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Comparing Variable Review Period model and Periodic Review Model

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Abstract: In this paper, a variable review period model considering order crossover is compared to periodic order review model. The simulation is applied with six scenarios and sensitivity analysis is also done. The result shows that a variable review period performs smaller inventory cost for small variation of lead-time. The result also shows variable review period model is sensitive with the changes in the lead-time distribution. On the other hand, periodic review model is sensitive with the changes in the variation of demand distribution and service level. The inventory cost of periodic review model will be smaller than the review period when a ratio of holding cost and stock out cost is 1:6.

Keywords: Order crossover, variable review period

Introduction

Nowadays, Companies are facing competitive environments by implementing their strategies in response to the challenges and customer demands. Recently, two generic strategies for companies occurred related to efficiency and responsiveness. Efficiency aims to reduce operational costs. On the other hand, responsiveness is designed to react quickly to satisfy customer demands. The customer satisfaction can be achieved by carrying a huge amount of inventory to meet their demand. However, Most of the companies strive to simultaneously reduce operating costs and customer service. In order to achieve it, one of the most important drivers that should think through is inventory.

Inventory in companies occurs since the demand is unpredictable and ordering lead time is variable. Sometimes, orders arrive in a different sequence than that in which they were placed; it referred to as order crossover. Many researches in developing inventory model neglected order crossover. Tersine [8] developed periodic review, where ordering is done routinely within a certain period by the number of change orders. Chan *et al.* [2] proposed an algorithm that optimize in order fulfillment considering uncertainties present in the production lead time, transportation lead time, and due date of orders. Kulkarni and Yan [4] developed a production and inventory model in stochastic demand and lead-times. They assume that lead-time is exponential distribution, and orders may or may not be allowed to cross.

Silver *et al.* (1998) (in Riezebos and Gaalman, [5]) formulates a theory that takes into account the condition of inventory order crossovers.

Riezebos [6] in his research stated that the classical theory needs to be modified so that it can be used to solve the problems of order crossover. This paper is organized as follows. Section 2 discusses relevant literature review. Section 3 details simulation methodology. Section 4 compares and evaluates periodic review and variable review period model with order crossover. Finally, conclusion is provided in Secion 5.

Methods

Periodic Review Period

Periodic review model is classic independent inventory system that the inventory is counted only at fixed period review. This model produces order quantities that vary each period depending on the usage rate. This model assumes reorders are placed at the time of review (P) orders arrive in the same sequence as they were ordered. Maximum inventory (T) should be covered demand during the period review and lead-time. The periodic review system with constant lead-time (L) can be shown in Figure 1.

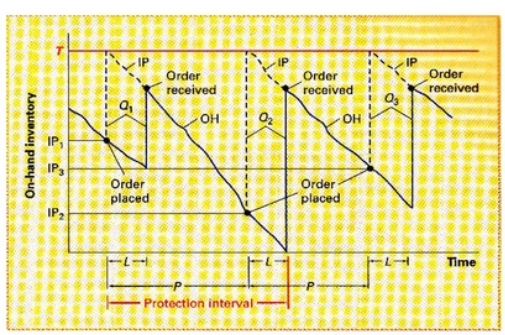

Figure 1. Periodic Review System
Source: Krajewski and Ritzman [3]

The maximum inventory (T) and safety stock are as follows:

$T = d(P + L) + \text{Safety stock}$ (1)

$\text{Safety stock} = z\sigma P{+}L$ (2)

$\sigma P{+}L = \sigma t(P{+}L)0.5$ (3)

Total Inventory cost = total holding cost + total ordering cost + total stock out cost

$= {}_{t=1}^{12}\ I_t h + O_t CO + S_t SO$ (4)

where:

σ_{P+L}	demand variation during review period and lead-time
h	the holding cost of material per unit item per unit time
SO	the stockout cost of material per unit item per unit time
CO	ordering cost per order
O_t	binary, 1 if an order is placed and 0, the rest
t	time period from 1,2,3,...,12
I_t	number of inventory at period t
S_t	number of stock out at period t

Variable Review Period with Order Crossover

Riezebos [6] define order crossover as follows, ordering time of order A and order B is denoted as OA and OB, respectively. Order A is done first therefore OA < OB. The arrival time of order A and order B is denoted as RA and RB, where RA = OA + LA and RB = OB + LB. The phenomenon of order crossover occurs when RB < RA.

Bradley and Robinson [1] evaluate base-stock policy in order crossover problem. Base-stock level (S) in periodic review period is applied considering demand distribution during lead-time. They conclude that base stock policy is not reliable enough when order crossover occurs. Srinivasan [7] tried to find the optimal formula taking into account the order crossover. His research tries to compare between policies which order crossover phenomenon ignored (naïve base-stock policy) with policies that take into account the order crossover (best base-stock policy). Simulations with various assumptions made to get the best model for conditional orders crossover.

