INVENTORY POLICY FOR AFTER SALES SPARE PARTS TO MINIMIZE OVERSTOCK USING PERIODIC REVIEW AND ABC-XYZ CLASSIFICATION IN PT PQR

Ghifari Irfaan Swastomo[1], Ari Yanuar Ridwan, S.T.,M.T[2], Budi Santosa, S.T.,M.T[3]

[1]Industrial Engineering Major, Industrial Engineering Faculty, Telkom University
[2]Industrial Engineering Major, Industrial Engineering Faculty, Telkom University
[3]Industrial Engineering Major, Industrial Engineering Faculty, Telkom University

[1]ghifariis@telkomuniversity.ac.id, [2]ariyanuar@telkomuniversity.ac.id, [3]budisantosa@telkomuniversity.ac.id

Abstract

PT PQR is company that stand as a single agent that hold Peugeot brand in Indonesia. It is selling cars and spare parts for Peugeot. Other than that, it also provides after sales service for Peugeot car. As a company that sells spare part, it is important to maintain stock of those spare parts well in order to face unpredictable demand. Generally problem that occurs in PT PQR is spare parts stock that occurs in company's inventory system run into pile up. It causes total inventory cost that expensed by company exceeds inventory cost allocation. Total inventory cost that exceeds inventory cost allocation is Rp167.766.171.

Based on that problem, spare parts classification and inventory policy is necessary important to minimize overstock that experienced by company. In this research, spare part classification is performed using ABC-XYZ analysis. ABC analysis for determine which group of spare part that contribute a lot to inventory cost. Then XYZ analysis used for grouped spare parts based on their demand variability. Inventory policy determined using periodic review (R,s,S) and (R,S) method. Because in current condition company has agreement with parent company to order spare parts following ordering batch or once a month. The objective of using those methods are determine optimal review or replenishment interval, re order point and maximum inventory level in order to minimize overstock.

The result of proposed inventory policy using periodic review (R,s,S) and periodic review (R,S) is reduction of total inventory cost by 37,78% due to reduction of total inventory cost component. This reduction, results total inventory cost Rp167.671.572 below total inventory cost allocation.

Keywords : Inventory Policy, Overstock, Periodic Review (R,s,S), Periodic Review (R,S)

1. Preliminary

In recent years the development of automotive business in Indonesia experiencing an attractive growth. Data from "Gabungan Industri Kendaraan Bermotor Indonesia" (GAKINDO), in 2019 sales of cars reaches 851.430 units. It increases 10,85% from 2018. To facing this condition, besides make sure that production or import process of vehicles going well, they also needs to maintain the inventory of spare parts well.

One company that runs automotive business is PT PQR. It is a company that stand as a single agent that hold Peugeot brand in Indonesia. Business that run by this company are selling cars and spare parts. All cars and spare parts are imported in CBU from Peugeot automobile in France. Other than that, this company also offer after sales service for customer that use Peugeot car.

The unpredictable demand is a challenge for company that runs in automotive business and provide after sales services. To survive and even gain much profit, it is important to maintain stock of those spare parts well. So, the usage and stock could be balance. If not there could be problem that occurs in their inventory system such as overstock and stock out. Inventory condition of PT PQR is shown in figure 1.

