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Inventory Level Improvement in Pharmacy Company Using Probabilistic EOQ Model and Two Echelon Inventory: A Case Study

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Abstract. *This research is aimed to maintain the inventory level in a two-echelon pharmacy company. The company is a pharmacy company that has 16 branches that operate in Bandung and the surrounding area. The company has a problem with its high inventory cost. To solve the problem, the authors compare two methods that suit the company condition, i.e., the decentralized system using probabilistic EOQ model and the centralization system using the multi-echelon inventory technique. We analyzed sales data and on-hand inventory data acquired from the company information system to perform the study. We limit the scope to the class A items only. We also assume the lead time, setup cost, and holding cost used in this study with the company's owner's consent. To conclude, using the decentralized system, the company will save 31% of their inventory cost, while using the centralization system with the multi-echelon technique, the company will be able to save 61% of their inventory cost. We recommend the company to refer to its competitive strategy before deciding which model it would be implemented.*

Keywords: *Centralization, Decentralization, Probabilistic Economic Order Quantity (EOQ), Multi-Echelon Inventory, Pharmaceutical Inventory Management*

1. Introduction

There have been many changes in the global healthcare industry for the past several years (Olson & McLaughlin, 2012). According to Hanna and Sethurahman (2005), healthcare organizations have to attempt to improve operational efficiencies and reduce costs while improving quality of care since there is a gradually challenging value chain environment that presses on those organizations. According to Olson and McLaughlin (2012), the answer to this challenge lies within organizational operations. One of the many components that make a major contribution to the organization's operating costs is the inventory cost (Heizer & Render, 2011). In the healthcare industry, a high level of inventory means a high level of service for medical supplies since the medicine shortages and inappropriate use of pharmaceuticals can lead to financial losses and have a major impact on patients (Uthayakumar & Priyan, 2013). Unlike the retail industry, the healthcare industry cannot afford to depend on backorders to satisfy demand at a future date because of the customers' life and death scenario (patients). There are also the legal costs that a healthcare provider can face if death or any other health problem occurs due to a shortage of particular items (Nicholson, 2001). In specific, Ali (2011) also mentions that a pharmaceutical product's unavailability may cause them to lose a customer, inconvenience the prescribing physician, and affect the patient's wellbeing. Many healthcare providers experience difficulties in achieving the balance between stock level and service level since they have not addressed how medicines are managed, supplied, and used to save lives and improve health (Uthayakumar & Priyan, 2013).

Managing inventory for a pharmacy serves two purposes according to Santhi & Karthikeyan (2016); the first is to ensure that

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there are no out of stock of medication products when the patients need them, and the second is to keep medication costs a minimum. Therefore, the organizations must keep the medications regularly used in the warehouse and not expired or damaged. In line with Ali (2011), efficient inventory management plays a great role in pharmacy practice since they impact the financial and operation function. In the financial function, inventory represents the large assets since they hold high value, thus consuming a large portion of pharmacy capital. Therefore efficient inventory management will increase gross and net profit. Meanwhile, in the operation field, inventory needs to be held to retain future demand and maintain the service level. Another relevant problem in the healthcare supply chain is determining appropriate inventory levels in each echelon (Guo & Li, 2014).

This research focused on evaluating a pharmacy company's inventory level in Indonesia with a two-echelon inventory system. As a case study, we investigate inventory level in a pharmacy company in West Java, which has one central warehouse located in Bandung and has 16 branches throughout the West Java area. Currently, the company is facing a high inventory level, which impacts their operation cost. The inventory cost occupies more than 60 percent of the company's operation cost. In the meantime, the high inventory level was caused by the absence of an appropriate inventory model that can control their inventory level.

Assessing this condition, hence the objective of this research is to identifying issues related to the company inventory management, evaluating the company's current inventory level, and proposing the recommendation to improve efficiency on the company's inventory management. This research proposed a multi-echelon inventory approach for analyzing inventory decisions using a centralized and decentralized system. We choose this approach since the company's distribution network follows the two-stage supply chain with one party supply of many retailers, therefore fit with the multi-echelon inventory model (Mouaky, Berrado, & Benabbou, 2019). Meanwhile, we choose to evaluate the centralized and decentralized system since the company is also facing a difficult situation, whether to stock their inventory in each branch or pool the inventory in their warehouse. According to Sun (2020, in supply chain multi-echelon inventory control, these two systems are commonly used since their characteristics and scope of application are related to the prior system. Meanwhile, to calculate how much to order and when to order, we use the probabilistic EOQ model with demand vary over time, and the lead time is assumed to be constant.