Riezebos and Gaalman [6] describe a mathematical formulation for variable review period considering order crossover as follows:

$$Q_j = D^{O_j}_{O_j, r_{j+1} - O_j} + M_{r_{j+1}} - E_{O_j} \quad (5)$$

The equation (5) shows the number of reservations that must be ordered in each review period considering forecast demand before the next order, minimum stock, and also inventory position at that time.

$$E_{O_j} = I_{O_j} + {}_{t:Q_t<Q_j \Delta r_t \geq O_j} Q_t \quad (6)$$

Formula (6) shows that there are two components at variable E_{O_j} as follows: current on hand inventory available for future demand and already released but not yet received orders ($t : O_t < O_j$) and $r_j \geq O_j$).

$$E_{O_j} = E_{O_{j-1}} + Q_{j-1} - D^{act}_{O_{j-1}, O_j - O_{j-1}} \quad (7)$$

where:

Q_j	size of order *j*, at order moment O_j
L_j	lead time of order *j*
M_t	minimum required stock just before time *t*
$O = \ O_j; j = 1, \ldots, J$	ordered set of ordering moments $O_j < O_{j+1}$
$R = \ r_j; j = 1, \ldots, J$	set of arrival moments $r_j = O_j + L_j$
E_t	echelon inventory position at time *t*
I_t	net on hand inventory at time *t*
$D^{act}_{t,u}$	actual demand from *t* to *t* + *u*
$D^{s}_{t,u}$	at time *s* forecasted demand from time *t* to *t* + *u*
E_{O_j}	echelon inventory at order moment O_j

In this paper, variable review period that proposed by Riezebos and Gaalman [6] will be applied and compared with periodic order review. In next section, simulation methodology for comparing the models is presented.

Simulation Methodology

Under the simulation steps used to compute the inventory cost for periodic review model and variable review period model, the demand and order arrival for order placed during a particular period is drawn with normal distribution and uniform distribution, respectively. Simulation is designed with six scenarios. In this paper two forms of Demand distribution and three forms of lead-time distribution are considered, as shown in Table 1. Each scenario is simulated to periodic review model and variable review period model. The simulation is run for 12 numbers of periods, keeps a cumulative inventory costs. The simulation of each scenario is repeated until 100 times in order to achieve the optimal result. Sensitivity analysis will be performed to periodic review model and variable periodic review model in order to comprehend the influencing of the cost to these models in term of the inventory cost. Parameters that are applied are the ordering cost, holding cost, stock out cost, and service level. The costs that are applied in this paper as follows:

- Holding cost (h) : 10/unit/period
- Stock out cost (so): 50/unit/period
- Ordering cost (oc): 100/unit/period
- Beginning inventory: 200 unit
- Service level : 95%

Results and Discussion

From the result of the simulation, it is observed that variable review period model performs better than periodic review for four scenarios (scenario 1, 3, 4, and 6). Variable review period model gives better than periodic review model in terms of inventory cost for small variation of lead-time. The cost performance of two models can be seen in Table 2 as follows.

Periodic Review Period is sensitive with the changes in the variation of demand distribution and service level. Higher demand variation increases the holding cost (h). Variable review period is fairly sensitive with the changes in the lead-time distribution. Higher lead-time variation increases the stock out cost (so) which causes inventory cost larger.

The number of inventory in the periodic review is greater than variable review period since target inventory level is affected by mean and variation of the demand. It is also found, the robustness of forecast demand is worked on variable review period model. Higher the error of forecast increases the inventory cost, that is quite rationale.

From the sensitivity analysis of the experimental, the following facts occur:

- The lower service level in periodic review period model reduces total inventory cost. It is obviously since safety stock is influenced by service level and variation of demand leadtime and periodic review.
- Service level for periodic review should be lowered to 90% to keep the cost the same as the variable generated review period which has 95% service level. The result can be shown in Table 3 as follows.
- The inventory cost of periodic review model will be smaller than the review period when a ratio of holding cost and stock out cost is 1:6. In this case, ordering cost does not change. It is shown in Table 4.

Table 1. Demand and lead-time distribution

No.	Scenario	Demand	Lead-time
1	Scenario 1	N(200,50)	U(1,4)
2	Scenario 2	N(200,50)	U(1,7)
3	Scenario 3	N(200,50)	U(1,2)
4	Scenario 4	N(550,225)	U(1,4)
5	Scenario 5	N(550,225)	U(1,7)
6	Scenario 6	N(550,225)	U(1,2)

Table 2. The cost performance and comparison of periodic review model and variable review period model

No. (1)	Demand (2)	Lead time (3)	Cost performance: Periodic review (4)	Cost performance: Variable review period (5)	Percentage cost difference (4)-(5)
1	N(200,50)	U(1,4)	69,099	66,050	4.41%
2	N(200,50)	U(1,7)	114,583	126,477	-10.38%
3	N(200,50)	U(1,2)	53,829	33,181	38.36%
4	N(550,225)	U(1,4)	258,896	255,242	1.41%
5	N(550,225)	U(1,7)	383,921	456,472	-18.90%
6	N(550,225)	U(1,2)	195,123	136,189	30.20%

Table 3. The Effect of inventory cost with changes in the service level

Service level	Z	Cost performance: Periodic review	Cost performance: Variable review period
95%	1.645	69,099	66,050
90%	1.28	66,039	66,050

Table 4. The cost performance of the changes holding cost dan stock out cost

Ordering cost (1)	Holding cost (2)	Stock out cost (3)	Cost performance: Periodic review (4)	Cost performance: Variable review period (5)	Percentage cost difference: (4)-(5)
100	5	50	46459	55709	-19.91%
100	10	50	69099	66050	4.41%
100	50	50	250215	148781	40.54%
100	75	50	363413	200488	44.83%
100	100	50	476611	252195	47,09%
100	10	60	73623	74962	-1.82%

Conclusion

Variable review period performs the better solution than periodic review model in term of inventory cost for small variation. Variable review period model is sensitive with the changes in the leadtime distribution. On the other hand, periodic review model is sensitive with the changes in the variation of demand distribution and service level. Service level for periodic review should be lowered to 90% to keep the cost the same as the variable generated review period which has 95% service level. The inventory cost of periodic review model will be smaller than the review period when a ratio of holding cost and stock out cost is 1:6.

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