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An Application of SLA in Small Business Sectors with Multi Item Inventory Management

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Abstract

Lateral transshipment plays an important role in inventory management. As the extension the service level adjustment (SLA) which combines preventive lateral transshipment with emergency lateral transshipment, increase the system performance level and decrease the total cost of the system in small business sector. At finally we give a numerical study of multi item small business sector, we examine SLA will be more effective in multi item small business sectors.

Keywords: SLA; Lateral transshipment; Inventory management; Remaining period

Introduction

All type of retailers face an uncertainty of consumer demands. The retailer who having long replenishment lead time from the original supplier and located close to each other are coordinated to prevent stock out and increase service level of their customer. This coordination is simply called lateral transshipment which defines the redistribution of stock from retailer with stock on hand to the retailer who is expecting significant loss due to high risk [1].

If transportation cost is increased, lateral transshipment is known as a better approach than a policy of no transshipment. The execution of lateral transshipment was done by Young Hae Lee [2] at airport to inspect the airplane. However this is difficult in the companies or in department due to the information extinction and insufficient understanding between companies.

Lateral transshipment can be divided into emergency lateral transshipment (ELT) and preventive lateral transshipment (PLT). The former group includes Krishnan and Rao, Tagaras [1] and Robinson. And the latter include Allen,

PLT reduce the risk by redistribute stock between the stores before the realization of customer demand while ELT is done after the arrival of customers demand. Further many extensions are done by, Bertrand and Bookbinder, Banerjee Figure 1 explains the lateral transshipment in supply chain [3-5].

As for the model we propose a new service level adjustment analysis in a small business sector who selling multi item, to effectively deal with retailer demands. This policy will reduce the risk of retailer by combining ELT with PLT. In section 2, we propose SLA using the service level in the adjustment period SLAP. In section 3, we analysis the same in small business sector; finally we provide the conclusion in section 4 (Figure 1).

Symbols and Notations

- AP(t)-Adjustment period
- i,j,k is an indices indicates retailer i,j, and k
- I,J,K is a set of retailers with J is a set of retailer with more stock than desired, $J \subset I$,K is a set of retailer with less stock than desired, $K \subset I, J \cap K = \emptyset$
- NR – number of retailers
- RP – review period
- L – lead time for lateral transshipment from a supplier to the retailer
- DEi(t) – demand of the retailer i at time t
- $DE_{i,AP(t)}(t)$ – demand of the retailer during the adjustment period AP(t)
- $m(DE_{i,AP(t)}(t))$ – mean of the retailer during the adjustment period AP(t)
- $\sigma(DE_{i,AP(t)}(t))$ – standard deviation of the retailer during the adjustment period AP(t)
- $Q_i(t)$ – order quantity of the retailer i at the end of the period

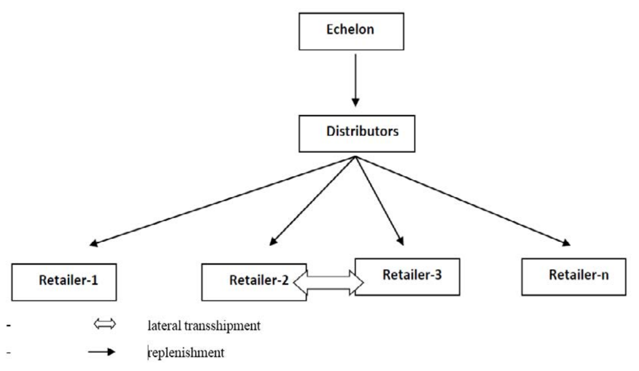

Figure 1: Lateral transshipment in supply chain.