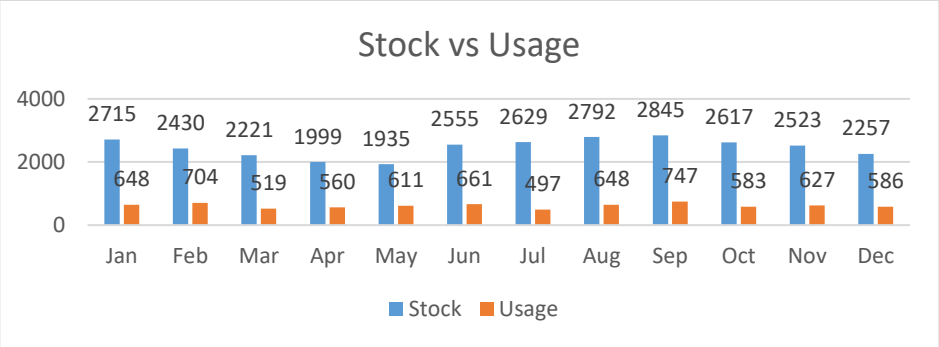

Figure 1 Spare Parts Stock and Usage Comparison

As it seen on figure 1, number of stock is around 1900- 2900 and number of usage is around 450 - 750. Number of stock is so much higher than its usage. It means stock in the company inventory system is run into pile up. This condition could be recognized as an overstock. Overstock condition affects total inventory cost that expense by company, it exceeds inventory cost allocation that has been set. Total inventory cost that exceeds the inventory cost allocation is Rp167.766.171. Total inventory cost condition shown in figure 2.

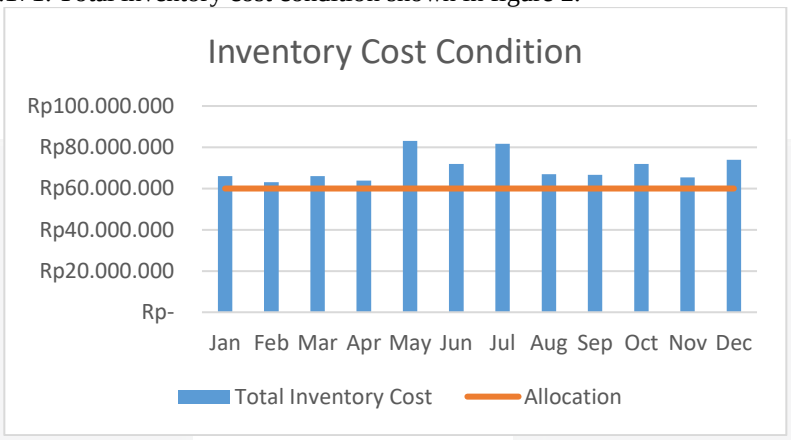

Figure 2 Inventory Cost Condition

Overstock condition occurs because company considers all spare parts have same importance. Hence, purchasing or replenishment decision for all spare parts are same. Other than that, amount they ordered to do replenishment is also high because company only uses historical usage data of every spare parts to determine amount of required spare parts. The calculation of required spare parts sometimes inaccurate, it leads to not fixed result of required spare parts. Hence it affects amount of spare parts that they should ordered. Amount of ordered spare parts shown in figure 3.

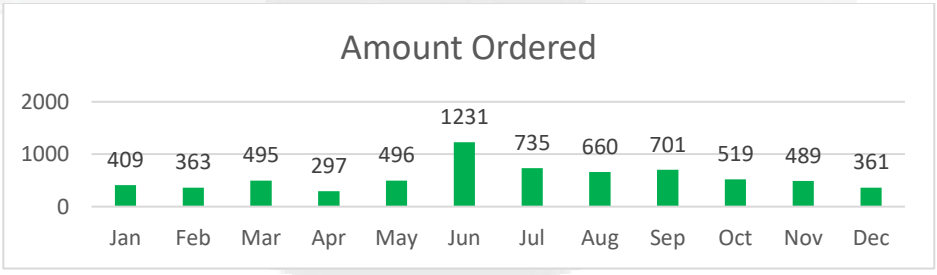

Figure 3 Amount of Spare Parts Ordered

Generally problem that occurs in PT PQR is spare parts stock that occurs in company's inventory system run into pile up. It causes total inventory cost that needs to expense by company is high and exceeds inventory cost allocation. This condition considered as overstock. Regarding to this condition, it is important for company to take a look at their inventory policy. Company needs to do classification for their spare parts to determine importance of

each spare parts. Then they can determine maximum stock and re-order point for inventory policy. Because the objective of inventory management itself is to have the appropriate amounts of materials in the right place, at the right time and at low cost [1]. In this research, inventory classification will be done using ABC-XYZ analysis in order to classify spare parts based on its cost consumption and demand variability. For inventory policy, it will be done using periodic review (R,s,S) and periodic review (R,S) because in current condition company have agreement with parent company to order spare parts based on their order batch or once a month. This inventory policy could be a consideration to minimize overstock that caused total inventory cost high