To carry out this research, we performed the qualitative method using desk study analysis of literature reviews and interviewed the pharmacy management and staff to gather data and information. We compare two methods that suit the company's condition: the decentralized and centralization system using the multi-echelon inventory technique to solve the problem. To perform the research, we limit stock scope into the class A items only, which have the highest value among other items. We also assume the lead time, setup cost, and holding cost used in this research with the owner's consent. We then compared the decentralized system and centralized system results to find the best solution.

The next section of this paper is organized as follows. Section 2 describes the literature review of pharmaceutical inventory and downstream supply chain. As well as literature in a centralized and decentralized system and multi-echelon inventory. Sections 3 illustrates the overview of the case study and methodology. Section 4 presents the proposed model and the analysis in centralized and decentralized cases. Then section 5 presents the result of this study, and some potential improvements and further research are also detailed.

2. Literature Study

Inventory in the Pharmacy Industry

In pharmacy operations, inventory is defined as the stock of pharmaceutical products reserved to meet upcoming demand (Ali, 2011). In the pharmacy industry, inventory is the largest asset in pharmacy practice, and its value continues to increase because of the growth in the variety and cost of pharmaceutical products (Ali, 2011). Kelle, Woosley, & Schneider (2012) also mentions that pharmaceutical items represent a significant percentage of costs in the healthcare industry. According to Simchi-Levi, Kaminsky, Simchi-Levi, and Shankar (2008), inventory is one of the dominant costs. Hughes (1984) mentioned that the costs associated with pharmacy inventory are carrying costs, shortage costs, and replenishment costs. All costs are related to the inventory level. Thus, if we want to excel in effective operation, we need to reduce inventory levels. In the meantime, inventory management's objective is to maintain a balance between inventory investment and customer service (Heizer & Render, 2011).

Therefore, reducing cost simply by reducing the inventory level is not the optimal solution since certain items' availability becomes an issue, and the customers will not be satisfied if the service level did not accommodate their need for the items (Bowersox, Closs, & Helferich, 1996). Consequently, optimizing the inventory level by keeping the low inventory level while at the same time meeting the requirement is a must if one wants to stay in business. However, there is a perceived need to supply very high levels of service in the pharmacy business by keeping lots of stock in their inventory, since the healthcare product can save lives (Beier, 1995).

Among various inventory control models in pharmacy settings, one proven robust method is the EOQ method (Heizer & Render, 2011). EOQ has been used to balance the total costs, and it has been proposed to be effective and efficient (Singh, Gupta, & Devnani, 2015). EOQ method is used to gain information regarding how much (economic order quantity/EOQ) and when to order goods (reorder point/ROP) to keep the setup cost and holding cost the lowest. The objective of EOQ's method is to make inventory decisions that minimize total inventory cost, not to minimize inventory (Schwarz, 2008). However, one weakness of the EOQ model is that demand must be constant. Whereas in real life almost all company has unstable demand. In this situation, the probabilistic EOQ model is a better choice than the deterministic EOQ model since the former model can incorporate the variation of the demand and uncertain lead time (Taha, 2017). To calculate the EOQ and ROP, we need the information of demand, lead time, setup cost, and holding cost data. This method can be used in a firm with a single facility or multi-facility. In a multi-facility company, a firm or company usually must consider the application of a decentralized distribution system or a centralized distribution system.

Centralized vs. Decentralized Supply Chain

A centralized or decentralized system can be differentiated by how decisions are made. In a decentralized system, decisions are made by each member with no consideration given to the other, while decisions in a centralized are made centrally by considering all members together. A centralized system is more cost-effective than a decentralized one, but it normally requires a higher degree of integration (Duan & Liao, 2013). According to Baboli, Fondrevelle, Neghab, & Mehrabi (2007), the centralized and decentralized inventory can be characterized by how the replenishment process is carried out. In decentralized control, distribution channels /branches make their replenishment decisions based on their local information independently. Branches are treated as an individual system in which they aim to minimize their own inventory cost regardless of the system cost. In centralized inventory control, decisions are made to minimize the overall inventory cost (Duan & Liao, 2013).

To help reduce these costs, a company can pool the inventory for products into a centralized network, holding inventory in a small fraction of the distribution centers or even in one central location (Ward, 2017). By pooling the inventory, the overall inventory holding costs are reduced, though additional transportation costs are incurred. In line with Iannone, Lambiase, Miranda, Riemma, & Sarno (2014), centralization is a way to minimize the holding and penalty costs of inventory and shared supply chain risks. In a decentralized system, usually, a firm has local inventories in each region, and in a centralized system, all inventories are aggregated into one centralized facility (Chopra & Meindl, 2007).