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- $IN_i(t)$ – inventory of the retailer i at time t
- $ONH_i(t)$ – on hand inventory of retailer i at time t
- $STO_i(t)$ – Stock out of retailer i at time t
- $STO_i(t)$ –quantity back order of retailer i at time t
- $SLAP_{i,AP(t)}$ – service level adjustment period of retailer i at time t
- *HC*–holding cost of any retailer per unit stock
- PC – penalty cost of any retailer per unit stock
- TPC – transportation cost of any retailer per unit
- ORC – ordering cost of any retailer per unit stock
- $LTRS_i(t)$ – quantity for lateral transshipment that retailer i can take from other retailer at the end of period t
- $LTERS_i(t)$ – required quantity for lateral transshipment except $ONH_i(t)$ from transshipment target stock level for retailer i at the end of period t
- $AQS_i(t)$ – available quantity to supply at period t
- Int(.) – function that return integer values
- α – service level of SLAP in upper – order fulfilled from stock
- β – service level of SLAP in target – order fulfilled from on hand inventory
- γ - service level of SLAP in lower – order fulfilled from lateral transshipment
- φ(.) – denotes probability density function of normal distribution with mean 0 and S.D 1
- QX_{jk} – quantity of lateral transshipment from retailer j to k at the end of period t
- Te_{jkt} – decision variable takes the value 1 if lateral transshipment is performed between j and k at period t.

Research Method

The study is related to the retailer who having better understanding and is ready to increase their service level. The retailer will vary with their demand and independent to the other retailer. Normally retailers are located much closer to each other than their supplier. The retailer follows ordered up to policy (R,S) at the end of each period the retailers must place an order to increase their inventory. Table 1 gives the values to find order up to level. The lead time is too short for the lateral transshipment while compare with the original lead time with the supplier. Each retailer is focus on multi item. In this study we propose service level adjustment for small business sector that uses the SLAP based on the concept of safety stock.

As we consider in our study with multi item inventory in a small business environment. We use a periodic review policy on each item. Since in a multi item inventory model each item carries random demand and hence all items are kept under identical conditions and use periodic review policy. Spare parts inventories supply chain consists of multiple local ware houses and one are few central warehouses. Since the technology is improved today even the small business environment also keeps their inventory in systems. If they doing by periodic review policy, they can easily coordinate by SLA (Table 1).

NR	5
R	20(days)
L	7(days)
S_i	$m_i(R+L)+z_{0.7}(\sigma_i\sqrt{R+L})$
HC	1,5,10
PC	4,44,78
TPC	1,10,20
ORC	1,10,20

Table 1: Input parameters.

Define the service level Adjustment level as follows

$SLAP_i\ [AP(t)]=P(DE_{i,AP(t)}<IN_i(t))$

$$=\varphi\left[\frac{INi(t)-mi(AP(t))}{\sigma i(AP(t))}\right]$$

Where AP(t)=A – t

The study will relax the implementation of inventory control method in previous. Assume that there are 3 types of retailer in an echelon at the end of period t. Let J is a set of retailer having high stock level to meet customer's demand. Similarly K be a set of retailer having low stock level at a given time t.

In calculation find the on-hand inventory and backordering by the following equalities

$ONHi(t)=ONHi(t-1) - DE_i(t)$

$BAO_i(t)=DE_i(t) - ONHi(t-1)$

Find the Set of retailer J that satisfies

$m_i(AP(t))+z\alpha\ \sigma i(AP(t))+0.5 \rightarrow A$

$Int(A) < ONHi(t)-BAO_i(t)$

Find the Set of retailer K that satisfies

$mi(AP(t))+z\alpha\ \sigma i(AP(t))+0.5 \rightarrow B$

$Int(B) \geq ONH_i(t)-BAO_i(t)$

If set J and K exist, then find the quantity for lateral transshipment in the given period t by

$LTERS_j(t)=\max\{int\{mj(RP(t)+z\beta\ \sigma j\ (RP(t))+0.5\}, 0\}- (ONH_j(t) - BAO_j(t)), j\in J$

If $AP(t)=0$ then $LTERSj(t)=0$

$LTRS_k(t)=ONH_k(t) - \max\{int\{m_k(AP(t)+z\alpha\ \sigma k\ (AP(t))+0.5\}, 0\}, k\in K$

