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.

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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.**

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.

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

We used existing literature and case studies to determine the state-of-the-art inventory management techniques and models to reduce stock-out and undesired effects of discounts pushed by suppliers. For the sake of scope, we limit our analysis to the

$$Q_D = P_u + \left\lfloor \frac{P_u}{r_f} \right\rfloor * q_f$$

$$TRC_{DC} = \frac{C_h * P_u}{2} + \frac{D_D * (C_{di} + C_t) + (C_u * P_u)}{P_u + \frac{q_f * P_u}{r_f}} + C_{do} * \sum_{0}^{S} \frac{D_S}{Q_S} + C_{ss} * \frac{D_D}{Q_D} * P[x > Q_D]$$

$$P_u{}^* = \sqrt{\frac{2 * (C_{di} + C_t) * D * r_f}{C_h * (q_f + r_f)}} * \sqrt{1 + \frac{C_{ss} * P[x > Q_D]}{C_{di} + C_t}}$$

$$TRC_S = C_{SS} * \frac{D_S}{Q_S} * P[x > Q_s] + (C_{do} + C_{si}) \frac{D_S}{Q_S} + \frac{C_h * Q_S}{2}$$

$$Q_s^* = \sqrt{\frac{2 * (C_{do} + C_{si}) * D_s}{C_h}} * \sqrt{1 + \frac{C_{ss} * P[x > Q_S]}{C_{do} + C_{si}}}$$

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

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

Methodology

<u>Notation</u>

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

We started by conducting process and stakeholder mapping to understand the whole supply chain network and different processes of the retail pharmacy chain affecting product availability and, thus, determining accurate inventory levels. Using the datasets of 16 SKUs and over 1.5 million data points collected from the company, we study the demand level, frequency and the inventory records to understand patterns, drivers and trends via plots and descriptive, exploratory statistics. This allowed us for applying models drawn from the existing literature to reduce the impact of the identified drivers. We then determined the relevant costs functions for the sponsor and the corresponding first derivatives (Figure 1).

First, we established the relationship between the DC order size, Q_D, and the units paid for, P_u. Using this equation and the relevant cost components for the DC (holding costs, ordering costs, DC inbound costs, DC outbound costs, and stock-penalties) we form, TRC_{DC}, the relevant costs function at the DC level. Similarly, we establish the relevant costs function at the store level, TRC_S, using holding costs, store inbound costs, and stock-penalties. P_u plays no role at the store level as the store's order size from the DC is not directly affect discounts. Considering opportunities and challenges faced by the sponsor company, we formulated a couple of inventory models based on *(Q, R)* periodic review and *(s, S)* continuous review replenishment policies.

After experimenting with the *(Q, R)* and *(s, S)* replenishment policies, we performed a series of sensitivity analyses on three parameters: forecast horizon, stock-out penalties, and CSL.

Results

Changing the company's replenishment policy resulted in an estimated cost savings of 33% compared to the baseline for *(Q, R)* inventory model and an average of 37% for the *(s, S)* model. These savings are mostly derived from the inventory reduction. While the team observed savings, the service level was affected by an average of -2.53% for *(Q, R)* policy and an average of -2.09% for the *(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.

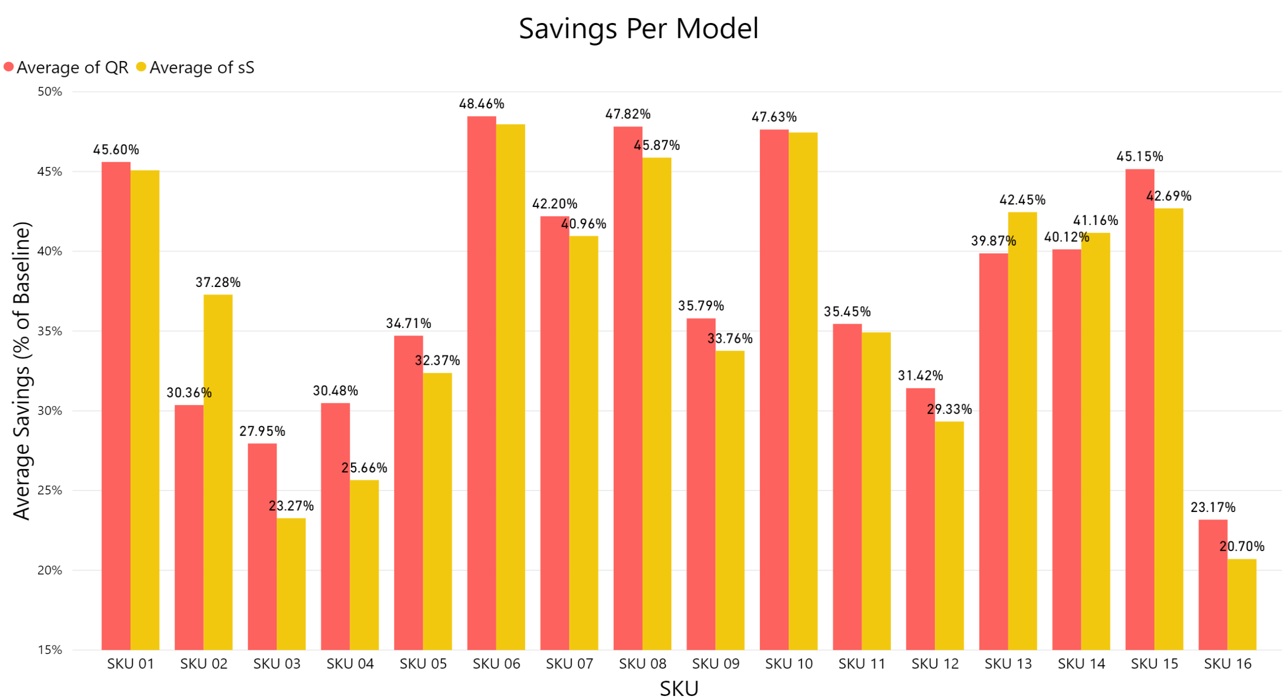

Figure 2 – Total Costs Savings per Policy per SKU Against Baseline

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.

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.

Table 1 – Sensitivity Analysis of SKU 01

Forecast Horizon	(Q,R)-(Q,R) Total Cost As % of Baseline	QR Fill Rate Difference	(s,S)-(s,S) Total Cost As % of Baseline	sS Fill Rate Difference
SKU 1				
Annual	59.45%	-3.72%	58.38%	-3.53%
Biweekly	58.87%	-4.77%	58.98%	-4.77%
Monthly	59.67%	-3.64%	58.32%	-3.48%
Weekly	59.43%	-3.63%	58.78%	-3.51%
SKU 1				
0.85	58.68%	-5.17%	58.68%	-5.01%
0.9	58.53%	-4.43%	58.41%	-4.33%
0.95	58.80%	-3.66%	58.28%	-3.57%
0.99	58.58%	-2.51%	57.97%	-2.36%
SKU 1				
x0	54.40%	-3.95%	54.92%	-3.85%
x10	64.02%	-3.99%	62.98%	-3.88%
x2	56.50%	-3.92%	56.40%	-3.79%
x5	59.67%	-3.91%	59.04%	-3.76%

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.