Therefore, in the decentralized system, the total safety stock would be the sum of the safety stock in each facility; meanwhile, in the centralized system, the safety stock will be pooled in the central facility. In a decentralized case, each facility's lead time and service level are considered separately; meanwhile, in a centralized system, we need to consider each facility's information to achieve an optimum result (Chopra & Meindl, 2007). Two major disadvantages of aggregating all inventories in one location are the increase in customer orders' response time and the increase in transportation cost. However, the aggregation will greatly reduce the inventory cost since the firm does not need to keep inventory in its branch facility (Chopra & Meindl, 2007).

Multi-Echelon Inventory System

The challenge of managing inventory can be increased significantly for a company with a multi-echelon distribution network (Lee, 2003). The multi-echelon inventory represents a special category of inventories which has several stages or level are involved. The terms "multi-echelon" or "multi-level" production/distribution networks are synonymous with networks/supply chains, where an item moves through more than one stage before reaching the final customer. The number of levels in these structures is created by subsequently occurring intermediaries.

In the single level structure, between suppliers and customer's intermediaries are only at the one level, without any relationships with other intermediaries, as seen in figure 1. Figure 1 illustrates the simple single echelon network, with one supplier supply one retailer. In this situation, we only need to consider replenishment lead time from supplier to retailer and the safety stock held in the retailer to anticipate the uncertain demand from customers.

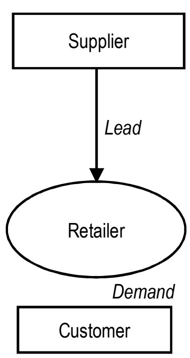

Figure 1.
Single-Echelon Net-work

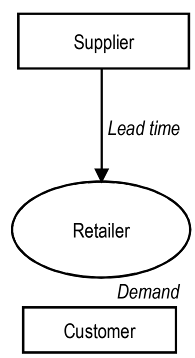

Figure 2.
Two-Echelon Network

However, in the multi-level (multi-stage) structure, agents are present at every distribution level, entering a relationship with a higher-level intermediary (Czwajda & Kosacka, 2017). Figure 2 shows the situation of a simplified two-echelon supply chain system, with one supplier supply one warehouse and one warehouse served one retailer. In this situation, we need to consider the replenishment lead time of each echelon and the decision to hold safety stock in the warehouse or retailer. You & Grosmaan (2010) stated that one of the most significant differences between single-stage inventory systems and multi-echelon inventory systems is the lead time. For a single-stage inventory system, lead time, which may include material handling time and transportation time, is exogenous and generally can be treated as a constant. However, for a multi-echelon inventory system, the lead time of a downstream node depends on the upstream node's inventory level and demand uncertainty, and thus the lead time and internal service level are stochastic.

