Replenishment Policies for Retail Pharmacies in Emerging Markets

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Summary: This research focused on understanding the effects of supplier-pushed discounts and stock-outs on overall costs in retail pharmacies. We conducted interviews with the sponsor company’s management and collected data from the ERP system. Through experimentation of replenishment policies in existing literature for hospital pharmacies and other retail industries, we found maximizing supplier-pushed discounts may be detrimental to the sponsor. Additionally, through sensitivity analysis of forecast horizon, stock-out penalties and customer service levels, we examined the tradeoffs in inventory holding costs versus enforcing high service levels while leveraging supplier-pushed discounts. We determined that optimal replenishment policies are subject to SKU characteristics, such as rate of backorders. Finally, the sponsor company will achieve 34% of savings thanks to our proposed inventory models.

Prior to MIT, Kevin completed his bachelor’s degree in biological chemistry at the University of Toronto and worked in the retail pharmacy industry for 7 years. His experience formed his interest in healthcare supply chain management, bringing him to MIT.

Prior to MIT, Juan worked in the retail pharmacy industry for 4 years. He received a bachelor’s degree in Industrial Engineering at Instituto Tecnológico de Santo Domingo. His interest is in retail supply chain and supply chain strategy, bringing him to MIT.

KEY INSIGHTS

1. Tradeoffs exist in inventory holding costs versus leveraging supplier-pushed discounts as well as with minimizing stock-outs.

2. Maximizing supplier-pushed discounts and customer service level may be more costly than accepting stock-outs.

3. Replenishment policies should be determined based on SKU characteristics, such as the likelihood of backorders.

Inventory management is crucial for retailers as inventory is often one of the largest investments and total current assets, and directly influences customer service level (CSL) and supply chain responsiveness. However, having too much inventory can cause financial difficulties due to the impact on cash flow, but carrying too little can lead to stock-outs and backorders, which can lead to lost sales. Some of the undesired effects of high inventory levels are inefficient supply chains, high demand variability, supplier-pushed inventory, and reactive policies. Also, marketing strategies such as supplier-pushed promotions can further increase inventory.

The key research question that we answer with this study is what replenishment policies will improve a retail pharmacy’s supply chain while:

- maintaining efficient inventory levels
- minimizing undesired effects of discounts
- minimizing stock-outs to keep a sustainable high-performance operation

Introduction

Global prescription drugs and over-the-counter (OTC) therapy sales in 2016 were around US$768 billion. Drugs are commonly dispensed through retail pharmacies and hospitals and can be expensive to store, handle and distribute due to inaccurate, non-effective inventory management. This could create stock-outs, shortages of essential medicines, inappropriate handling and excessive costs due to high inventory levels and urgent shipments to avoid lost sales.
Understand patterns, drivers and trends of level, frequency and the inventory records to thus data affecting product availability and network and different processes of the retail pharmacy chain. We started by mapping to understand the whole supply chain.

**Methodology**

**Notation**

\[ TRC_{DC} = \text{Total Relevant Cost for DC} \]
\[ TRC_s = \text{Total Relevant Cost for Stores} \]
\[ C_{di} = \text{Inbound costs to DC} \]
\[ C_{do} = \text{Outbound costs from DC} \]
\[ C_{si} = \text{Inbound costs to Stores} \]
\[ C_{ss} = \text{Outbound costs from Stores} \]
\[ C_{i} = \text{Order cost (set-up cost)} \]
\[ D_0 = \text{Demand at DC (Aggregated demand from all stores)} \]
\[ D_s = E[D_s] = \text{Expected value of the demand per Store} \]
\[ C_u = \text{Catalog cost per unit} \]
\[ h_r = \text{Holding fee Rate} \]
\[ C_h = C_u * h_r \]
\[ q_f = \text{Free Units per every } r_f \text{ Units Ordered.} \]
\[ r_f = \text{Units required for } q_r \]
\[ P[x > Q_s] = \text{Expected Units Short at Store} \]
\[ P[x > Q_D] = \text{Expected Units Short at DC} \]
\[ P_u = \text{Purchased Units (Paid Units)} \]
\[ Q_o = \text{Units Ordered at DC} \]
\[ Q_s = \text{Units Ordered at Store} \]
\[ S = \text{Number of Stores} \]

\[ Q_D = P_u + \left[ \frac{P_u}{r_f} \right] * q_f \]

\[ TRC_{DC} = \frac{C_h * P_u}{2} + \frac{D_0 * (C_{di} + C_i)}{P_u} + \left( C_{do} + \frac{D_f * P_u}{r_f} \right) + C_{do} * \sum_0^s \frac{D_s}{Q_s} + C_{ss} * \frac{D_D}{Q_D} + P[x > Q_D] \]

\[ P_u^* = \frac{2 * (C_{di} + C_i) * D * r_f}{\sqrt{C_h * (q_f + r_f)}} \]

\[ TRC_s = C_{ss} * \frac{D_s}{Q_s} * P[x > Q_s] + (C_{do} + C_{si}) * \frac{D_s}{Q_s} + \frac{C_h * Q_s}{2} \]

\[ Q_s^* = \frac{2 * (C_{do} + C_{si}) * D_s}{C_h} \]

