Inventory Control Systems with Safety Stock and Reorder Point Approach

by R. Rizal Isnanto

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Devi Ajeng Efrilianda

Mustafid

R. Rizal Isnanto

I. Introduction

Inventory control system has an important to monitor the goods condition on supply chain distribution from central warehouse to retail with consumer demand. Demand for goods is dynamic on retailers, it makes problem in inventory control. The problems are inventory goods unbalanced in the central warehouse. Several methods have been developed to solve the problem of inventory control process at central warehouse. Reorder Point (ROP) is one method using analyze the stock control.

The aim of inventory control is controlling inventory of goods so the company does not the deficiency of stock and optimizing the cost of supply chain distribution at central warehouse. Optimizing inventory of goods can be ordered to meet customer with approach [1]. Optimizing safety stock can affect the cost of logistics in a company [2]. However, the results of inventory control still experiencing delays. Because the inventory control in central warehouses only estimates, it needs average sales and maximum sales. There is no safety stock and schedule for re-stock.

It has known the flow of inventory distribution of goods, so it needs inventory control at central warehouse. Then central warehouse not over and less of goods. Inventory control computation is using the safety stock approach as inventory control to make available of goods at the central warehouse. Safety stock has used to determine the minimum and the maximum stock inventory in the central warehouse with minimum cost supply chain. While ROP is the point where the re-stock of goods and distribution of goods can be on time.

This research aims to develop inventory control systems on the supply chain distribution of goods from suppliers to the central warehouse with minimal supply chain costs. Minimization of supply chain cost using martingale model. Minimum cost of supply chain are derived using methods martingale of forecast evaluation models (MMFE) based on consumer demand, and the results using computation safety stock and reorder point

II. Methodology

Design of inventory control systems in supply chain distribution of goods from supplier to central warehouse, it is starting with design planning model of minimum cost supply chain using MMFE method, and the results used computation safety stock and reorder point. In planning modeling, prediction of demand used for decision making and actual sales used to determine the actual cost with demand data in any period. Schemes of supply chain cost optimization modeling with placement of the safety stock, it can be depicted in Figure 1 [3]. The time of evaluation supply chain and management policies is automatically, personal skills and time for simulation model applied on supply chain [4]. Planning model minimum cost of the supply chain is to computation safety stock and reorder point on framework inventory control system with the input of demand predictions data and actual data demand. The case of this study observed the supply chain distribution from the central warehouse to retail, observation data for certain product during the fourth period within two months.

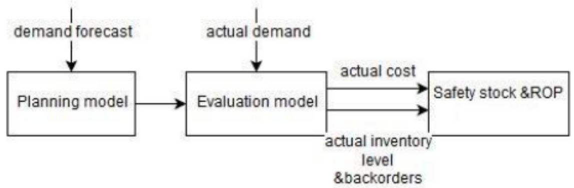

Figure 1. Schematic of safety stock placement approach

Observation data have used such as actual inventory data (I), actual demand data (D) and actual backorder data (B) at central warehouse. In Table 1 shows data from 4 periods (t), and each period consists of 14 days of sales

Table 1. Total sales, inventory and reorder goods

t	D	I	B
1	1267	1245	1281
2	1389	1345	1214
3	1246	945	854
4	1193	1423	1102

a. Model optimization of supply chain

Demand forecast data is an input data for the planning model, using MMFE as model to predict demand. MMFE method has good prediction accuracy and minium cost supply chain cost. Let $d_{t,t+1}$ is demand forecast, assuming that:

$$d_{t+1.t+2} = d_{t.t+2} + \varepsilon_{t+1.t+2} \quad (1)$$

$$d_{t+1.t+3} = d_{t.t+3} + \varepsilon_{t+1.t+3} \quad (2)$$

$$d_{t+1.t+T+1} = \mu + \varepsilon_{t+1.t+T+1} \quad (3)$$

Demand prediction of consumer at the central warehouse for next period $(d_{t,t+k})$ demand prediction for previous period $(d_{t-1,t+k})$ and variable error for next period $(\varepsilon_{t,t+k})$, it can be seen from equation (4) [3].

$$d_{t,t+k} = d_{t-1,t+k} + \varepsilon_{t,t+k}$$
$$= d_{t-2,t+k} + \varepsilon_{t-1,t+k} + \varepsilon_{t,t+k}$$
$$= \cdots = \mu + \sum_{i=1}^{T-k} \varepsilon_{t-i,t+k} \quad (4)$$

