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Inventory Planning for XYZ Mart using EOQ and Monte Carlo

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***Abstract*—XYZ Mart is a convenience store in Tulungagung regency. Founded in 2012, this store is designed to serve the daily needs of surrounding residents. In addition, this store also caters for the needs of families visiting patients at the hospital in front of XYZ Mart. Along with the store growth, there are more and more customers, and so the more demand. To handle the increasing demand, the store has to increase its inventory of goods. Problems arise when the number of goods keep increasing while the store inventory space does not. Therefore, in order to avoid overstocking or understocking, a research and planning are conducted to determine the optimal number of an order. The method used for inventory optimization is Economic Order Quantity (EOQ) to calculate the most optimal number of goods ordered. To anticipate the uncertainty of demand, Safety Stock (SS) is also used. To determine the average demand per year based on historical data, as a basis for EOQ and SS calculations, a Monte Carlo simulation is used. The expected outcome of this research is to provide recommendations of when and how much goods must be ordered so that the store can optimally use its limited space of inventory.**

***Keywords*—Economic Order Quantity, Reorder Points, Safety Stocks, Monte Carlo Simulation.**

I. INTRODUCTION

ECONOMIC of Indonesia is growing from year to year, this can be seen from the continued increase in the growth rate of Indonesia's GDP, from 5.007% in 2014 to 5.171% in 2018 [1]. One of the things that drives high economic growth is high household consumption [2]. Increased growth in household consumption will also trigger demand and growth in the retail industry sector such as hypermarkets, supermarkets, and minimarkets.

Minimarket is a small shop and can be likened to that of traditional indonesian grocery store that sells all kinds of goods and foods, but not as complete or as large as a supermarket [3]. In contrast to traditional indonesian grocery store however, minimarkets implement a self-service system, in which the buyer can pick up the goods they needed themselves form the shelves and pay for them at the cashier. All transactions are carried out cash & carry or paid in cash, except for a few minimarkets that do allow credit card transactions. Growth in the retail industry sector, especially in minimarket, will benefit many parties, such as households as consumers, or the retail sector supporting companies, such as producers of household needs and suppliers or distributors, and thus good planning is needed to address the problems that occur due to increase in demand and growth of minimarket. One of the problems faced by many minimarket managers is the limited space availability in the minimarket building [4]. Because the nature of minimarkets that tends to be built smaller compared to other retail stores such as supermarkets or hypermarkets. Therefore, it becomes important for minimarket managers to optimize the inventory given how much a little space available.

Inventory management is an issue that is often discussed because of the complexity of the problems. One method that is widely used to optimize inventory is to use Economic Order Quantity or EOQ. One of the previous studies on EOQ is a research conducted by Cárdenas-Barrón relating to the EOQ model with demand for nonlinear dependent stock and nonlinear holding costs [5]. This inventory model is developed from the retailer's perspective, where suppliers offer a trading credit period to retailers.

Studies of this research will be conducted at XYZ Mart. XYZ Mart is a local minimarket in a small regency in East Java that has been established since 2012. At the beginning of its establishment, this minimarket was targeted to serve the needs of the surrounding residents and the families of patients of the hospital in front of it. With the growth of minimarkets from year to year, more and more customers come from other districts in the regency, so XYZ Mart had to make some adjustments. One of the adjustmence to increaese the number of stock products to avoid stock vacancies when there are floods of buyers. Due to the large number of items and suppliers found in the minimarket, this research will therefore focus more on items from just one supplier. The selected supplier is the one with the most items sold at XYZ Mart, namely supplier FA01, that accounts for 20.23% items sold during 2019.

Because the calculation only uses data from supplier FA01, to ensure it is not influenced by items from other suppliers, the amount of space used in this calculation is also limited to 20.23% of the total inventory space, which is 71.82m3. To further focus on this research, the Pareto principle is also used, that is in many instances, around 80% of the effects are caused by about 20% of the population [6].

As shown in Figure 1, of all items that belongs to supplier FA01, only few items are significant in number, so by using the Pareto principle, items are taken that represent 80% of the population. The selected items are as listed on Table 1.