2. Theoretical Baseline

2.1 Inventory

Inventory is an idle resource which its existence is waiting for advance process. Advance process could be manufacturing activity which happen in manufacture or it could be consumption activity which happen in household, office and etc. [2]

2.2 ABC Analysis

ABC analysis is a classification method based on capital absorption using Pareto diagram principle [2]. According to Pareto principle, goods can be classified into 3 group category. There are :

1. A Category (80-20)
   It contains 20% of total goods in the inventory that absorb 80% of capital that needed.
2. B Category (15-30)
   It contains 30% of total goods in the inventory that absorb 15% of capital that needed.
3. C Category (5-50)
   It contains 50% of total goods in the inventory that absorb only 5% of capital that needed.

2.3 XYZ Analysis

XYZ analysis is used when demand of some company can be so vary from one to another of certain product [3]. XYZ analysis categorized products into 3 groups. There are group X for product with continuous demand, characterized by very slight oscillations and it is possible to forecast the demand with good accuracy. Then group Y for product that sold discontinuously, fluctuating demand and has middle-degree demand forecast accuracy. The last is group Z for product that sold time to time, has big difference in the volume of the demand and very difficult to forecast.

2.4 ABC-XYZ Analysis

To determine inventory policy through the result of classification, according to [4] ABC-XYZ that produce 9 classes categorized again into 2 major category. The first category contains AX,AY,AZ,BZ and CZ classes. While second category contains BX,BY,CX and CZ classes. Category 1 should be ordered based on information of stock level while periodic inspection with regular purchase should be applied for category 2.

Table 1 ABC-XYZ Classification Characteristic *[5]*

Predicted/Value	A	B	C
X	High value, High predictability and Continuous demand	Medium value, High predictability and Continuous demand	Low value, High predictability and Continuous demand
Y	High value, medium predictability and fluctuating demand	Medium value, medium predictability and fluctuating demand	Low value, medium predictability and fluctuating demand
Z	High value, low predictability and irregular demand	medium value, low predictability and irregular demand	low value, low predictability and irregular demand

2.5 Periodic Review Inventory Model

Periodic review model is one of the inventory policy that reviews physical inventory at specific interval of time and orders the quantity order as many as the maximum level of inventory [6]. In this model, it does not need to do intensive inventory review to determine time to order. Because it will be executed based on T (interval). The number of goods ordered is not constant. It depends on inventory level when the time has reach T. Because number of goods ordered is the difference between maximum stock and stock position when order time has come.

1. Periodic Review (R,s,S)
   Periodic Review (R,s,S) is an inventory policy model that do a review every fixed interval time (R) and when the stock level has reach reorder point (s) replenishment will be executed. Amount of order (Q) is amount to fulfill stock level until it reaches maximum level (S). Model formulation : [7]

$$X_R = RD \quad (1)$$

$$X_{R+L} = (R + L)D \quad (2)$$

$$Q_p = 1{,}3\, {X_R}^{0{,}494} \left(\frac{A}{vr}\right)^{0{,}506} (1 + \frac{{\sigma_{R+L}}^2}{{X_R}^2})^{0{,}116} \quad (3)$$

$$S_p = 0{,}973\, X_R + \sigma_{R+L}(\frac{0{,}183}{z} + 1{,}063 - 2{,}192z) \quad (4)$$

$$z = \sqrt{\frac{Q_p r}{\sigma_{R+L} B_3}} \quad (5)$$

$$p \geq (k) = \frac{r}{B_3 + r} \quad (6)$$

$$S_0 = X_{R+L} + k\sigma_{R+L} \quad (7)$$

$$s = \text{minimum}\ \{s_p, S_0\} \quad (8)$$

$$S = \text{minimum}\ \{s_p + Q_p, S_0\} \quad (9)$$

2. Periodic Review (R,S)
   Periodic Review (R,S) or order up to level inventory policy model is a method for inventory control that do review and replenishment in every fixed interval time (R). Amount of order (Q) is amount to fulfill stock level until it reaches maximum level (S). Model formulation : [2]