In the model optimization (5) describes the maximum goods are distributed in the supply chain process, and which will be used to determine safety stock and reorder point. Before computation safety stock and reorder point, it must know the minimum cost supply chain planning. So, the central warehouse can optimize goods distribution. Planning minimum total cost supply chain distribution with formula [3]:

$$\Pi = \sum_{j=1}^{J}\left(\alpha^j \sum_{t=1}^{T} \hat{I}_t^j\right) + \sum_{j=1}^{J}\left(\beta^j \sum_{t=1}^{T} \hat{B}_t^j\right) \quad (5)$$

such that:

$$\hat{I}_t^j - \dot{B}_t^j = (\hat{I}_{t-1}^j - \dot{B}_{t-1}^j) + (R_t^j - d_t^j) \quad (6)$$

$$R_t^j = P_{t-L^j}^j \quad (7)$$

$$P_t^j = (1-\gamma) F_t^j + \gamma A_t^j \quad (8)$$

$$P_t^j \le C^j \quad (9)$$

$$d_t^j = \delta^{j-1.j} . P_t^{j-1} . \forall_j \ge 2 \quad (10)$$

$$\gamma = \begin{cases} 0 \; if \; t \le L \\ 1 \; others \end{cases} \quad (11)$$

$$I_t^j, B_t^j, A_t^j \ge 0 \quad (12)$$

where :

α^j	Unit cost of distribution and inventory planning at the stage of j
β^j	Unit cost distribution and backorder planning at the stage j
$\delta^{j-1.j}$	Bill of materials factors from stage j-1 to stage j
$\hat{I}_t^j$	Planned inventory level in time period t at stage j
$\dot{B}_t^j$	Planned backorder quantity in time period t at stage j
P_t^j	Production quantity in time period t at stage j
F_t^j	Distribution quantity in time period t at stage j
A_t^j	Stocks quantity in time period t at stage j
R_t^j	Replenishment quantity in time period t at stage j
C^j	Level of capacity at the stage j
Π	Planned total supply chain cost
L^j	Lead time of stage j

The flow of supply chain information systems for goods distribution is shown in Figure 2.

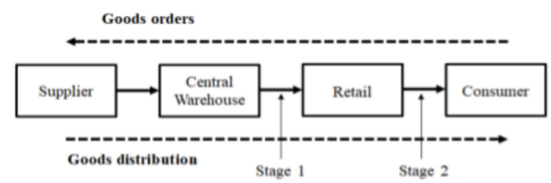

Figure 2. Supply chain information systems for goods distribution

In optimizing total cost of inventory and backorder can be obtained from distribution unit and inventory planning cost at the central warehouse (j) in time t $(\alpha^j \sum_{t=1}^{T} I_t^j)$ and distribution backorder planning cost and backorder items at the central warehouse for time period T $(\beta^j \sum_{t=1}^{T} B_t^j)$. Then, computation minimum cost of the supply chain from supplier to central warehouse using equation (5).

After computation of supply chain planning cost (d_t^j), the next step determining actual inventory and backorder are using actual sales data (D_t^j). This affects on the computation of the service level in the central warehouse. Actual inventory and backorder items in the equation:

$$\mathrm{I}_t^j = \left((\mathrm{I}_{t-1}^j - \mathrm{B}_{t-1}^j) + (\mathrm{R}_t^j - \mathrm{D}_t^j)\right)^+ \quad (13)$$

$$\mathrm{B}_t^j = \left((\mathrm{B}_{t-1}^j - \mathrm{I}_{t-1}^j) - (\mathrm{R}_t^j + \mathrm{D}_t^j)\right)^+ \quad (14)$$

where:

I_t^j Actual inventory level in time period *t* stage *j*

B_t^j Actual backorder quantity in time period *t* stage *j*

D_t^j Actual demand quantity in time period *t*

Π Actual total supply chain cost

SL_j Actual service levels at the stage *j*

Computation of *Service level* (SL) actual defined inventory at retailers request by consumer have to be fulfilled. Service level has based actual backorder and actual demand, to measure customer satisfaction with the existing order fulfillment, then expressed in the equation:

$$SL_j = 1 - \frac{Actual\ B}{Actual\ D} \quad (15)$$

b. The computation of the safety stock

Computation of safety stock data from stationary and not stationary, it is used to optimize inventory of goods [5]. To gets amount of safety stock (SS_j) amount of backorder at the central warehouse at time t ($\sum_t B_t^j$) and service level in the central warehouse (SL_j) with actual demand of goods in the central warehouse at time t ($\sum_t D_t^j$), The value of service level is smaller than standard service level expressed in equation (16).

$$SS_j = \begin{cases} \sum_t B_t^j - (1 - SL_j) \sum_t D_t^j & if \quad SL_j < SL_j^* \\ 0 & otherwise \end{cases} \quad (16)$$

c. The computation of reorder point (ROP)

Reorder point is an amount of reordering, it is demand consumer during lead time. ROP is a method used to analyze stock control [6]. The function objective cost per time to order quantity reorder point (ROP). ROP can optimize re-stock of goods at the company [10]. ROP gets the amount of inventory goods with stock out. Computation of ROP during lead time and safety stock at central warehouse, usually, ROP effects by inventory in lead time. Computation of ROP expressed in equation (17) [8].

$$ROP = L_j * \frac{\sum_t^{t+t-1} D_t}{t} + SS \quad (17)$$

III. RESULTS

In this research, design of inventory control system using a framework of the supply chain distribution on stage one (Figure 2). Data input is demand data forecast and actual data demand, while data output is a report minimal cost of the supply chain, the amount of safety stock and reorder point. The aim is optimizing inventory to meet customer orders [9].

