Managing the Inventory of perishable products during switch period

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Summary:
This research is performed to propose an inventory model which can be used in the case of product transition of perishable products. The sponsor company, Siara is a pharmaceutical giant. Pharmaceutical companies need to undergo periodic license renewal to be able to import drugs into a country. While switching old license to new license, the company will not be able to import the drugs once the old license is expired and hence there is a need to maintain the inventory which would suffice the demand in this period. The inventory model is suggested to the company with different variable parameters such as forecast accuracy, cycle service level and remaining shelf life of the products. Monte-Carlo simulation was performed on the results obtained from the methodology to determine expected shortage and obsolescence of drug products. The results are analyzed and recommendations are provided to Siara regarding inventory management and its breakup with different remaining shelf lives of the products.

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KEY INSIGHTS

- (R, S) inventory policy is suggested to decrease the obsolescence.
- Holt Winters method of forecasting is suggested to improve forecast accuracy.
- It is recommended that minimum remaining shelf life of products in the stock should be 10 months to reduce expected obsolescence to zero, when the products with least remaining shelf life are distributed first.
- As the same forecasting technique does not suit a product throughout its entire life cycle, tracking signal is suggested for continuous monitoring of forecasting errors.

Introduction

"Siara" is one of the largest multinational pharmaceutical companies with operations spread across different parts of Europe, Asia and America. Siara is a pioneer in research-focused healthcare with strengths in both drugs and diagnostics. In the pharmaceutical division, Siara is a patented drug manufacturer and seller and does not deal with generic drugs. The production and distribution of drugs is highly regulated. pharmaceutical companies must have a license to import drugs into most countries and this license needs to be renewed periodically. During the renewal, which is switching from the old license to new license, the company is not allowed to import those drugs whose license is under renewal. As the drug products are perishable, maintaining high inventories may result in obsolescence, which has happened in the past. Therefore, the company needs to plan the inventory to minimize obsolescence by avoiding shortages for the drug product. In October 2017, the license of a product is going to expire, let's say product "A". The products whose inventories were obsoleted in the past are product B and product C.

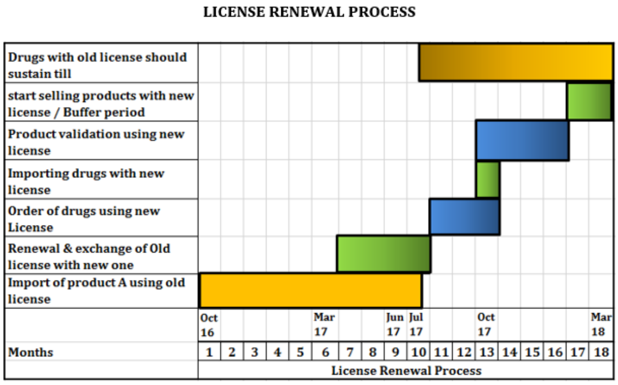

Figure 1 License renewal and inventory building process

From figure 1, which shows the license renewal process, we can see that the product A cannot be imported into the country using old license after July 2017 as the new license is expected to get exchanged with the old license then. After the license gets exchanged, the drugs can arrive in to the country after three months as the lead time is three months and they have to undergo validation process according to the new license which would take another four months. Two months of safety stock to be maintained as the process time may extend further. Therefore, the inventory has to be build which should last for another none months to have no stock outs during this period.

Research Question

1. During the licenses switch period (Switching from old license to new license), how much inventory of finished drug product does Siara has to maintain in the country to ensure no product shortage while minimizing obsolescence.

Literature Review

The literature based on obsolescence, product transition, single, multi-period inventory replenishment techniques and forecasting is reviewed.

According to Brown et al., [1] "Obsolescence may occur for a particular item because units are replaced by a suitable item which performs similar or identical functions or because of a program of systematic replacement by a substitute item." Thus, obsolescence results in the partial or total loss in the value of the product.

According to Gustavsson [2], one-third of the pharmaceutical products are obsoleted in the end to end process due to lack of proper inventory infrastructure or efficient supply chain management strategies.
For effective inventory planning and production planning/scheduling, forecasting is essential in order to predict future and act accordingly. Forecasting can have a major impact on various supply chain decisions such as procurement, manufacturing, sales and operations, etc.
According to Silver et al. [3], most companies have huge buffer stocks due to variability in the demand of products, and hence there is need for forecasting to make inventory decisions.

Hongmin et al. [4] in his research on optimal planning quantities for product transition, suggested a model for optimal planning quantities, in which no replenishment is possible during the transition period, which is similar to one of the constraints in our research question. But, he did not consider perishability of products which is a critical criteria in the current research.