$$\alpha = \frac{Th}{Cu} \quad (10)$$

$$R = DT + DL + Z\alpha\sqrt{T0 + L} \quad (12)$$

2.6 Previous Research

There are several research that has been done involving goods classification. [8] Have done a research a research using ABC analysis and XYZ analysis for classification. Research found that ABC can be used to plan and take action in order to increase global income from sales. While XYZ analysis can shows different between goods in stock and the used. [4] Also done a research using ABC-XYZ classification. ABC analysis performed based on sales income and XYZ classify based on sales volume variability. This research give conclusion about purchasing decision that should be taken according to the result of classification.

For inventory policy there are several research that has been done to. [9] Have done research in aircraft company using periodic review (R,S). Research found that it generates lower total inventory cost than existing condition. [10] Also done a research using periodic review. It used ADI-CV analysis and ABC analysis as classification. In this research, parts in A class calculated using periodic review (R,s,S) while periodic review (R,S) performed for B and C class. The result is proposed total inventory cost is lower than existing inventory cost. [11] Also done a research for spare parts. In this research, multi criteria classification using fuzzy is performed and bas stock (S-1,S) performed. Research found that those method able to reduce inventory cost. [12] Also done a research for production spare parts. In this research markov chains used to predicting amount of spare parts needs, then it used to determine inventory policy such as quantity to order, re order point and safety stock. Different research of inventory have done by [13]. This research discuss about scheduling of raw material arrival. It used mixed linear programing to scheduling based on several parameters such as price, lead time, and stochastic demand variation. Research found that by finding optimum schedule for each raw material, it can reduce inventory cost.