The input process is demand data, inventory data, and backorder data of goods in databased of inventory control system by an administrator, the data will be display on the main menu inventory control system.

The process stage is activities of inventory control system, to determines minimum cost supply chain to input data on the system. The service level, the process is a computation of satisfied customer based on demand goods. The safety stock is determining inventory control. The aim to prevent over capacities of inventory in the central warehouse. Computation of cost supply chain is processing distribution any period. The computation of reorder point based on safety stock with the central warehouse.

The output process is given information by inventory control system. Output system such as supply chain cost report, safety stock report and reorder point report. The report can be seen minimum limit or safety stock standard at central warehouse. Reorder point reports, a report that contains are ordered by consumer, so central warehouse are known the limit of stocks, then, the requirements on formula (6) until (10) are met. Computation using one type of products at the central warehouse with 4 periods and lead time for 2 days. Provided that:

1. $\hat{\mathrm{I}}_4^1 - \dot{\mathrm{B}}_4^1 = (\hat{\mathrm{I}}_{4-1}^1 - \dot{\mathrm{B}}_{4-1}^1) + (R_4^1 - d_4^1)$

   $1423 - 1102 = (945\text{-}854) + (1423\text{-}1193)$
   $321 = 91 + 230$
   $321 = 321$

2. $R_4^1 = P_{4-L^1}^1$

   $1423 = 1423$

3. $P_4^1 = (1 - \gamma) F_4^1 + \gamma A_4^1$

   $P_4^1 = (1 - 1) F_4^1 + 1.A_4^1$
   $1423 = 1423$

4. $P_t^j \leq C^j$

   $P_4^1 \leq C^1$

   $1423 \leq 5000$

5. $d_4^1 = \delta^{j-1.j}.P_4^{j-1}.\forall_j \geq 2$

   $1193 = \delta^{j-1.j}.1423.\forall_j \geq 2$

6. $\mathrm{I}_4^1, B_4^1, A_4^1 \geq 0$

   $1423, 1246, 1423 \geq 0$

Thus, the condition from formula (6) until (10) has to be fulfilled. Furthermore, the computation minimum cost of the supply chain from supplier to central warehouse with formula (6) until (10) to get the amount of minimum cost supply chain costs. The unit cost of distribution, inventory, and backorder of goods are 3% from the average price of goods. The data used such as inventory and backorder data from historical data first until the fourth period. The computation minimum cost of the supply chain from supplier to central warehouse shown in the following in formula:

$\Pi = \alpha \ \Sigma \qquad \Sigma$

Σ

= 1245+1345+1240+1423 = 5253

Σ

= 1281 + 1214 +854 + 1246 = 4595

$\Sigma \qquad \Sigma$

= (615 x 5253) + (615 x 4595)

= 3.230.595 + 2.825.925 = 6.056.520

Computation of actual inventory and actual backorder will be used for computation service level. Service level is used to measure the level of satisfaction services at central warehouses. The service level such distribution of goods ordered by the previous of retail demand. The next process is the computation of actual Service Level (SL) used period (T=4) based amount actual backorder of goods and actual demand of goods on 4 periods :

= 1-

= 1- 0.9 = 0.1

a. The Computation of safety stock

Safety stock predictions of goods are used safety stock approach. Computation of safety stock is affected by the service level in retail, the amount of backorder and inventory at a central warehouse. Data from CT001 products in the fourth period will be the computation of safety stock on fourth periods so it can be known the minimum limit of safety stock from CT001 products. Computation of safety stock can be shown in the equation.

$\Sigma \qquad)\Sigma$

= 4595 – 509

= 4085

b. The Computation of reorder point

Reorder predictions of goods at the central warehouse, to meet the demand for retail and consumer. Computation of reordering goods is using reorder point (ROP) method. ROP is determined by the lead time (L), the amount of demand and safety stock at central warehouse. Values of lead time get from waiting time to use reorder of goods with demand consumer.

Σ_t^t

=

= 6901

If the result of ROP are getting, the central warehouse must re-stock 6901 pieces in the fourth period. Warehouse must restock in order to meet the demand for retails. Inventory control system with MMFE method produces minimal cost supply chain of distribution because of the major factor in inventory control at the central warehouse. Then, the inventory control system can determine safety stock of goods. Computation of ROP produces the amount of re-stock that must be fulfilled at the central warehouse and supplier will distribute the number of demands.

IV. CONCLUSIONS

Inventory control system at supply chain distribution from supplier to retail with central warehouse so to minimum the cost of supply chain. Inventory control system can determine the amount of supply chain cost, safety stock and reorder point in the central warehouse. The product of goods gets minimum cost of supply chain distribution based on the fourth periods. Then, amount of safety stock and reorder point can be derived using inventory control system. Inventory control system can optimize of supply chain cost for controlling of inventory goods at central warehouse. Inventory control systems can know minimum cost supply chain of distribution, safety stock levels and reorder point on real-time. It will make easy in central warehouse to manage inventory. So there is no shortage or vacancy goods.

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