Comparison of Periodic Review Policy and Continuous Review Policy for the Automotive Industry Inventory System

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Abstract. Industries which apply make to stock production systems depends on inventories to respond of fluctuating demand. The accuracy of determining consumer demand becomes very important. Incorrect of inventory policy causes overstock or stock out. This research was conducted on companies engaged in the automotive industry. This study aims to obtain optimal inventory system policy. The optimal inventory system is capable of generating order quantities to support the fulfilment of consumer demand by low inventory cost and order costs. Continuous Review Policy and Periodic Review Policy were conducted to find of inventory system policy which is able to handle of overstock or stock out with dynamic probabilistic demand characteristics. Continuous Review Policy uses 3 variations of lead time demand (M=25, M=15, and M=8) to obtain the probability density function. The probability density function influences the quantity of order and reorder point. The Periodic Review Policy provides of optimal ordering intervals. The result proves that Continuous Review Policy is able to provide a lower total inventory cost than Periodic Review Policy on this automotive industry by 53.89%.

1. Introduction
Inventory system is a set of policies applied to maintain and control inventory levels [1]. Specify some orders to the appropriate vendor for submission to a production facility, involving of search minimum total production costs. A good inventory management will maximize business profits, and vice versa. failure to control inventory will lead to losses for the company [2]. Critical decisions about the balance of ordering and transportation costs. If the number of orders were small then the order size in one order will increase, resulting of higher order costs, although transportation costs are very low. Sometimes, the result could be stock out and market loss. Otherwise, if the number of orders were a lot, then the size of units ordered were a less, then the order cost is lower, but transportation cost will increase. Thus, a balance between transportation costs, order costs, and inventory costs are necessary. Developing an effective inventory model will determine the number of order sizes with the minimum total inventory cost.

There are two frequently replenishment policies used, the Continuous Review Policy and the Periodic Review Policy. The Continuous Review Policy indicates that the inventory status continues to be tracked and ordered according to lot size (Q) when reorder point (ROP). The advantages of this policy could handle the situation when demand is high but the loss of order quantity is variant. The supplier has a great possibility to make a number of orders variation. This situation is contrary to the periodic review policy [3]. The Periodic Review Policy indicates that inventory status tracked at
specified time intervals, performed periodically, and reorder was made to raise the inventory level to a predetermined point. This inventory system policies are not comprehensive, but provides enough solutions to the problem on inventory management system [4]. Many studies of inventory management policies in a variety of manufacturing and service industries. Syntetos [5,6] recommends a deterministic inventory model for spare parts that takes into consider several forecasting methods. Spare parts demand is estimated and the optimal inventory level is determined by several formulas. Drake did research of inventory control research with periodic review policy on dynamic inventory models [7].

A study of inventory management policies was undertaken by Denniz on perishable products [8]. Most of the problems in inventory management on perishable product are by optimal ordering policy system to minimize operating costs, such as inventory controls, information of inventory level, optimal ordering policies of any product viewed from the product life. Another study related to hospital inventory management policy was did by Setyaningsih [9]. The inventory management policy has been successful in saving the inventory cost of each product inventory policy is able to minimize inventory cost in the research is periodic review policy. Another study of the determination of inventory policy was carried out by Aisyati [10]. This study used a periodic review policy in grade C spare part of aircraft industry. Investigation of optimal inventory level on 36 products. The result of total inventory cost in periodic review policy is 35.38% lower than the company’s current policies.

Teunter and Sani were conducted a research on inventory control policy on lumpy product [11]. They used order-up-to policy to determine inventory level which previously employed Croston Method to forecast the demand. The results of this research indicated that integrating Croston Method and order-up-to policy results in optimal service level. Furthermore, Porras and Dekker determine the level of spare parts inventory in oil companies. They use different reorder points to find optimal inventory levels to minimize total inventory costs [12]. However, until now there are not some research on control of automotive industry inventory especially in Indonesia. This study aims to determine the best policy in managing inventory on automotive spare parts and also want to know the right period to manage the inventory system.