3. Method

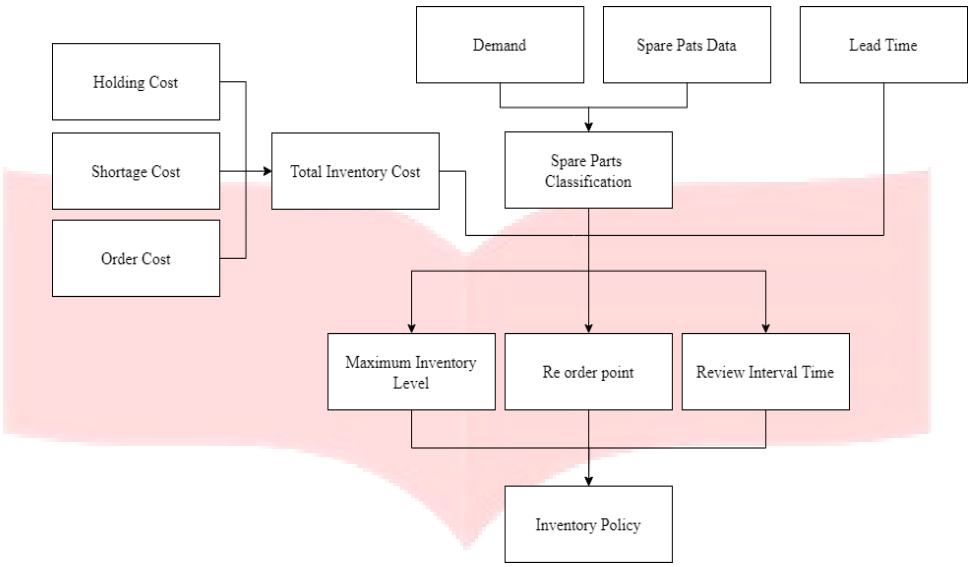

Figure 4 Research Model Conceptual

Figure 5 shown the path of this research through conceptual model. First, demand data from January 2019 – December 2019 as an input will be tested using Kolmogorov – Smirnov Test to determine its distribution pattern. Next step is do spare parts classification using ABC-XYZ analysis. ABC analysis to classified spare parts based on its cumulative percentage of inventory cost consumption. XYZ analysis classified spare parts based on its demand fluctuating. There are 9 combinations category as classification result. According to [4] It will grouped again into 2 major category. Category 1 contains spare parts with AX,AY,AZ,BZ, and CZ category. Then category 2 contains spare parts with BX,BY,CX, and CY category. Final result of spare parts classification will be used to calculate periodic review parameters. Category 1 will use Periodic review (R,s,S) and category 2 will use Periodic review (R,S). Calculation of periodic review parameters includes demand data that has been tested, inventory cost component such as order cost, holding cost and shortage cost and lead time. After all parameters have been calculated, inventory policy has been determined.

4. Data Processing

4.1 ABC-XYZ Analysis

ABC analysis used to grouped spare parts based on its cost consumption. While XYZ analysis used to grouped spare parts based on demand fluctuation level. Result of ABC-XYZ analysis shown in table below

Table 2 ABC-XYZ analysis result summary

Demand Variability	Cost Consumption		
	A	B	C
X	18 Parts	7 Parts	1 Part
Y	29Parts	30 Parts	23 Parts
Z	2 Parts	2 Parts	3 Parts

As it seen in the table, there are 18 parts in AX, 29 parts in AY, 2 parts in AZ, 7 parts in BX, 30 parts in BY, 2 parts in BZ, 1 part in CX, 23 parts in CY and 3 parts in CZ. It means there are 54 parts in category 1 and 61 parts in category 2. Spare parts in category 1 will be calculated using periodic review (R,s,S) and periodic review (R,S) will be used for category 2.

4.2 Periodic Review (R,s,S)

Calculation of periodic review (R,s,S) parameters will be used part 98199-38480 as an example of calculation.

Data for 98199-38480

R : 0,3244
D : 64
L : 2 Months = 2/12 = 0,1667 year
r : Rp 204.095
B_3 : Rp 8.381.630
A : Rp 741.630
v : Rp 7.640.000

1. Determine value of X_R, X_{R+L} and σ_{R+L} using II.7 and II.8 formula

$X_R = RD$
$X_R = (0{,}3244)(64)$
$X_R = 20{,}766$
$X_{R+L} = D(R + L)$
$X_{R+L} = 64(0{,}3244 + 0{,}1667)$
$X_{R+L} = 31{,}433$
$\sigma_{R+L} = \sigma\ (R + L)$
$\sigma_{R+L} = 2{,}211\ (0{,}3244 + 0{,}1667)$
$\sigma_{R+L} = 1{,}0859$

2. Determine value of Q_p and S_p using II.9 dan II.10 formula

$$Q_p = 1{,}3\ {X_R}^{0{,}494} \left(\frac{A}{vr}\right)^{0{,}506} (1 + \frac{{\sigma_{R+L}}^2}{{X_R}^2})^{0{,}116}$$

$$Q_p = 1{,}3\ (20{,}766)^{0{,}494} \left(\frac{741630}{(66208)}\right)^{0{,}506} \left(1 + \frac{1{,}0859^2}{20{,}766^2}\right)^{0{,}116}$$

$Q_p = 19{,}75781$

$$s_p = 0{,}973\ X_R + \sigma_{R+L}(\frac{0{,}183}{z} + 1{,}063 - 2{,}192z)$$

$$s_p = 0{,}973\ (20{,}766) + (1{,}0859)(\frac{0{,}183}{0{,}0068} + 1{,}063 - 2{,}192\ (0{,}0068))$$

$s_p = 31{,}3605$

$$\frac{Q_p}{X_R} = \frac{19{,}75781}{20{,}766}$$

$$\frac{Q_p}{X_R} = 0{,}9514$$

Q_p/X_R <1,5 So the calculation should be continue to step 3.