Karaesmen et al. [5] have reviewed literature on perishable products having fixed or random life-times. They have classified the literature into periodic and continuous review inventory control. For each category, they provide a detailed classification concerning specific model assumptions, e.g., replenishment policy (optimal control policy, order-up-to policy, or heuristic), excess demand (backlogged or lost), and lead time (zero or strictly positive).

Urban (6) and Donaldson (7) studied the effect of various parameters on inventory replenishment models, which describes price, time (trend in the demand data/ demand pattern in the past) and inventory level on hand as major factor affecting inventory decisions. In the scope of our thesis, the price of the product is going to remain constant. Therefore, the effect of time on demand is to be studied by considering the historical data.
Study of time series and demand trends is another focus of our research thesis.

Methodology

Figure 1 shows the methodology that was used in solving the research question.

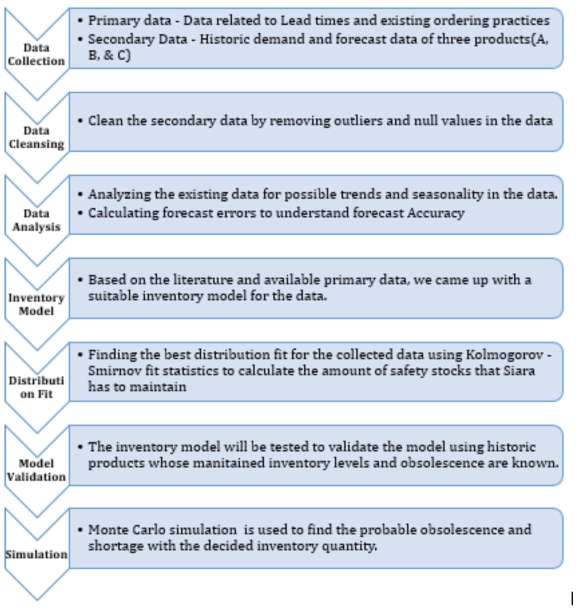

Figure 2 Research process flow diagram

This research initially focused on understanding the company's current forecasting practices, collecting the primary data related to past obsolescence reasons and secondary data related to products A, B and C. The secondary data constitutes of historic sales data and forecasted demand of all the three products and the actual stock up inventory and the obsolete inventory quantities of product B and product C.

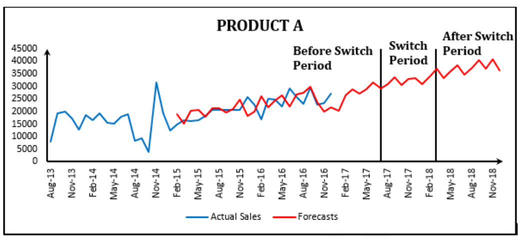

Figure 3 Actual sales and forecasted demand of product A

As the forecasted demand data is the basis for inventory modelling, the forecast errors are calculated to find Siara's forecast accuracy. Mean absolute percent error (MAPE) is calculated for all the products, A, B and C in order to calculate the errors in their forecasts.

The MAPE of the products A, B and C till Dec 2015 are 13%, 63% and 42% respectively. Whereas, the MAPE of the products A, B and C till Dec 2016 are 15%, 116% and 75%. This reflected the obsolescence in the past and hence there was a need to suggest a better forecasting method before suggesting an inventory model as the forecasted demand with high forecast errors would either lead to obsolescence or stock outs.

Various forecasting methods were tried to find the better forecasting technique for the given products. Table 1 shows the comparison of various MAPEs using different forecasting methods. From Table 1 is it clear that, Holt-Winters method has least forecast errors for all the products and hence it is recommended.

Forecast errors using various forecasting models – considering demand till Dec 2015				
Product	Original forecast	Simple Exponential Smoothing	Holt Winters Method	Regression
A	14.76%	23.62%	12%	27.45%
B	63%	25.65%	22%	21%
C	42.43%	21%	16%	40%

Table 1 Comparison of forecasting errors

Inventory Model:

For the current scenario, which is one time replenishment, news vendor policy would best suit if the products would become obsolete once the products with new license gets validated. But, in this case only the company is not allowed to import the drugs using old license. But, it is still eligible to sell the already imported drug products if they are not perished even after the license gets renewed. So, the news vendor model is not a best fit in this case.

According the current practices, Siara places an order once a month to the manufacturing plant.

Continuous review and continuously placing an order to the manufacturing firm is not a feasible option. Therefore, a periodic review and order up to policy (R, S) is suggested to the company.

