Optimization of omnichannel inventory system

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1 Introduction

Customers can be fulfilled through different channels (physical, online, BOPS (Buy-Online-and-Pick-up-in-Stor), and SS (buy online and Ship from Store)) while each channel has a separate dedicated inventory to fulfill its demands [1, 2, 3]. To have a connected and cohesive network, instead of considering the dedicated inventory to each channel independently we considered a shared inventory system at the store level and convert the multi-channel into an omnichannel (OC). How to specify an appropriate inventory strategy for an omnichannel with stochastic demand has become one of the most critical issues facing omnichannel retailers [4].

2 Methodology and approaches

This study considers an omnichannel with four complementary channels to fulfill jointly the customers. Figure 1 shows an omnichannel with four fulfillment channels.

The inventory can be controlled in the OC by applying an efficient Distribution Requirements Planning (DRP) policy [5]. Here, we extend and adjust this policy to an OC. We model the problem as a mixed-integer stochastic optimization problem. The objective is to minimize back-orders and reduce the transportation and holding costs while determining the replenishment level of items by considering their stochastic demand in all three channels simultaneously. Equation 1 identify the objective function. Decision variables and parameters are shown in Tables 1 and 2 respectively. The constraints have not mentioned here in sake of brevity.

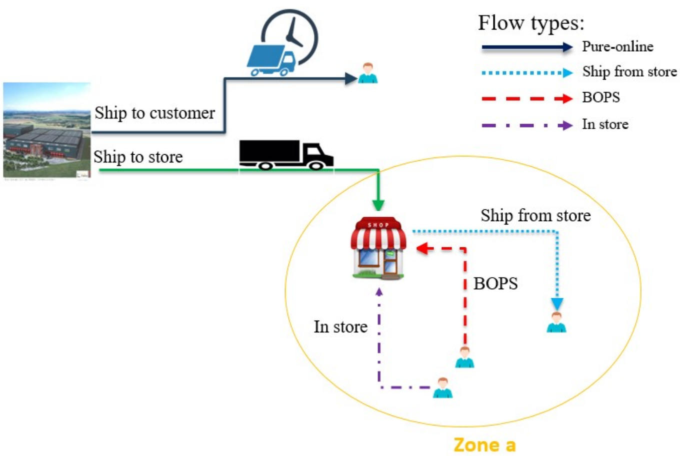

FIG. 1 – An omnichannel which is consisted of four channels with store fulfillment in both Ship from Store (SS) and BOPS

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\begin{aligned}
Min \sum_{\omega \in \Omega} p(\omega) \Big[& \sum_{p \in \mathcal{P}} \sum_{t \in \mathcal{T}} co_e^p \, Y_e^{tp}(\omega) \, O_e^{tp}(\omega) + \sum_{p \in \mathcal{P}} \sum_{t \in \mathcal{T}} co_b^p \, O_b^{tp}(\omega) \\
& + \sum_{p \in \mathcal{P}} \sum_{t \in \mathcal{T}} cb_e^p \, I^{-^{tp}}(\omega) + \sum_{p \in \mathcal{P}} \sum_{t \in \mathcal{T}} cb_b^p \, I^{-^{tp}}(\omega) \\
& + \sum_{p \in \mathcal{P}} \sum_{t \in \mathcal{T}} ch_e^p \, I^{+^{tp}}(\omega) + \sum_{p \in \mathcal{P}} \sum_{t \in \mathcal{T}} ch_b^p \, I^{+^{tp}}(\omega) \\
& + \sum_{p \in \mathcal{P}} \sum_{t \in \mathcal{T}} ct_e^{tp} \, Y_e^{tp}(\omega) O_e^{tp}(\omega) \\
& + \sum_{p \in \mathcal{P}} \sum_{t \in \mathcal{T}} ct_b^{tp} \, O_b^{tp}(\omega) \Big]
\end{aligned} \tag{1}
$$

$I_e^{tp}(\omega)$	Inventory level of product p at time t for online channel under scenario ω
$I_b^{tp}(\omega)$	Inventory level of product p at time t for retail under scenario ω
$O_e^{tp}(\omega)$	Number of replenishment products p at time t in online fulfillment under scenario ω
$O_b^{tp}(\omega)$	Number of replenishment products p at time t from a store in zone z under scenario ω
$Y_e^{tp}(\omega)$	Binary variable set to 1 if an online order fulfill demand with product p at time t under scenario ω

TAB. 1 – Decision Variables

co_e^p/co_b^p	Unit replenishment(ordering) cost of product p in online/retail fulfillment
cb_e^p/cb_b^p	Unit backlog cost of product p in online/retail fulfillment
ch_e^p/ch_b^p	Unit holding cost of product p in online/retail fulfillment
ct_e^{tp}	Unit transportation cost of product p at time t in online fulfillment
ct_b^{tp}	Unit transportation cost of product p at time t from warehouse to store in retail fulfillment

TAB. 2 – Parameters

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