3. Determine value of k using II.12 formula

$$Pu \geq (k) = \frac{r}{B_3 + r}$$

$$Pu \geq (k) = \frac{(0{,}3244)(204095)}{(8381630) + (0{,}3244)(204095)}$$

$Pu \geq (k) = 0{,}0078$
$k = 2{,}4163$

Value of k can be found in normal table.

4. Determine S_0 value using II.13 formula

$S_0 = X_{R+L} + k\sigma_{R+L}$
$S_0 = (31{,}4332) + (2{,}4163)(1{,}0859)$
$S_0 = 34{,}0571$

5. Determine (s,S) parameters using II.14 and II.15 formula

$s = minimum\ \{s_p, S_0\}$
$s = minimum\ \{31{,}3605\ , 34{,}0571\}$
$s = 31{,}3605$
$s \sim 32$
$S = minimum\ \{31{,}3605 + 19{,}75781, 34{,}0571\}$
S = 34,0571
S ~ 35

From the calculation it can be concluded that for 98036-73380 spare parts the interval review time (R) is 0,3244, re order point (s) is 32 and maximum inventory level (S) is 35. It means spare parts 98036-73380 would be reviewed every 0,3244 years or 4 months and would be ordered if the stock level has reach or below 32 units and amount ordered should fill the stock until it becomes 35.

4.3 Periodic Review (R,S)

Calculation example for periodic review (R,S) Parameters will be done using part 16074-01680. In this calculation R parameters have predetermined before.

Data for part 16074-01680

D : 38
s : 1,4624
L : 0,1667
T : 0,427
A : Rp 741.630
H :Rp 204.095
Cu : 2.471.630

Calculation of periodic review (R,S) parameters will be done using Hadley & Within model : [2]

1. Determine value of α

$$\alpha = \frac{Th}{Cu}$$

$$\alpha = \frac{(0{,}427)(204095)}{(2471630)}$$

$$\alpha = 0{,}035286$$

$$Z\alpha = 1{,}808$$

2. Determine value of maximum inventory

$$R = DT + DL + Z\alpha\sqrt{T + L}$$

$$R = (38)(0{,}427) + (38)(0{,}1667) + (1{,}808)\sqrt{(0{,}427) + (0{,}167)}$$

$$R = 24{,}1423$$

$$R \sim 25$$

From the calculation result of periodic review (R,S) value, it can be seen that part 16074-01680 has review interval time 0,427 and maximum inventory level is 25. It means part 16074-01680 will be reviewed or replenished every 0,427 years or 6 months. Amount of replenishment should be fulfill their inventory level until 25.

5. Result and Discussion

5.1 Category 1 Total Cost Comparison

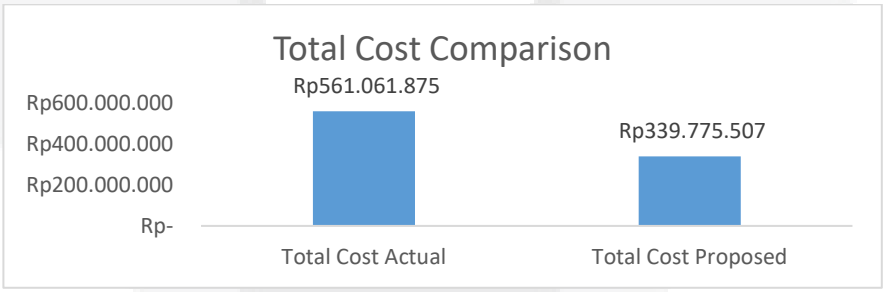

Figure 5 Category 1 Total Cost Comparison

Total inventory cost for category 1 that calculated using periodic review (R,s,S) is less than actual total inventory cost. This major reduction is caused by inventory cost component such as order cost and holding cost experience a decrease in proposed condition. Only shortage cost that higher than actual condition. The reduction reaches 39,44%.