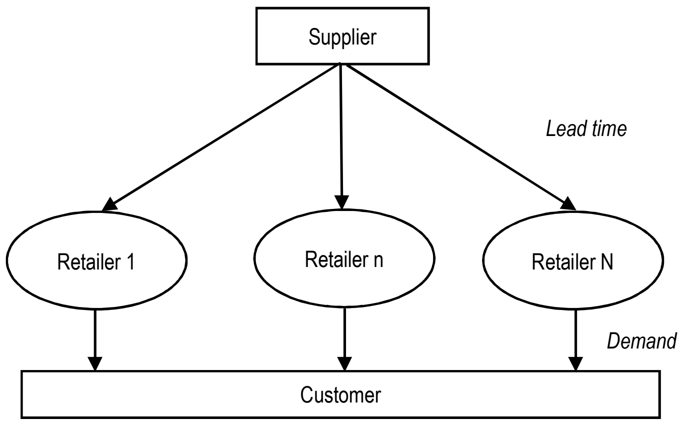

Figure 3.
Single-Echelon Network with One Supplier Supply Many Retailers

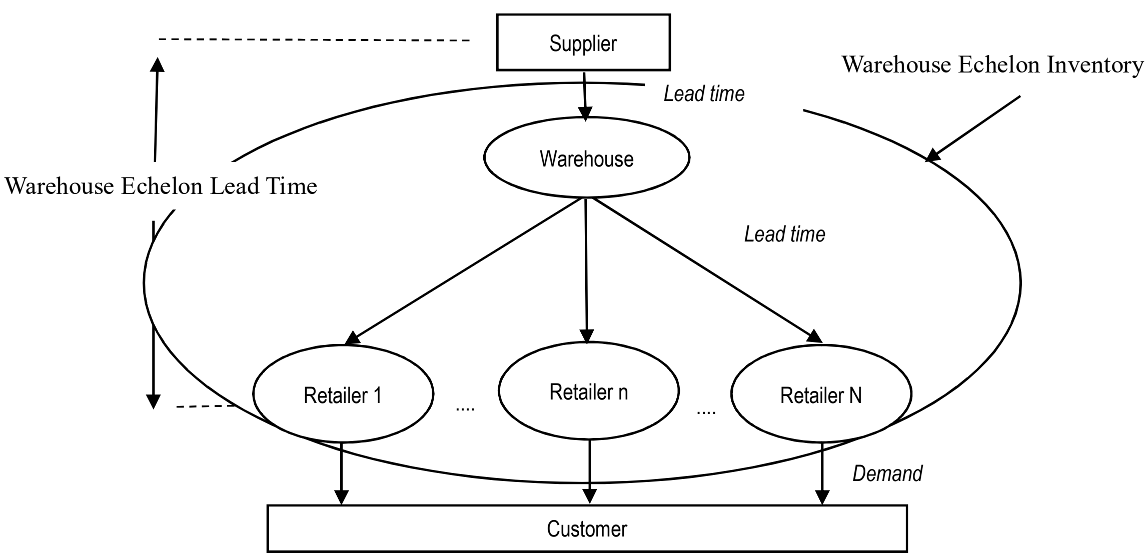

Figure 4.
Two-Echelon Network with One Warehouse Served Many Retailers

Centralization of storage has been a topic of interest in logistics since distribution networks began to be diffused. In a single-echelon inventory system with one supplier supply multiple stocking locations (figure 3), inventory cost can be decreased by saving safety stock by grouping each retailer's demand (Eppen, 1979). This practice was called risk pooling effect or centralized mode.

For two stage-echelon networks with one warehouse served many retailers, such as shown in figure 4, we can also practice the risk-pooling effect by considering the lead time for each echelon. In a centralized system, to optimize the inventory level, we can use the multi-echelon inventory technique (Simchi-Levi et al., 2008). A multi echelon system's objective is to decrease total costs by coordinating orders across the supply chain (Chopra & Meindl, 2007). In a multi-echelon setting, reorder points, and order-up-to levels at any stage should be based on echelon inventory and not local inventory (Simchi-Levi et al., 2008).

Whenever the echelon stock falls to or below the reorder point, order as EOQ is needed to increase the echelon inventory stock above the reorder point. In a decentralized case, the reorder point is calculated individually on its echelon, while centralized case, the reorder point is calculated based on the aggregate demand of the lower echelon. Thus, a distributor (in this case is the pharmacy's warehouse) should decide its safety inventory levels based on the level of safety inventory carried by all retailers (in this case is the pharmacy's outlet branch) supplied by it. The more safety inventory the outlet branch carry, the less safety inventory the warehouse needs to carry. As retailers decrease the level of safety inventory they carry, the distributor has to increase its safety inventory to ensure regular retailers' regular replenishment (Chopra & Meindl, 2007). In other words, inventory in each stage should be synchronized to lower total cycle inventory, which will decrease the total cost. In a multi-echelon inventory system, it is also important to group retailers based on their order frequency (Chopra & Meindl, 2007). The replenishment policy of high-demand retailers should be differentiated from low-demand retailers to maintain efficiency and responsiveness in the supply chain.

According to Lee (2003), the multi-echelon approach's primary objective is to minimize the total inventory level in all spheres of the regional distribution center/warehouse and distribution channel or retailer while satisfying service commitments to end customers. What is more, the concept also considers the impact of the costs of transport and warehouse operations because their cost factors are part of the optimization. Czwajda & Kosacka (2017) also mentioned that the concept of multi-echelon inventory management provides possibilities for optimization throughout the supply chain, but it needs a holistic perspective. To implement the concept of multi-level inventory management to ensure current access to data at multiple levels of the supply chain simultaneously, there is a need for an efficient, complete, and transparent information flow throughout the supply chain. It is related mainly to the following data, including demand, inventories, lead times, and the factors causing an unexpected increase in stocks.

3. Methodology

In this paper, a case study approach is adopted to investigate the pharmacy company's inventory level in Indonesia with a two-echelon inventory. Using a case study will help us gain in-depth knowledge and understanding of what is going on within an organization. The study involves two echelons in the supply chain, the central warehouse, and 16 branches retailer.

