially the safety stock planning at distribution centers. We analyze the current safety stock levels in relation to that planning and study how the planned safety stock is sensitive to different factors. We focus our study on improving the structure of the model used for planning safety stock.

Sales and Inventory Patterns

The sales of the patented product have been quite stable and predictable compared to those of the off-
patent product; hence, the patented product should have a stable inventory pattern. However, we observe a varying inventory pattern at DCs for the patented product, as shown in Figure 1.

We see a decline in the sales of the off patent product. However, the inventory levels are kept high for this product, as shown in Figure 1.

Thus, it can be concluded that company maintains a very high inventory level for both products, which signifies a high working capital investment.

The company uses a planning tool to compute the safety stock at its distribution centers. The safety stock is defined using the following formula:

\[
SS = k \left( \frac{AS}{12} + f - \frac{AS}{12} \right)^2 \frac{LT}{4 + 7} + k \left( \frac{AS}{12} + SR - \frac{AS}{12} \right)^2 \frac{LT}{4 + 7}
\]

where \( SS \) = safety stock maintained at the facility, \( AS \) = annual sales of the product in number of SKUs, \( k \) = safety stock factor, \( LT \) = lead time in days, \( f \) = forecast accuracy (%) and \( SR \) = supply reliability (%).

Based on this formula, the safety stock is a combination of traditional parameters such as forecast accuracy, service level requirements and average lead-time with a non-traditional upstream uncertainty parameter defined as supply reliability. Traditionally upstream uncertainty is measured by variability in lead time rather than reliability in the quantity delivered. In addition, the company does not actively measure the supply reliability and instead sets the value based on intuition.

Comparing theory and practice, we find the actual inventory levels to be much higher than the levels recommended by the planning tool. The red horizontal line in Figure 1 shows the days of inventory recommended by the tool. For patented product, the actual inventory approximately twice as much as recommended while the off-patent product is moved to be well over twice the recommended level.

Revised Model

We propose a new formula for safety stock that addresses two issues. First, the safety stock equation used assumes the number of days in the planning period to be 28, based on a 4-week month. But, all the other parameters are based on a monthly time period. Hence, the assumption about the number of days in a month should be corrected to 30 days, as shown in the equation below.

\[
SS = k \left( \frac{AS}{12} + f - \frac{AS}{12} \right)^2 \frac{LT}{30} + k \left( \frac{AS}{12} + SR - \frac{AS}{12} \right)^2 \frac{LT}{30}
\]

Second, the variation of the gap (\( \sigma_g \)) between demand and supply is caused by variation in demand – in this case driven by the forecast error (\( \sigma_f \)) – and variation in supply (\( \sigma_s \)). Combining these random variables gives us a variation of

\[
\sigma_g^2 = \sigma_f^2 + \sigma_s^2 + 2 \text{Cov}(F,S)
\]

Generally, the process driving demand and the process driving supply are assumed to be independent, which implies \( \text{Cov}(F,S) = 0 \).

Hence,

\[
\sigma_g^2 = \sigma_f^2 + \sigma_s^2,
\]

and the standard deviation is \( \sigma_g = \left( \sigma_f^2 + \sigma_s^2 \right)^{1/2} \).
Using this logic in the equation for safety stock, where

\[ \sigma_f = \sqrt{\left(\frac{AS}{T^2} \cdot f - \frac{AS}{T^2}\right)^2} \]

and

\[ \sigma_s = \sqrt{\left(\frac{AS}{T^2} \cdot SR - \frac{AS}{T^2}\right)^2} , \]

the safety equation becomes:

\[ SS = k \cdot \frac{1}{\left[ \frac{AS}{T^2} \cdot f - \frac{AS}{T^2} \left] \right)^2 + \frac{AS}{T^2} \cdot SR - \frac{AS}{T^2} \right)^2 + \frac{LT}{36} \]

Table 1 shows the difference when calculating inventory using the current and the proposed safety stock formula. The proposed formula reduces the recommended safety stock since the number of days (in the denominator) increases and since the variance decreases. For the patented product, the difference ranges from 20-27%. For off patent product, the difference is around 30%.

<table>
<thead>
<tr>
<th>SKU DESCRIPTION</th>
<th>DOI (Current Model)</th>
<th>DOI (Proposed Model)</th>
<th>% Change in Safety Stock</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patented Product</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SKU 1</td>
<td>24</td>
<td>17</td>
<td>-27.21%</td>
</tr>
<tr>
<td>SKU 2</td>
<td>20</td>
<td>16</td>
<td>-19.24%</td>
</tr>
<tr>
<td>SKU 3</td>
<td>34</td>
<td>27</td>
<td>-20.53%</td>
</tr>
<tr>
<td><strong>Off Patent Product</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SKU 1</td>
<td>54</td>
<td>38</td>
<td>-29.76%</td>
</tr>
<tr>
<td>SKU 2</td>
<td>59</td>
<td>42</td>
<td>-28.72%</td>
</tr>
<tr>
<td>SKU 3</td>
<td>53</td>
<td>37</td>
<td>-30.01%</td>
</tr>
<tr>
<td>SKU 4</td>
<td>45</td>
<td>31</td>
<td>-31.47%</td>
</tr>
<tr>
<td>SKU 5</td>
<td>37</td>
<td>26</td>
<td>-30.13%</td>
</tr>
</tbody>
</table>

Table 1: Comparison of Current and Proposed Model

**Sensitivity Analysis**

We perform a sensitivity analysis on safety stock for both products over a range of input values for different variables. Figure 2 shows the sensitivity of safety stock to variation in the input parameters for two of the largest selling SKUs. The x-axis in the figure represents the change in input factors while the y-axis represents the change in safety stock.

Safety stock is found to be most sensitive to supply reliability for the patented product and to forecast accuracy for off patent product. However, for the patented product under study, the forecast accuracy is very high (95%) and hence there is not much room for further improvement as compared to the off patent product.

![Patented Product](image1)

![Off Patent Product](image2)

**Figure 2: Sensitivity to Supply Chain parameters**

**Conclusions**

This research investigated the theory and the practice related to finished goods inventory. We determined that the current safety stock formula does not follow traditional theory and suggest correcting it for all products. Further, we identified that the inventory in practice more than twice as high as the currently inflated recommendation. Both changes would lead to a significant reduction in the safety stock carried across distribution facilities without comprising service levels, in theory.

Furthermore, our sensitivity analysis demonstrates how variations in input parameters, especially ones like supply reliability that are set intuitively, can dramatically impact inventory levels. We recommend that the sponsor should measure these critical factors regularly and calibrate the parameters with the service levels they experience in practice. Closer alignment of theory and practice can dramatically reduce working capital while maintaining service levels.