5.2 Category 2 Total Cost Comparison

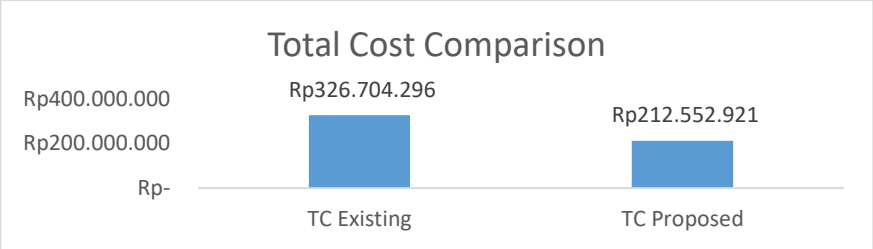

Figure 6 Category 2 Total Cost Comparison

Proposed total inventory cost for category 2 that calculated using periodic review (R,S) is less than actual total inventory cost. This reduction caused by cost component such as order cost and holding cost experience a reduction. Only shortage cost is higher to actual condition. The reduction reaches 34,94%.

5.3 Overall Total Cost Comparison

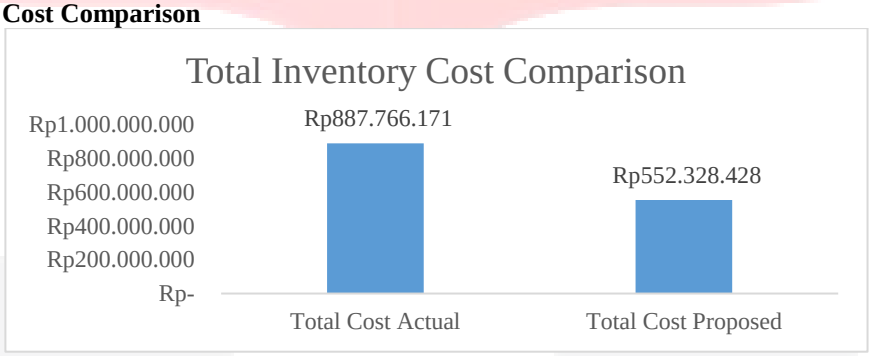

Figure 7 Overall Total Inventory Cost Comparison

Proposed overall total inventory cost is less than actual total inventory cost. It caused by proposed total cost for category 1 that used periodic review (R,s,S) and proposed total cost for category 2 that used periodic review (R,S) experience a major decrease. Both results a reduction for total inventory cost for 39.44% and 34,94%. Hence overall total inventory cost results a decrease that reaches 37,78%.

In existing condition, total inventory cost exceeds inventory cost allocation for Rp167.766.171. Amount of total proposed inventory cost is Rp552.328.428. This amount is Rp167.671.572 below total inventory cost allocation.

5.4 Sensitivity Analysis Result

The purpose of sensitivity analysis is to see effect of parameters change to the optimal solution, in this research is total inventory cost. Parameters that used to do sensitivity analysis are demand, order cost, holding cost and shortage cost**.**

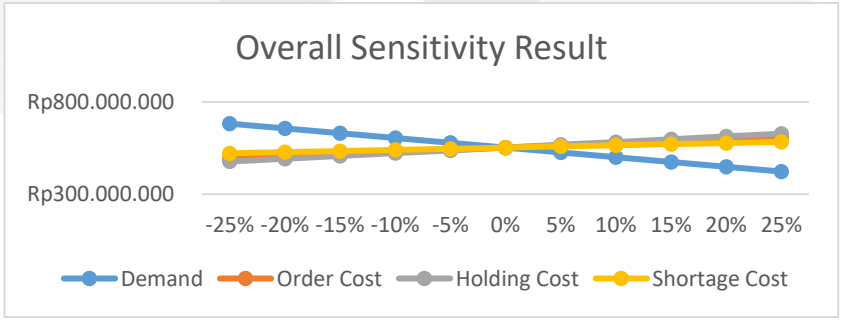

Figure 8 Overall Sensitivity Result

1. Sensitivity To Order Cost

As the one of inventory cost component, order cost changes affects total inventory cost. It gives influence in linear. If order cost increase, total cost also increases and if it decreases total inventory cost decreases. 5% change of order cost increase or decrease results 2,13% change of total cost.