The methodology used in this research is shown in figure 5. To carry out the study, first, we did the interview. Semi-structured interviews were carried out at the central warehouse and the branches. Interviewees included the company owner, inventory control staff, IT managers at the central warehouse, and pharmacy staff to map the business process and determine the problem they faced. We collected the information on the current inventory policy and delivery process at the central warehouse, and the supported IT systems.

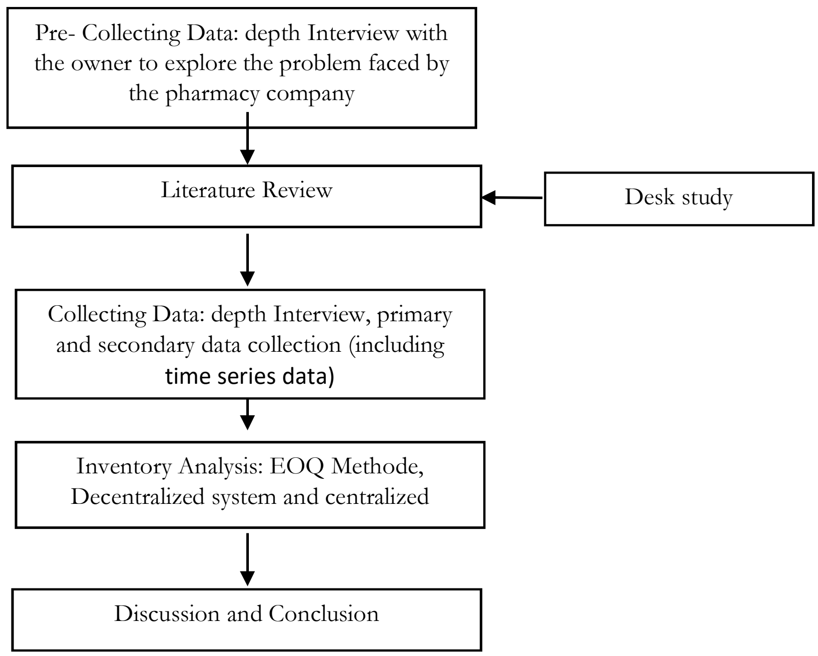

Figure 5.
Research Methodology

Next, we implemented a desk study to do the literature review. The literature review was performed to determine the right method to solve the company's inventory problem. The research was achieved using a qualitative and quantitative method. The qualitative method was used to collect the data. Meanwhile, the quantitative method was used to process and analyze the data. Since the data is very vast, we use Tableau software and Microsoft Excel program to process them, and then to analyze the data, we conduct the EOQ method and multi-echelon inventory technique to produce the needed information by the company in reducing their inventory cost. Then, we collected data, both primary and secondary data, including time-series data provided from IT systems.

In data analysis, we implemented the continuous review (Q, R) policy for the inventory system at the warehouse and the retailer with a probabilistic EOQ model. Hence, when the demand occurs at the branches, it is fulfilled from the branches' available stock. Under this policy, the inventory position is checked continuously; when it declines to the reorder point R, a batch size Q is ordered to the central warehouse. For the probabilistic EOQ model used in this research, the model's main assumption is that the demand per unit time follows the normal distribution with mean demand d and standard deviation σ. Meanwhile, the lead time is assumed to be constant. Variable costs used are setup cost and holding cost, and inventory is received instantaneously and complete. Another assumption is that stock out can be circumvented if orders are placed at the right time.
A batch size Q is calculated using:

$$Q = \sqrt{\frac{2DS}{H}}$$

whereas;
Q = Economic Order Quantity
D = Annual demand ($d \ x \ 12 \ months$)
S = Setup cost
H = Holding cost

This study considers a two-level supply chain consists of one central warehouse and 16 branches. The proposed model's objective is to compare the average inventory level in the centralization and decentralization inventory replenishment context. Each branch tries to optimize its own total cost in a decentralized case by performing continuous review (Q, R) policy independently from other branches (local optimization). While in centralized inventory replenishment, the central warehouse attempts to find a global optimization for all chains by aggregating the demand from all branches and performing continuous review (Q, R) policy centrally.