Based on interviews conducted by the author with the minimarket managers, problems arise when the number of goods keep increasing while the store inventory space does not. Therefore, in order to avoid overstocking or understocking, a research and planning are conducted to determine the optimal number in order.

II. METHOD

One approach to improve the performance of inventory management in addition to using the EOQ method, is also

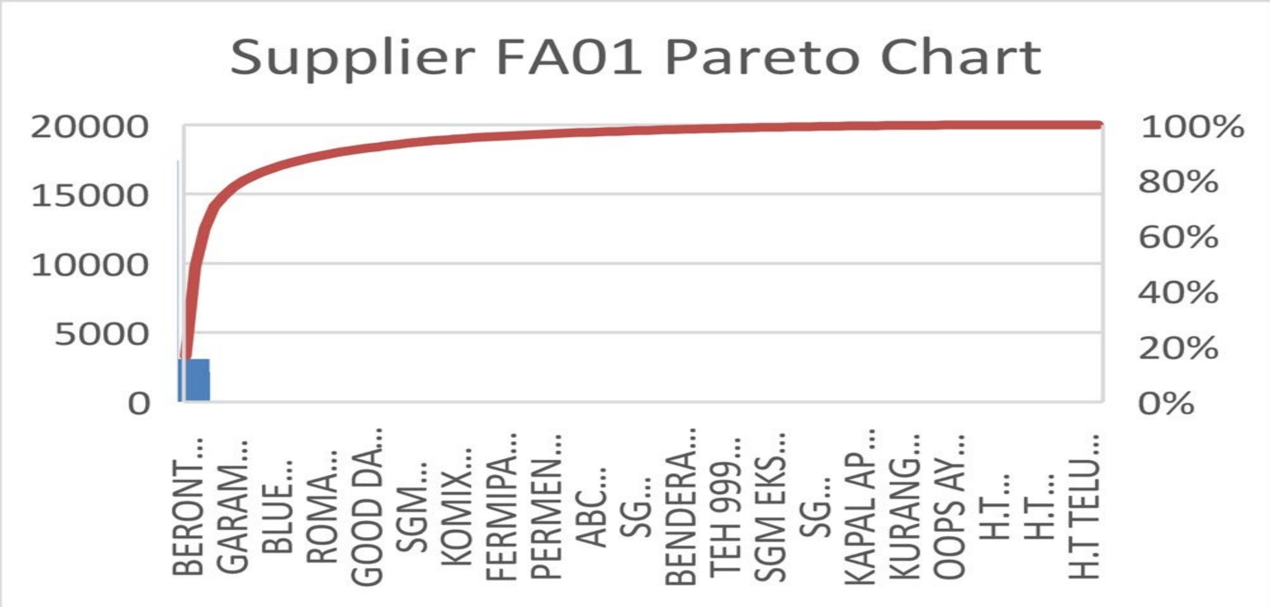

Figure 1. Pareto chart of items sold by supplier FA01.

Table 1.
Selected items

No	Item Name	Item Rename	Percentage
1.	Aqua 1500 ml	Item A	14.29%
2.	Aqua botol 330ml	Item B	3.00%
3.	Aqua botol 600ml	Item C	9.17%
4.	Aqua galon isi ulang	Item D	0.98%
5.	Bear brand milk can 189ml	Item E	2.95%
6.	Berontoseno ekonomis	Item F	16.53%
7.	Bodrex 20 tablet	Item G	0.71%
8.	Flow 1500ml	Item H	1.22%
9.	Flow air mineral 600ml	Item I	1.06%
10.	Garam cap kapal 250g	Item J	1.00%
11.	Le minerale 1500ml	Item K	3.17%
12.	Le minerale 330ml	Item L	1.76%
13.	Le minerale 600ml	Item M	8.64%
14.	Luwak white koffie original	Item N	2.06%
15.	Pucuk harum jasmine 350ml	Item O	7.23%
16.	Roma biskuit kelapa 300g	Item P	0.74%
17.	Sidomuncul susu jahe 27g	Item Q	0.62%
18.	So nice sosis ayam/sapi 24x20	Item R	3.39%
19.	Sunlight j nipis 755ml	Item S	0.71%
20.	Tolak angin cair 15ml	Item T	1.09%
	Total		80,32%

done using simulations. Simulation is used to mimic a system that is stochastic in nature, or the parameter value cannot be determined before the event occurs. The use of simulation technique is quite effective for use in inventory management [7]. In this study, the simulation used is the Monte Carlo simulation. Monte Carlo simulation complements decision makers with various possible outcomes and probabilities that will occur for each choice of action, and is popularly used because of its simplicity [8].