2. Sensitivity To Holding Cost

Holding cost also affects total inventory cost. It affects in linear, if holding cost increase total inventory cost decreases and if it increases total inventory cost increases.5% change of holding cost increase and decrease results 2,72% changes in total inventory cost .

3. Sensitivity To Shortage Cost

Shortage cost is parameter which total inventory cost less sensitive to. 5% change of shortage cost increase or decrease only results 1,12% change of total inventory cost. It is the lowest than the other parameters. Shortage cost affecting in linear, if shortage cost increases total inventory cost will increase.

4. Sensitivity To Demand

Demand is parameter which total inventory cost most sensitive to. 5% change of demand increase or decrease results 4,70% change of total inventory cost. It is the highest than the other parameters. Demand affecting in linear, if demand increases total inventory cost will decrease and vice versa.

6. Conclusion

1. Inventory classification that plausible to support purchasing decision is ABC-XYZ. Its classified spare parts based on cost consumption and demand variability.
2. Inventory policy that can be used to reduce overstock caused high inventory cost that expensed by company are periodic review (R,s,S) and periodic review (R,S) by determining optimal review or replenishment interval, proper re order point and maximum inventory level.
3. Calculation result of proposed total inventory cost is Rp552.328.428 It's 37,78% less than existing condition Rp887.766.171.

References

[1] R. J. Tersine, Principles of Invenotry and Materials Management, PTR Prentice-Hall, Inc., 1994.

[2] S. N. Bahagia, Sistem Inventory, Bandung: ITB Press, 2006.

[3] M. Stojanovic and D. Regodic, "The Significance of the Integrated Multicriteria ABC-XYZ Method for the Inventory Management Proces," *Acta Poltechnica Hungaria,* 2017.

[4] J. Bulinski, C. Waszkiewicz and P. Buraczewki, "Utilization of ABC/XYZ analysis in stock planning," *Agriculture No 61 (Agricultural and Forest Engineering),* pp. 89-96, 2013.

[5] P. Schonsleben, Integral Logistics Management Planning and Control of Comperhensive Supply Chain, Zurich: CRC Press LLC, 2016.

[6] J. D. Wisner, K. C. Tan and G. K. Leong, Principle of Supply Managamenet : A Balanced Approach, South - Western Cengage Learning, 2012.

[7] E. A. Silver, D. F. Pyke and R. Peterson, Inventory Management and Production Planning and Scheduling, 2017.

[8] I. Nowotynska, "An Application of XYZ Analysis in Company Stock Management," *Modern Management Review,* 2013.

[9] A. Aisyati, W. A. Jauhari and C. N. Rosyidi, "Periodic Review for Determining Inventory Policy for Aircraft Consumable Spare Part," *International Journal of Business Research and Management,* p. 41, 2014.

[10] P. P. Suryadhini, A. F. Setiawan and W. Juliani, "Inventory Control Policy for Farm-Out Parts at Cold Section Module CT7 Engine with Periodic Review (R,s,S) and (R,S) To Minimize Total Inventory Cost," *Atlantis Highlights in Engineering (AHE), volume 2,* 2018.

[11] A. Maulaya, A. Y. Ridwan and B. Santosa, "Spare Part Inventory Policy Planning based on FRMIC (Fuzzy-Rule-based approach for Multi-Criteria Inventory Classification) using Base-Stock Policy Method (S-1, S)," *Advance in intelegent system research,* vol. 173, p. 8, 2019.

[12] H. Nurhasanah, A. Y. Ridwan and B. Santosa, "A Condition-based maintenance and spare parts provisioning based on markov chains," *IOP Conf. Series: Materials Science and Engineering,* vol. 673, p. 7, 2019.

[13] P. Amelia, A. Y. Ridwan and B. Santosa, "Designing of Raw Material Scheduling Supply Multi On Supplier Strategies with Price, Lead time, And Stochastic Demand Variations. Case Study: Electricity Manufacturer," *IOP Conf. Series: Materials Science and Engineering,* vol. 598, p. 8, 2019.