If $AP(t)=0$ then $LTRSk(t)=0$

To adjust the required quantity between retailer *j* to *k* use the following expression

$AQSk_j(t)=int(BAO_j(t).\ \Sigma\ LTRS_k(t))/\Sigma\ BAO_j(t)$

Now the transshipment process is completed calculate the no of quantity transshipped and update the current stock of retailer j and k as follows

$QX_{k,j}(t)=\min[\max(AQSj(t)), \max(LTRS_k(t))]$

Now

$LTERS_j(t) - QX_{k,j}(t)\rightarrow LTERS_j(t)$, for $j\in J$

$LTRS_k(t)+QX_{k,j}(t)\rightarrow LTRS_k(t)$, for $k\in K$

Retailer	Set A: $N(m_i,\sigma i_i^2)$		Set B : $N(m_i,\sigma_i^2)$	
	Mean	Standard deviation	Mean	Standard deviation
1	10.5689	0.868752	10.5698	21.3144
2	11.3236	1.10897	10.3163	6.788
3	10.0833	3.432202	14.7457	8.070068
4	14.7457	2.27434	11.3236	19.7631
5	10.3163	1.4491	12.0229	13.5748

Table 2: Mean and standard deviation of retailers.

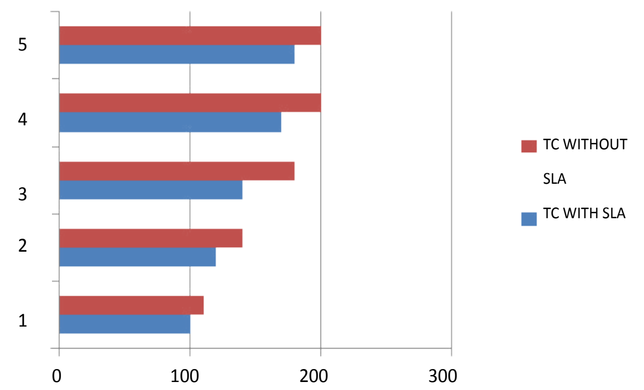

Figure 2: Total cost of the inventory system.

The service level adjustment analysis in the current period is completed. The total cost of the system is given by

$$C_{total}=\Sigma_t\{\Sigma_i\,(h.ONH_i(t)+v.BAO_i(t))+\Sigma_k\,\Sigma_j(a.QX_{k,j}(t)+c.Te_{k,j}(t))\}$$

Numerical Study

The demand is normally distributed and we assume the SLAP is divided into 3 levels α, β, γ. When α denotes upper level of Adjustment period and β denotes the target level of Adjustment period finally γ denotes the lower level of Adjustment period. All must satisfies the condition that $\gamma<\beta \leq \alpha$, $0<\gamma$, $\alpha<1$. Let us fix the upper level between 0.6 to 0.8, target level as 0.4 to 0.6 and for the lower level 0.1 to 0.3. Table 2 gives the average and standard deviation of the 5 retailers.

By applying the calculation, the quantity shipped from retailer 2 to retailer 3 is 4. And the total cost is ensured by the system is $1, 20,000. If SLA is not used among the Echelon the system is ensured with the total cost of $1, 34,000. This is depicted by Figure 2.

Conclusion and Future Work

In this study, we derive the Service level adjustment analysis in inventory systems. This was evaluated in small business sector with multi item. In numerical study, this is clear that the total cost of the system if it follows SLA is $1,20,000, and the total cost of the system if it does not follow SLA is $1,34,000. Hence the system saves by $14,000 per period. This study finally shows that even in a small business sector SLA can be apply, if the information is shared among the retailer via electronically.

The added flexibility of allowing retailer will tend to be the inventory cannot be optimized. Under the condition SLAP of multi item in a small business sector we derive the model. This can be elaborate for the retailer with large business sectors. And this can be a future work too.

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