The data needed in this study include demand data, item data, item requirement data during waiting time, and inventory cost data. Inventory cost data consists of purchase costs, ordering costs, holding costs, and item shortage costs. This monte carlo simulation is carried out to get the item demand for a year which will be used as input for the calculation of EOQ. The steps taken include data distribution testing, simulation of the number of requests, and evaluation and validation of simulation results.

III. RESULT AND DISCUSSION

A. Data Gathering

The data needed in this study are the item sales and inventory cost data, consisting of purchase costs, ordering costs, and holding costs. Item sales data is historical data on item sales from supplier FA01 during the period from January 1 to December 31, 2019. The data used are for the 20 items listed in Table 1, we will take Item A as an example. The time period used is daily. As mentioned before, inventory cost data consists of purchase costs, ordering costs, and holding costs. Purchase costs are the price paid to purchase item from supplier, while ordering costs are cost incurred each time XYZ Mart buy items from suppliers that include communication costs, administrative costs, and labor costs. Holding costs are generally calculated with 20% - 35% of the inventory cost [9]. Table 2 is the data for Item A.

Table 2.
Item aactual previous data

Item A	Value
Average Demand per day (pcs)	25
Purchased Cost (IDR)	3,892
Order Cost (IDR)	2,750
Annual Holding Cost per pcs (IDR)	778.33

Table 3.
Item an empirical distribution

Class Interval	Frequency	Chance of occurence	Cumulative chance of occurrence	Random Number Interval
2 – 8,78	5	0,01	0,01	0 – 0,01
8,78 – 15,56	41	0,11	0,13	0,01 – 0,13
15,56 – 22,33	111	0,30	0,43	0,13 – 0,43
22,33 – 29,11	107	0,29	0,72	0,43 – 0,72
29,11 – 35,89	59	0,16	0,88	0,72 – 0,88
35,89 – 42,67	21	0,06	0,94	0,88 – 0,94
42,67 – 49,44	10	0,03	0,97	0,94 – 0,97