In this case, the review period, R would vary based on the number of months for which Siara has to maintain the inventory

Inventory to be stocked-up was calculated in three different methods.

1. Applying (R, S) policy to Siara's forecasts.
2. By removing the trend from the actual data, the errors in the data was found. Cycle stock was calculated by extrapolating the trend line in to future and safety stock was calculated by finding the distribution of the errors in the data.
3. Applying (R, S) policy to the forecasted demand using Holt-Winters method.

In the case of second method, the safety factors for various distributions were calculated based on the distribution fit of the errors in the demand using the formula by Silver et al. [3],

Safety factor at a required service level,

$$k = \frac{x - \mu}{\sigma}$$

Where, x = the value at the required service level (cumulative probability in the distribution)

μ = mean of the distribution

σ = standard deviation of the distribution

Model Validation:

After calculating the stock up quantities for products B and C, the obsolescence is calculated based on historic sales data. This calculated obsolescence is compared with the actual obsolescecne by using all the three methods mentioned above.

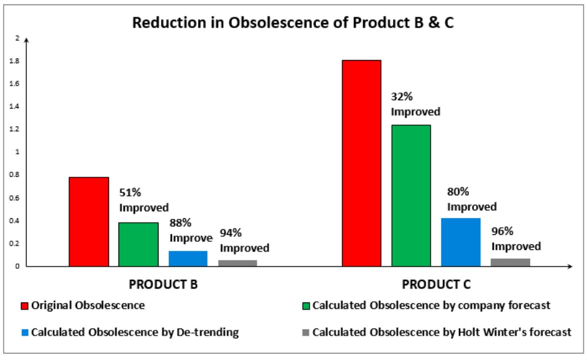

Figure 4 Reduction in obsolescence

Simulation and Sensitivity Analysis:

After calculating the stock up quantity, expected obsolescence and expected shoratges simulated by generating random customer demand based on historic demand distribution.

The simulation is performed considering two different scenarios.

1. The product with least remaining shelf life is distributed first.
2. The remaining shelf life is not considered and the products are distributed randomly.

In the above two cases, the minimum remaining shelf life of products that is to mainatained is also simulated. Table 2, shows the maximum pecentage contribution of products in the total stock to minimize obsolescence.

The expected shoratges are zero in both the scenarios. Figure 5 and 6 shows the expected obsolescence in the above two scenarios.

With 7months RSL, the quantity	<= 6.6% of the total stock-up quantity
With 8 months RSL, the quantity	<= 8.6% of the total stock-up quantity.
With 9 months RSL, the quantity	<= 9.5% of the total stock-up quantity.

Table 2 Percent contribution of products with particular remaining shelf life

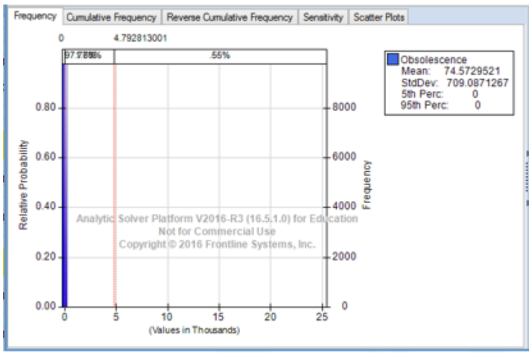

Figure 5 Expected obsolescence by distributing least RSL products first

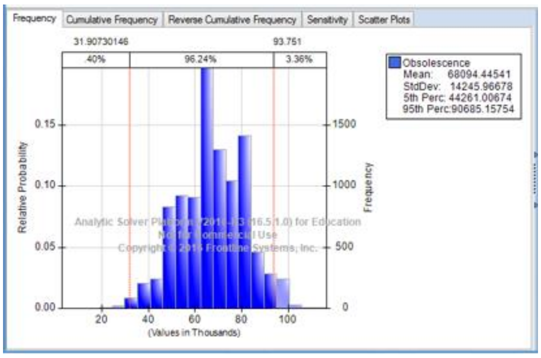

Figure 6 Expected obsolescence by distributing randomly

Results and Conclusions:

1. Holt-Winters forecasting method is suggested as it predicts more accurate forecasts (lowest forecast errors (MAPE))
2. As the same forecasting method is not suitable for a product during its entire life cycle, it is suggested to use a tracking signal to continuously monitor the forecast errors and choosing the better forecasting method during different phases of the product.
3. An (R, S) inventory policy is recommended, as this policy along with forecast data from Holt-Winters forecasting method resulted in the reduction of obsolescence by 94% for product B and 96% for product C.

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