**Figure 1 - Total Relevant Costs Equations and First Derivatives for DC and Store**

The retailer’s supply chain and no collaborative strategies with the suppliers are considered.

The savings are mostly derived from the inventory reduction. While the team observed savings, the reduction was affected by an average of -2.53% for (Q, R) policy and an average of -2.09% for (s, S) policy compared to the baseline. In general, SKUs
with higher profit performed better with the \((Q, R)\) model (Figure 2). Holding costs at the DC level increased for all SKUs, but significantly more for SKUs with lower profits. This held true for the retail stores, with SKUs with high profits benefiting from reduced holding costs. The lowered total costs also had increased average cost per unit and decreased CSL compared to the baseline, with high profit SKUs experiencing a greater CSL decrease, but a lower increase of average cost per unit. This suggested the costs of placing larger orders to leverage the supplier-pushed discounts and maintaining a high CSL may outweigh the resulting benefits.

However, \((s, S)\) policy only performed better in 3 out of the 16 analyzed SKUs. Two of the SKUs were low profit and the increase in both DC and store holding costs had a lower increase than the \((Q, R)\) policy. As the \((s, S)\) policy accounts for existing inventory to determine the order size when placing orders, larger orders than the \((Q, R)\) policy will be preferred, increasing leveraging of supplier-pushed discounts. The \((s, S)\) model proved better than the \((Q, R)\) policy for low profit products, as the low product costs make the tradeoff between increasing holding costs and decreasing average cost per unit more favorable towards large orders.

In our sensitivity analyses, we observed a tradeoff in holding costs versus CSL and stock-out penalties (Table 1). At lower stock-out penalties, ensuring high CSL was marginally more costly due to the increased holding costs. At high stock-out penalties, it was least costly to have high CSL as the stock-outs outweighed the increased holding costs. Biweekly forecast horizons had the most stock-outs and were favored for low stock-out penalties and annual forecast horizons were preferred for high stock-out penalties.

**Figure 2 – Total Costs Savings per Policy per SKU Against Baseline**

The research suggests that different replenishment policies should be used depending on the characteristics the SKU has. For high profit and unit cost products, \((Q, R)\) inventory policy should be used due to the minimization of holding costs. For low profit and unit cost products, the \((s, S)\) inventory model should be used in order to leverage the supplier-pushed discounts without heavily impacting holding costs.

The sensitivity analysis suggest stock-out penalties should be calibrated by the company based on an opportunity cost and should quantify the possibility to lose a client. Even though the team performed analyses with four different penalties for the 16 SKUs, not all SKUs have the same stock-out penalty. This will depend on the SKU features, such as a customer’s willingness to accept backorders. As such, companies should determine different inventory policies based on the SKU features to minimize the total costs.

Conclusions

The research suggests that different replenishment policies should be used depending on the characteristics the SKU has. For high profit and unit cost products, \((Q, R)\) inventory policy should be used due to the minimization of holding costs. For low profit and unit cost products, the \((s, S)\) inventory model should be used in order to leverage the supplier-pushed discounts without heavily impacting holding costs.
For future research, the impact of the DC stock-outs could be examined. These were not directly addressed in the research but, the model can be adapted to include a DC stock-out penalty in the total relevant cost for the DC. These mentioned stock-outs may come from various factors such as suppliers item fill rate lower than 100% or an ordered quantity lower than needed. The implementation of the different replenishment policies analyzed has a high potential of costs reduction. While these policies may have an impact on the CSL, the overall savings can far exceed the penalties. From the research we concluded that the application of the analyzed policies can bring an average 33% saving of the total relevant cost.

### Table 1 – Sensitivity Analysis of SKU 01

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<tr>
<th>Forecast Horizon</th>
<th>(Q,R)-(Q,R) Total Cost As % of Baseline</th>
<th>QR Fill Rate Difference As % of Baseline</th>
<th>(s,S)-(s,S) Total Cost As % of Baseline</th>
<th>sS Fill Rate Difference</th>
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<tr>
<td>SKU 1</td>
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<tr>
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<td>-3.63%</td>
<td>58.78%</td>
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