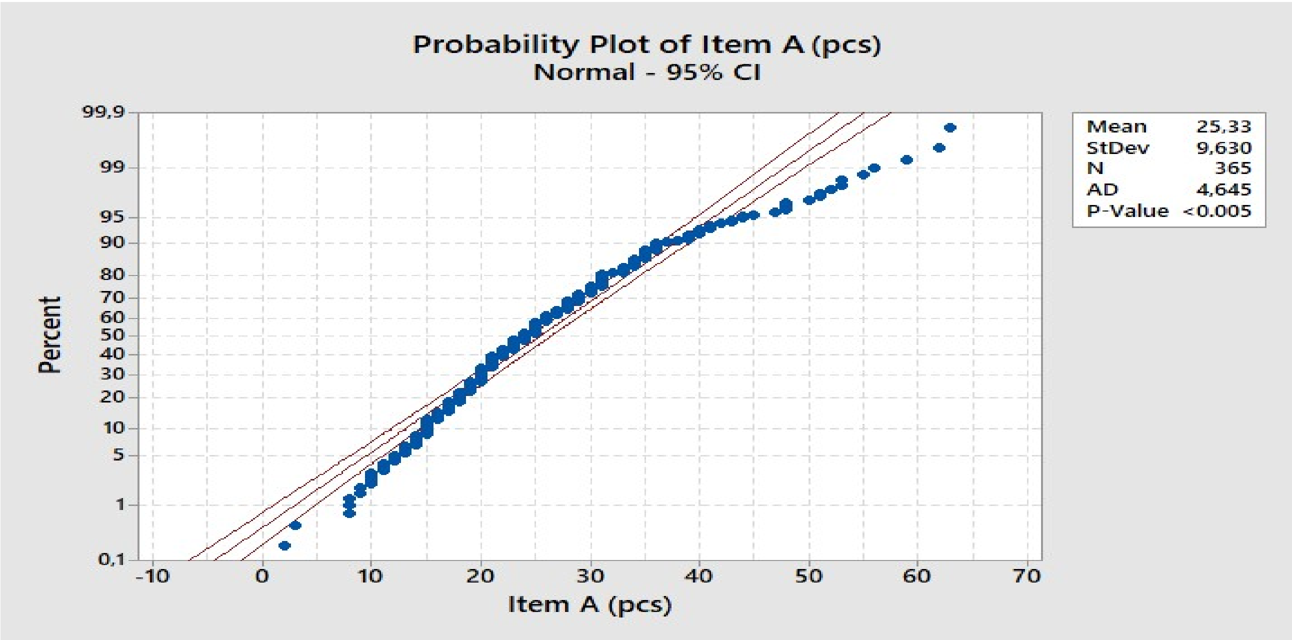

Figure 2. Probability plot of item A.

B. Monte Carlo Simulation

The monte carlo simulation is carried out to get the simulated item sales demand for next year which will be used as input for the calculation of EOQ. The steps taken include data distribution testing, simulation of the number of requests, and evaluation and validation of simulation results. Data distribution tests are done using statistical analysis software.

From the results in Figure 2 of distribution test, the p-value is less than 0.05, so it can be concluded that the data distribution does not follow the normal distribution. Therefore, an empirical distribution of demand will be built. From the 365 days of demand data obtained, it is known that the data is scattered randomly, for this reason a frequency distribution table will be made by determining the class range, determining the number of interval classes, and determining the length of the interval class. After the results are determined, then random number intervals are determined for each class interval based on the cumulative chance of occurrence.

After the data is tabulated into Table 3, an empirical distribution table, the next step is to simulate item sales demand for next year by generating random number using spreadsheet program. To obtain results that convergent to a stable parameter value, simulations are replicated for several times.

From simulation, total item A sales demand for next year is 8,952 pcs with average demand per day of 24.53 pcs. The rest of 19 other items are simulated using the same steps. To evaluate the simulation results, we compare the simulation results against the actual previous data. Comparison between actual data and simulation results is carried out on the cumulative value of item sales for 365 days (n).

$$\Sigma\Sigma|AA - BB| = \Sigma\Sigma|AAAAAAAAAAAA - SSSSSSAAAAAAAAASSSSSS| = 186{,}263.82$$