2. Continuous review policy and periodic review policy
The selection of inventory policy depends on how often of inventory levels are checked [13]. Inventory management policies with random demand are divided into two main categories: Continuous Review Policy and Periodic Review Policy. Continuous Review Policy is a continuous inventory checking policy, the ordering Q amounts is performed when the inventory level had reached the reorder point (r) [14]. The Continuous Review Policy on the backorder case means that the company will meet first an unenforceable demand on the previous period. Inventory management with continuous review policy begins by calculating the probability density function (p.d.f f(M)). The p.d.f quantity depends on the random variable of lead time demand (M) and the average lead time demand(M). The value of order quantity and optimal reorder point will differ in a different M values. The result of distribution test in this research is normal distribution. Probability density function, expected number of shortages per cycle, order quantity, optimal order quantity, reorder point, safety stock, and total inventory cost are calculated by the equation below [15].

\[ f(M) = \frac{e^{-\frac{(M-M_{0})^{2}}{2\sigma^{2}}}}{\sigma\sqrt{2\pi}} \] .... (1)

\[ S(x) = \int_{0}^{x} f(x)dx = \int_{r}^{x} (x - r)f(x)dx \] .... (2)

\[ Q^* = \frac{2D[A+S(x)]}{h} \] .... (3)

\[ \text{Reorder point} = \int_{r}^{x} f(x)dx = \frac{hQ^*}{D} \] .... (4)

\[ \text{Safety stock (k_1)} = 1 - P(x > r) = 1 - \int_{r}^{\infty} f(x)dx \] .... (5)

Expectations of total cost (TC) is the amount of order cost expectations, inventory cost expectations, and shortage cost expectations.
The Periodic Review Policy is one of the inventory management policies that review the physical availability of inventories at specified time intervals and ordered to place orders for a maximum level of inventory [16]. When a periodic review policy is applied “every R units of time a replenishment order is placed of sufficient magnitude to raise the inventory position to the order up to level S” [17]. The amount of safety stock on this policy is larger than the continuous review policy, due to a longer lead time. The fulfillment of demand along the period lead time, safety stock is used.

The value of order interval, safety stock, service level, ordering cost expectation, inventory cost expectation, shortage cost expectation, and total inventory cost are calculated with equation below [15].

\[
T^* = \sqrt{\frac{2C}{rh}} \quad \ldots(7)
\]

\[
\frac{R^* - \mu}{\sigma} = Z \left( \frac{\mu}{\mu + hT} \right) \quad \ldots(8)
\]

Service level per order interval = 1 - \( \frac{HT}{A} \) \quad \ldots(9)

Safety stock = \( R - D(l + T) \) \quad \ldots(10)

Ordering cost expectation = \( \frac{(V + A)}{T} \) \quad \ldots(11)

Inventory cost expectation(hI) = \[ R - Di - 1/2DT + \left( \sigma \phi(Z) - (R - \mu)(1 - \Phi(z)) \right) \] \quad \ldots(11)

Shortage cost expectation = \[ \frac{\pi S(R,T)}{T} \] \quad \ldots(12)

Expectations of The Total Cost of The Inventory Periodic Review Policy

\[
TC (R,T) = \frac{V + A}{T} + \left[ R - Dl - 1/2DT + \left( \sigma \phi(Z) - (R - \mu)(1 - \Phi(z)) \right) \right] + \frac{\pi S(R,T)}{T} \quad \ldots(13)
\]

Where,

\( S(x) \) : Expectation of shortage cost

\( S(x) \) : Shortage quantity

\( f(x) \) : P.d.f from x request during lead time

\( Q^* \) : The optimal order quantity

\( x \) : Average request during lead time

\( r \) : Reorder point

\( D \) : Average unit / year demand rate

\( A \) : Order cost per order

\( R \) : Average demand per year

\( h \) : Inventory cost per unit per year

\( \pi \) : Fraction of shortage cost per unit

\( V \) : Cost of checking inventory levels

\( T \) : Length of the booking interval

\( \sigma \) : Standard deviation of actual demand data

\( \phi(Z) \) : Ordinate under normal solid function

\( \Phi(z) \) : Cumulative area under normal distribution

\( M \) : Average monthly demand

\( R \) : Maximum inventory level

\( DL \) : Demand lead time

\( DT \) : Demand per month

3. Methods

This research is classified as a case study research which concentrate on inventory management system in one of automotive industry in Indonesia. The object of this research is the product by the highest stock out and overstock level is Minibus Standard Version. This study uses a set of data which collected from 2013-2016 for the calculation of inventory management system. This research was conducted by the following 5 steps. The first step is preparation had done by doing a preliminary study.
and observation in the automotive industry. The goal was to formulate the inventory problems facing the company. Output of this step is to obtain a research purposes could limit the scope of research. The second step is designing research to deepen the company’s condition and inventory problems that occur. This stage also conducts literature studies to obtain information on techniques and methods of inventory problems solving. This study was also conducted to determine the success of previous related research. The third step is analyzing and evaluating existing condition of the company related to inventory problem. The analysis of existing condition is done by calculating of company's expenditure based on current inventory system policy. The next step is to develop of inventory management system to be applied. At this step, the selection of appropriate inventory methods to solve company problems. The fifth step is test alternative inventory method by total inventory cost.