In the decentralized case, the Reorder point (R) is calculated using:

$$R = dL + SS$$

where:

dL = expected demand during lead time

SS = safety stock

Moreover, the total safety inventory in decentralized option is calculated using:

$$Total\ SS = \sum_{i=1}^{k} F_S^{-1}(CSL) \times \sqrt{L} \times \sigma_i$$

where:

CSL = Customer service level

L = Replenishment lead time

σ_i = Standard deviation of weekly demand in branch i, $i = 1, \ldots, k$

While in centralized case, multi-echelon Reorder point (R) is calculated using:

$$R = (L^e \times d) + (z \times \sigma \times \sqrt{L^e})$$

where:

$L^e =$ echelon lead time, defined as the lead time between the retailers and the warehouse plus the lead time between the warehouse and its supplier

$d =$ average demand across all retailers

$z =$ safety factor associated with the service level

$\sigma =$ standard deviation of aggregate demands across all retailers

Furthermore, the total safety stock for a centralized case is calculated using:

$$Total\ SS = F_S^{-1}(CSL) \times \sqrt{L^e} \times \sqrt{k}\sigma_D$$

where:

$k =$ number of regions

σ_D = standard deviation of aggregate demand

The inventory position is defined as the on-hand inventory plus stock on order. After an order is placed with the warehouse, an effective lead time L takes place between placing the order and receiving it. For the central warehouse, the inventory policy is the same at the branches, i.e., the continuous review (Q, R) policy. Then we compared the average inventory level both with the decentralization system and centralization system. The average inventory level is calculated using:

$$AIL = \frac{1}{2}Q + SS$$

Overview of the pharmacy company

The company is one of the healthcare providers located in West Java. They serve 16 units of pharmacy stores throughout West Java. The company has one central warehouse located in Bandung. At present, the company has already implemented a simple system to manage its inventory. Related to the ordering process, the existing mechanism required each branch to order to the warehouse. The order guideline for each branch is the maximum order, which is the maximum allowable inventory level, and the minimum order, which is the minimum inventory level. When the stock in each branch touches the minimum order point, then they must reorder the respective item to the warehouse. The amount to be ordered is the maximum order minus the minimum order. Maximum order and minimum order are changeable and determined based on the estimation of the demand.

Currently, the company has already implemented an IT system to know the real-time inventory level. Therefore, the company can implement a continuous review policy by the system because the IT system has already supported the process. However, the company does not record the inventory level status periodically. The absence of a periodic written record of inventory level becomes the system's weakness, which leads to a shortage of research data. Furthermore, even though they have implemented their own system, the management still thinks they have a very high operation cost. The high operation cost is related to their high inventory. The company also did not have the exact number that indicates the excess inventory because they have no criteria to determine whether an inventory level is too high or too low.

Furthermore, the company does not have a method to determine the appropriate amount of order since currently, the company does not have any inventory model. Having the appropriate order amount will help the company obtain the right inventory level and reduce its inventory cost. To guarantee constant availability of drugs and medical supplies, pharmacy stores must be organized efficiently using appropriate inventory management techniques (Roy, Manna, & Sarker, 2010). As a start, the company can implement a probabilistic EOQ inventory model to manage its inventory level since the model is robust and the total inventory cost is effectively proven to be insensitive to order quantities (Basri, Farmaciawaty, Adhiutama, Widjaja, & Rachmania, I. N. (2018) also has proven that the probabilistic inventory control model is the most approachable method to be used by the hospital.

4. Findings and Discussion

This research analyzed medicine sales' historical data and the company's on-hand stock from January 2015 until May 2016 (17 months). The data contain information about items, item's code, date, quantity sales, price, and on-hand medicine stock. All of these data are acquired from the company information system. We use sales as demand data to calculate the inventory level since the company does not have demand data. The company currently has 16 outlet branches and consists of 4,471 pharmacy items in general, and for class A items, the total is 1,400 items. Class A consists of items that give more value to the company. To obtain the categorization of the class, we perform the ABC classification technique.

The company's distribution network is following the two-stage supply chain with one party supply many retailers (as seen in figure 4). To generate the optimal solution for the company inventory problem, this research compares 3 inventory models: the existing policy in the company, the decentralized model using probabilistic EOQ model, and the centralized system using the multi-echelon inventory technique. In the existing condition, the company has the policy to have no stock in their warehouse. Thus, the stock is kept in each of their outlet branches, and the warehouse becomes a temporary transit. The information to order comes from the minimum order and maximum order sent from each branch outlet. The minimum order and maximum order were determined based on the consideration from each branch. In the existing condition, we calculated the company's actual stock and the average inventory level based on the on-hand stock.

In the decentralized system, the warehouse also did not keep the inventory, and the purchasing information comes from the EOQ and ROP that the authors calculate using the probabilistic EOQ method. In the decentralized system, we only consider the lead time from the retailer to the warehouse instead of the echelon lead time. Thus, in this method, we did not consider the multi-echelon supply network situation. Meanwhile, in the centralization system, safety inventory will be kept in the warehouse. We also use echelon lead time to calculate the reorder point, and the purchasing information comes from the centralized EOQ and ROP, which we calculate using the multi-echelon technique. To calculate the EOQ and ROP for each option, we use an assumption that setup cost is Rp 5.000- per unit per year, holding cost is 26 percent of the unit cost, the service level is 95%, and lead time to order goods from outlet branch to the warehouse in decentralization system is one day. For the centralization system using the multi-echelon method, the echelon lead time is four days, leading time from outlet branch to the warehouse (one day), and lead time of ordering goods from warehouse to supplier (three days).