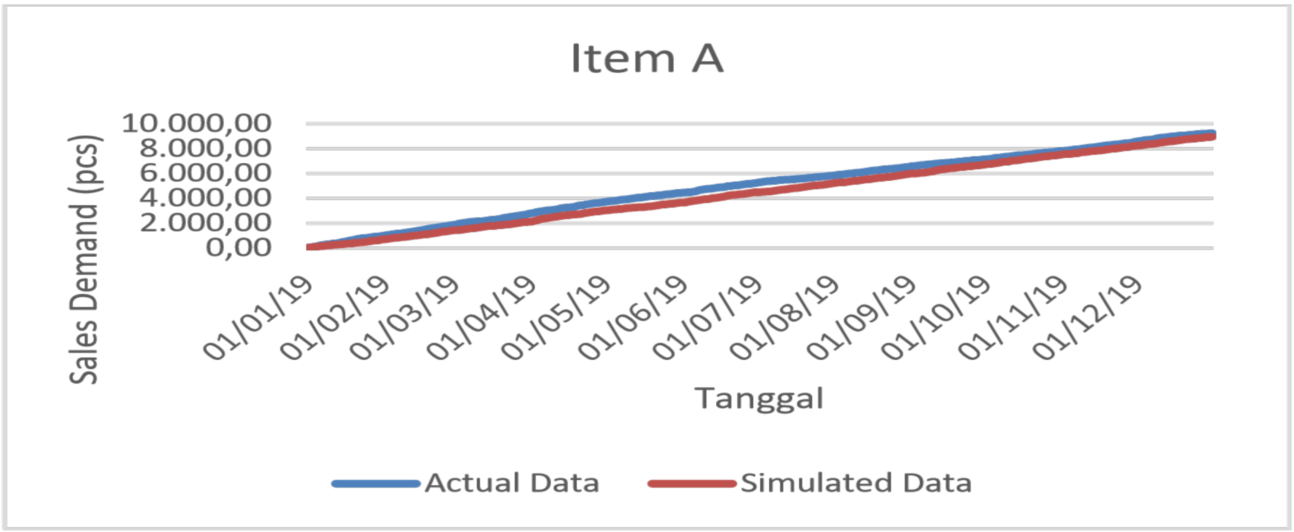

Figure 3. Comparison plot of item A actual and simulated data.

$$\Sigma\Sigma(AA - BB)^2 = \Sigma\Sigma(AAAAAAAAAAAA - SSSSSSAAAAAAAAASSSSSS)2 = 109{,}117{,}285.68$$

$$|AA - BB||AAcccccccccc - SSSSSScccccccSSSSSS| = 53{,}84$$

$$MAD = \frac{\sum|A - B|}{S} = 510{,}31$$

$$MSE = \frac{\sum(AA - B)^2}{S} = 298{,}951.47$$

$$MAPE = \frac{\sum\frac{|AA - B|}{A}}{SS} = 0{,}15$$

Furthermore, from the above results, a comparison data plot can be made between the actual demand data and the simulation results shown in Figure 3.

In Figure 3, it can be seen that the simulation results follow the actual data of selling items closely. Therefore, the simulation results of item sales with the Monte Carlo method can be used to plan the inventory system at XYZ Mart.

C. *Economic Order Quantity*

After the forecasted demand for each item in 2020 is known, XYZ Mart can do EOQ calculations to determine the optimal ordering plan to the supplier. To calculate EOQ (Qo), it is necessary to know the value of Demand per unit (D), Reorder cost (RC), and storage cost or holding cost (HC), and since there are space constraint in XYZ Mart, we will also check whether the calculation results still within the limit of constraint or not. For example, item A needs space of 0.002016 m^3 per unit, thus the calculation is as follows [10].

$$QSS_{AA} = 2\ x\ RR\ x\ D_A = 2\ x\ 2{,}750\ x\ 8{,}952 = 778{,}33$$

$$Average\ Space = SS_{AA}xxQQSS_{AA} = 0.002016xx251{,}51 = 0{,}25\ SS_3$$

$$HHCC_{AA} = 251{,}51\ ppAApp$$

Using economic order quantities, the average space occupied for all 20 selected item is 2.06 m^3 [11]. This is still within the limit set by XYZ Mart, so stock does not need to be reduced, and we can move forward to Reorder Point (ROP) and Safety Stock (SS) calculation, since EOQ only determines the quantity of items that needs to be ordered, but does not specify when the order must be placed [12].

To complete this inventory plan, it is also necessary to determine when XYZ Mart has to place an order using ROP. ROP is the point where an order is made before the minimarket stock runs out, but because there is uncertainty in item demand then XYZ Mart needs to be more careful planning the inventory, and to overcome this uncertainty is by using SS increases the value of the ROP so that the value of the ROP can cope if there is uncertainty in demand. Z is the desired service level, σLT is the standard deviation of lead time, and D avg. is average of demand per day.

$$SSSS_{AA} = ZZ\ xx\ \sigma\sigma LLLL\ xx\ DD\ AAaaaa = 1.64\ \text{xx}\ 6\ \text{xx}\ 24.53 = 241.3$$

$$RROOOO_{AA} = DD\ AAaaaa.\ xx\ LLLL + SSSS = 73.6 + 241.3 = 314.9$$

IV. CONCLUSION

From the results of study and calculations carried out on this research regarding inventory planning, we conclude that the simulation results closely follow the actual data of selling items, therefore the simulation results of item sales with the Monte Carlo method can be used to plan the inventory system at XYZ Mart. The results of calculations using the EOQ method obtained the optimal order amount of 251.51 pcs for Item A. By using the ROP and SS method, it is known that XYZ Mart should reorder more of Item A when its stock levels dip to 314.9 pcs so that the store can optimally use its inventory.

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