The design of inventory system of this research are Continuous Review Policy and Periodic Review Policy by the demand dynamic probabilistic characteristics. Continuous Review Policy by backorder case discussed in this research. The Continuous Review Policy begins by defining the actual data distribution pattern of demand data. Once known the pattern of data distribution, then calculate the number of orders and reorder point is optimal, the level of service level, and the number of safety stock. Once the information has been obtained then calculated the total cost of inventory that will be borne by the company when implementing this policy. Periodic Review Policy is performed by calculating the optimal order interval and maximum allowable stock levels. Further service level, the amount of safety stock is also calculated so that the policy is able to overcome the demand when experiencing surges. The total cost of inventory is a benchmark for the selection of alternative policies to be applied.

4. Results and discussion

4.1. Existing inventory policy

The prevailing inventory policy in the company recently is by re-ordering on the 9th day of each month. The company does not assign a fixed order amount each time an order is made. The number of orders obtained by looking at the difference between demand forecasting and on-hand inventory. This policy is able to provide a high service level is 95.25%. Opportunity occurrence of very low shortage only 4.75%. The company is able to maintain customer satisfaction as it could meet their demand. On the other hand, the company must bear the inventory cost due to the occurrence of overstock. Expectation of order cost is very low about Rp. 1.380.000,00 to order in large quantities. Expectation of inventory cost becomes very high that is equal to Rp. 8.538.512,50 due to overstock experienced by the company. But the shortage cost becomes very low is Rp. 141.924,38 with total inventory cost of Rp. 10.060.436,88.

4.2. Continuous review policy

The probability density function (p.d.f) depends on the quantity of lead time demand (M). Leadtime demand is a random variable selected to get the value of Q and r *. Different values of M selected will result in different Q and r * values. The M values used are 25, 15, and 8 units. From each value M is obtained by Q and r *. The magnitude of each variable (M, Q, and r *) could be seen in Table 1.

| No | M (unit) | Q* (unit) | r* (unit) | Service Level (%) | Safety Stock (Unit) | Total Inventory cost (Rp/year) |
|----|---------|----------|----------|------------------|-------------------|-------------------------------|
| 1  | 25      | 34.325   | 7.754    | 86.22            | 8.784             | 4.638.936,70                 |
| 2  | 15      | 31.952   | 11.681   | 87.53            | 9.161             | 4.969.153,45                 |
| 3  | 8       | 32.842   | 10.061   | 87.01            | 8.972             | 4.840.059,05                 |

Total cost is obtained by summing up the expectation of ordering cost, store cost, and stock out cost. Each of cost components could be seen in Table 2.
Table 2. Inventory cost with Continuous Review Policy

| No | M (unit) | Order cost expectation (Rp/year) | Inventory cost expectation (Rp/year) | Stock out cost expectation (Rp/year) | Total inventory cost (Rp/year) |
|----|---------|---------------------------------|-------------------------------------|--------------------------------------|-------------------------------|
| 1  | 25      | 2,315,565.25                    | 1,588,371.95                        | 734,999.50                          | 4,638,936.70                 |
| 2  | 15      | 2,487,582.25                    | 2,130,364.65                        | 351,206.55                          | 4,969,153.45                 |
| 3  | 8       | 2,420,162.35                    | 1,921,701.75                        | 498,194.95                          | 4,840,059.05                 |

Table 2 shows that the lowest total inventory cost at M = 25. Based on the continuous review policy, the company should implement the inventory management system on the lead time demand of 25 units. By the time the unit has reached inventory 7,754 units, the company made a reservation of 34,325 units. When provided a number of 8,784 as a safety stock then there is still a chance of shortage of 13.78%.

4.3. Periodic review policy
The Periodic Review Policy results a booking interval (T *) of 16 days by a reorder point of 9,375 units. The review is conducted periodically every 18 days. Booking part is done when stock warehouse has reached 9,375 units. Safety stock provided for 26,000 units for the company to reach the service level of 88.64%. Opportunity for the occurrence of shortage is 11.36%. By service level of 88.64%, the expected total inventory cost charged to the company each year is Rp. 9,768,485.25. Component of the total inventory cost is the expectation of order costs of Rp. 2,657,546.50 inventory costs of 5,714,247.65 and the shortage cost of Rp. 1,396,691.10.