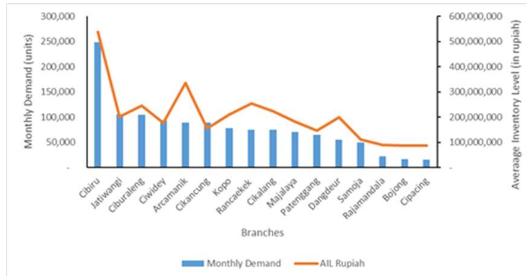

Figure 6
Monthly Demand and Average Inventory Level for all Class

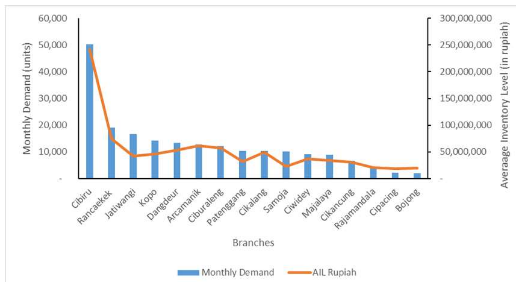

Figure 7
Monthly Demand and Average Inventory Level for Class A Items Only

The analysis result shown in Figures 6 and 7 below shows that each branch has different demand and different average inventory levels, either for all class or class A items only.
Figures 6 and 7 show that Cibiru has the highest demand and stock the highest average inventory. However, the branch with the lowest demand for all classes is the Cipacing branch, and the branch with the lowest demand for class A item is the Bojong branch. For this situation, the company should group the branch based on the number of demand since the high demand branch's replenishment policy is different from the low demand branch (Chopra & Meindl, 2007).

By grouping the branches, the company can differentiate which branch has high ordering frequency with low ordering frequency. The branch ordering more than the warehouse, the branch ordering frequency is an integer multiple of the warehouse's frequency. As for the branch ordering less frequently than the warehouse, the warehouse's ordering policy is an integer multiple of the branch's frequency. By knowing this information, the company will be able to cross-dock the inventory more efficiently.

The company should also take over the ordering control process. At the moment, each branch does the ordering process to the warehouse by themselves. Whenever the stock is lower than the minimum level, the branch will make the ordering process to the warehouse. Since the company has already implemented an IT system and knows the inventory situation in each branch in real-time, the company should control the ordering process. That way, the company can: synchronized the inventory level in each echelon, manage safety inventory level in the warehouse and each branch per the conditions of demand and supply, and reduce the ordering time. In the end, the company can lower the total cycle inventory and decrease the total cost.

The average inventory level for all classes is more fluctuated than the average inventory level for class A items. From figure 6, we can also see that several branches stock more inventory than other branches that have similar demand. For example, Arcamanik branch stocks more inventory than Ciwidey and Cikancung branch even though they have similar demand. Another example is Rancaekek branch; even though Rancaekek has similar demand with Kopo, Cikalang, Majalaya, and Patenggang branch, Rancaekek stocks more inventory. From this situation, we can see that several branches practice inventory hoarding for fear of not meeting customer demand.

This situation makes all the more reason for the company to control the ordering process. Thus the company can avoid the situation where one branch overstock items, and the company will also distribute inventory fairly. We also found out that, in general, their inventory level is in understock condition (Table 1).

Table 1
Overstock and Understock Condition in the Company for All Items and Class A Items

