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PERFORMANCE OF THE CONTINUOUS REVIEW ORDER-UP-TO POLICY FOR ON-LINE STORES UNDER VARIOUS RANDOM DEMAND AND STORAGE CAPACITY LIMITATION

Chao-Hua Chen
Dept. of Transportation Technology and Logistics,
Chung Hua University
707, Sec.2, WuFu Rd
Hsinchu, 30012, Taiwan

Che-Cheng Yeh
Ph.D. Program of Technology Management,
Chung Hua University
707, Sec.2, WuFu Rd
Hsinchu, 30012, Taiwan

ABSTRACT

Effects of demand variations on inventory management has long been recognized in academics and practice. Disney et al. (2015) showed that the periodic review order-up-to policy is more feasible for controlling fill rate and avoid over investment of warehouse under auto-correlated normally distributed demand of consumer electronics. Jalali and Nieuwenhuyse (2015) concluded that simulation method is more feasible in reflecting real stock keeping and managing process in terms of the composition of the supply chain, commodity types, stock picking and delivery, and lead-time variations. They also indicated that simulation optimization method is better than analytical models in investigation of real world inventory management problems, which involve with intractable random demands and multiple operational periods in supply chains with multiple echelons.

E-commerce is prevailing nowadays and quick response service is becoming a basic requirement for every on-line store. This situation makes the stock-keeping work of the on-line store even more challenging than traditional retail vendors since various types of goods are sold simultaneously and the storage capacity is often limited. This study considers a two-echelon supply chain composed of one supplier and one on-line store sailing daily supplies, popular goods, and fresh food. The supplier is responsible for replenishing stock for the on-line store under a VMI with continuous review mechanism. The demand patterns for daily supplies, popular goods, and fresh food are designed to be constant (mean=60), normal (mean=61.04, standard deviation=45.93), and exponential (mean=57.46, standard deviation=48.98) distribution respectively. The total demand of each commodity is set to be equal, the demand quantity of each commodity is generated randomly per hour, and the simulation time is set to be 30 days. The order-up-to-level (OUTL) and order-up-to-full (OUTF) models are employed in the VMI operation by the supplier with multiple inventory cycles and different storage capacities of the on-line store. The objective of this study is to investigate the optimal reorder point (ROP) and level for the OUTL model and the optimal ROP for the OUTF model with the minimization of total cost under different demand patterns and storage capacities. The total cost is composed of transportation cost of replenishment, holding cost, and shortage cost. Different types of unit costs for the replenishment system are designed based on practical information and listed in Table 1.

Table 1 Different Types of Unit Cost

Type of Unit Cost \ Commodity Type	Daily Supply	Popular Goods	Fresh Food
Unit Transportation Cost	1000	1500	2000
Unit Holding Cost	10	15	20
Unit Shortage Cost	100	150	200

This study applies Arena simulation software to construct the operation and replenishment model with VMI mechanism and uses OptQuest to solve for the optimal ROP and level for the OUTL model and the optimal ROP for the OUTF model. The operation and replenishment simulation model includes the demand generation and fulfillment process as well as the replenishment and delivery process, which are illustrated as follows.

(1) Demand generation and fulfillment process

IF $I_k - D_k \geq 0$ **Then** $I_k = I_k - D_k$

Else $C_{sr,k} = C_{sr,k} + (D_k - I_k)$

where I_k: inventory level at the k hour; D_k: demand at the k hour; $C_{sr,k}$: shortage volume at the k hour, k = 1,2,…, n.

(2) Replenishment and delivery process

IF $I_k \le ROP * W_{cap}$

Then $U_r = (1 - ROP) * W_{cap}$ (If the OUTF model is used)

$I_{k+LT} = (1 - ROP) * W_{cap} + I_k$, OR

$U_r = (Level - ROP) * W_{cap}$ (If the OUTL model is used)

$I_{k+LT} = (Level - ROP) * W_{cap} + I_k$

where W_{cap}: storage capacity of the on-line store's warehouse; U_r: replenishment quantity; LT: lead time of replenishment delivery; Level: the level of the OUTL model.

The simulation optimization model of this study is presented as follows:

Minimum $TC = TC_R + TC_H + TC_S$

s.t. $TC_R = (Q_r / S_{cap}) * N_r * C_T$

$TC_H = \sum I_{avg} * C_H$

$TC_S = Q_{sr} * C_S$

where TC: total cost; TC_R: total delivery cost of stock; TC_S: total shortage cost; TC_H: total holding cost; Q_r: replenishment quantity; N_r: number of times of replenishment; S_{cap}: capacity of the delivery truck; C_T: unit transportation cost of stock delivery; C_H: unit holding cost; C_S: unit shortage cost; Q_{sr}: shortage quantity; I_{avg}: average inventory level at k day of the on-line store;

The research results, demonstrated in Figure 1, indicate that the OUTL model outperforms the OUTF model in total cost as the storage capacity increases under three different types of demand patterns. Furthermore, the OUTL model, with the control of the ROP and level, is able to decrease the shortage quantity incurred by the surge demand quantity at the early time of sale for the exponentially distributed demand pattern.

In summary, the characteristic of multiple delivery with less quantity of the OUTL model is shown to be more feasible than the OUTF model in handing the variation and randomness resulted from different types of demand patterns incorporated with storage capacity limitations of the on-line store. However, further investigation with other types of demand patterns, complexity of supply chain structure, and associated conditions and limitations might be needed to confirm the general feasibility of the OUTL model.

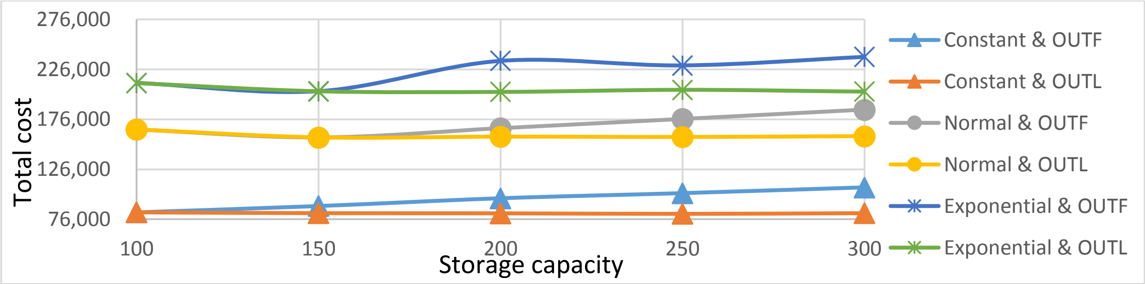

Figure 1: Simulation results

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