4.4. Data analysis and discussion
Continuous and periodic reviews are two common methods in tracking inventory system. Calculation and documentation of the periodic review policy made during a certain period, meanwhile the continuous review policy involves the calculation and documentation of each item to each time when the item was removed from inventory. The existing inventory policy provides the lowest ordering cost, but the storage cost becomes very high. The Continuous Review Policy for each variation of demand lead time provides the lowest total inventory cost. The Periodic Review Policy provides the largest order cost and shortage cost. However, the total inventory cost of this policy is still lower than the existing policy. By looking the total inventory cost, the automotive industry should implement continuous review policy by lead time demand (M) of 25 units.

The election of continuous review policy obtains inventory cost savings of 53.89%. Setyaningsih's research also shows that continuous review policy is capable of providing inventory savings than periodic review policy [9]. The advantage of using continuous review policy is to allow updating inventory counts in real time so it will be easier to know when reorder items in the future. Furthermore, it could facilitate an accurate accounting calculation, because the system could provide the costs of goods sell in real time. The disadvantage is the high cost of implementation. While the advantage of periodic review policy is the reduction of time to analyze the amount of inventory. The disadvantage is inaccuracies to determine the amount of inventory if a business were a high sales volume [3]. It takes an impact on the accounting inaccuracies.

5. Conclusion
Based on the opportunity of shortage, the policy applied by the company is currently smaller than the other two policies, but the total inventory cost which is guarantee by the company are very big. Based on the total inventory cost, Continuous Review Policy at M = 25 is better because it gives a lower total cost of Rp. 4,638,936.70 in a year. Periodic Review Policy will reduce of total inventory cost by 27.53%. However Continuous Review Policy will reduce of total inventory cost by 53.89%.
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References
[1] Kulkarni S and Rajhan N R 2013 Determination of Optimum Inventory Model for Minimizing Total Inventory Cost, Chemical, Civil and Mechanical Engineering Tracks of the 3rd Nirma University International Conference on Engineering(NUiCONE 2012) Sciverse ScienceDirect Procedia Engineering 51
[2] F. D. Hedrick 2012 Inventory Management. Purchasing for Owners of Small Plants Buying for Retail Stores and Inventory Management
[3] S Chopra and P Meindl 2010 Supply Chain Management Strategy, Planning and Operation 4th Ed, Pearson.
[4] C. Laeiddee 2010 Improvement of Re-Order Point for Drug Inventory Management at Ramathibodi Hospital Master Thesis, Mahidol University
[5] Syntetos A A and Boylan J E 2005 The accuracy of intermittent demand estimates International Journal of Forecasting 21 303–314
[6] Syntetos A A and Boylan J E 2006 On the stock control performance of intermittent demand estimators International Journal of Production Economics 103 36–47
[7] Drake, Matthew J and Marley Kathryn 2010 A Simulation to Illustrate Periodic-Review Inventory Control Policies. Spreadsheets in Education (eJSiE) 4 2 4
[8] B Deniz 2012 Managing Inventories of Perishable Goods: The Effect of Substitution GSIA Working Paper, Carnegie-Mellon University, Pittsburgh, S. Khan. (February, 2012). Definition of Perishable Products inMarketing. [Online]. Available: http://www.ehow.com/facts_6088827_definition-perishable-products-marketing.html
[9] Setyaningsih S and Basri M H 2013 Comparison Continuous and Periodic Review Policy Inventory Management System Formula and Enteral Food Supply in Public Hospital Bandung International Journal of Innovation, Management and Technology 4 2
[10] Aisyati A, Jauhari W A, Rosyidite C N 2014 Periodic Review Model for Determining Inventory Policy for Aircraft Consumable Spare Parts International Journal of Business Research & Management (IJBRM) 5 3 2014
[11] Teunter R and Sani B 2009 Calculating order-up-to levels for products with intermittent demand International Journal of Production Economics 118 82–86
[12] Porras E and Dekker R 2008 An inventory control system for spare parts at a refinery: An empirical comparison of different re-order point methods European Journal of Operational Research 184 101–132
[13] Cardós M, Babiloni E, Palmer M and Albarracín J M 2009 Effects on Undershoots and Lost Sales on the Cycle Service Level for Periodic and Continuous Review Policies International Conference on Computers & Industrial Engineering (CIE)
[14] Kuo-Chen Hung 2011 Continuous Review Inventory Models Under Time Value of Money and Crashable Lead Time Consideration Yugoslav Journal of Operations Research 21 2 293-306
[15] Tersine R J 1994 Principle of Inventory and Materials Management Fourth Edition Prentice-Hall International, Inc, New Jersey
[16] Wisner J D, Tan K C and Leong G K 2012 Principles of Supply Management: A Balanced Approach South-Western Cengage Learning
[17] Silver E A, Pyke D F and Peterson R 1998 Inventory Management and Production Planning and Scheduling 3rd ed, New York