**in rupiah*

	TOTAL ITEMS		CLASS A ITEMS	
Branch	**overstock**	**understock**	**overstock**	**understock**
1. Cibiru	71,320,180	- 410,240,491	62,123,313	- 103,616,351
2. Rancaekek	67,613,172	- 88,507,436	59,649,739	- 6,715,670
3. Cikalang	59,290,176	- 84,463,818	52,355,729	- 6,288,481
4. Ciburaleng	35,174,403	- 117,451,229	30,323,435	- 10,153,396
5. Dangdeur	62,104,336	- 64,932,069	98,753,879	- 4,718,976
6. Samoja	22,570,178	- 43,890,608	17,940,144	- 2,822,514
7. Jatiwangi	47,393,356	- 75,372,523	41,096,205	- 4,398,688
8. Cikancung	35,266,778	- 63,320,172	28,542,194	- 3,171,822
9. Majalaya	38,364,680	- 75,467,235	33,591,369	- 5,771,435
10. Cipacing	26,654,931	- 27,659,904	20,327,432	- 1,509,065
11. Kopo	53,570,217	- 80,015,728	44,249,687	- 4,631,115
12. Ciwidey	33,053,575	- 74,943,740	26,724,091	- 5,502,732
13. Patenggang	27,365,734	- 58,202,783	22,214,947	- 4,349,652
14. Rajamandala	21,127,356	- 31,078,023	15,980,559	- 2,861,714
15. Bojong	29,799,067	- 25,305,784	22,313,230	- 1,901,543
16. Arcamanik	87,453,702	- 86,144,710	82,127,191	- 7,016,773
TOTAL	**718,121,839**	**- 1,406,996,251**	**658,313,141**	**- 175,429,922**

Table 2.
Comparison of Inventory Level

	Existing policy	**Decentralized System**	**Centralized System with Multi-Echelon Inventory Technique**
Safety Stock (units)	-	60,316	8,539
AIL (Rupiah)	Rp1,224,224,046	Rp843,060,725	Rp471,428,895
GAP	Rp0	Rp381,163,321 (31%)	Rp752,795,151 (61%)

From the table below, we can see that for total items in the company; the overstock level is Rp 718,121,839; meanwhile, the understock level is Rp 1,406,996,251. The gap between the overstock items and the understock items is Rp 688,874,412, which means that the company is lacked in anticipating demand from the customer. However, if we consider the Class A items only, then the inventory level condition is in an overstock state. In the class A items, the gap for the overstock state is very high, which is Rp 482,429, 922. The situation shows that the com company tends to invest more in items with high value even though most of the top demand items are in the B and C class.

Regarding the inventory level, we compare the 3 options for items in class A only (table 2). The average inventory level (AIL) in the existing policy is Rp 1,224,224,046; in the decentralized system using the probabilistic EOQ model in each branch, the AIL value is only Rp 843,060,725. If the company implements this option, it can save 31% (Rp 381,163,321) from its inventory investment. In the centralized system using the multi-echelon inventory technique, the company will save 61% or Rp 752,795,151. In the decentralized system, each branch will have its own safety stock, and the total is 60.316 units; meanwhile, in the centralized system, the safety stock is aggregated and keep in the warehouse only. Since the safety stock is aggregated; thus, the warehouse can carry lower safety stock and reduce each branch's high inventory level. This result is in accordance with research done by Chen, Mao, and Fang (2016), which shows that the two-echelon centralized inventory control model can reduce inventory cost and improve service and is better compared to the two-echelon decentralized inventory control model.

5. Conclusions

To conclude, each branch has a different demand profile. The company should group the branch based on the demand number and ordering frequency, making the replenishment policy and the cross-docking inventory from the warehouse to each branch more efficient. The company should also control the ordering process since they already have an information system that supports checking stock in real-time at each branch. By implementing this policy, the company will be able to manage safety inventory in each echelon efficiently.

From the finding, we can see that the company tends to invest more in items categorical as high-value items in class A items, even though they are in understock condition. Saving made by reducing the inventory level in the overstock items can be used to invest in the understock items and other operational expenses. The understock situation also tells us that the company is lacked in anticipating the upcoming demand from the customer. Meanwhile, if the company implement the policy in a decentralized system, the company will be able to save 31% of their inventory cost, and if they implement the centralized system, the company will be able to save 61% of their inventory cost. Implementing the decentralized system will increase the customer lead time, which will eventually make the company's response time much shorter since they stock their inventory in much closer facilities to the customer. Meanwhile, by implementing the centralized system, the company will be able to decrease their safety stock, decreasing their inventory cost. Therefore, the implementation of these options will be depended on the company's strategic decision, whether they will maintain the service level in their outlet branch or keeping the low inventory level to save the inventory cost. Besides, implementing those two methods also will impact the transportation cost. However, the net impact on total transportation cost is not clear yet; it will need further research to calculate the transportation cost.

All in all, this research confirms that a two-echelon centralized inventory control model can reduce inventory cost while maintaining service level and is better compared to a two-echelon decentralized inventory control model. However, to decide which model should be implemented, the company should refer to its competitive strategy, whether it prioritizes efficiency or responsiveness. Future research extension could examine the average inventory level and the safety stock for all class not only limited to the class A items also the transportation cost, thus the company will have a better picture of the real condition of their inventory level and apply the more appropriate strategy to decrease their inventory cost while maintaining their service level.

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