Integration of ABC-XYZ Analysis in Inventory Management Optimization: A Case Study in the Health Industry

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Abstract

During the pandemic, the health sector has taken the lead. This is due to the growing demand for medical equipment and medications to treat COVID-19, which has caused the healthcare industry to expand. Manufacturing industry developments are inextricably linked to the strength of the supply chain. Inventory management is a vital activity in supply chain management since, to fulfil consumer demand, especially during a pandemic like this, medical equipment supplies raw materials must be accessible to avoid stockouts, which have a serious effect. Given these conditions, further investigation is required. This study aims to create an adequate inventory policy for medical items based on characteristics. Inventory policy is defined by categorizing commodities using the ABC and XYZ classification methods integrated. Based on the list of products and demand information, these things are categorized and prioritized in problem-solving to create improved and effective inventory management techniques.

Keywords
Inventory Management, Pandemic Covid-19, Health Care Industry, ABC Analysis, XYZ Analysis.

1. Introduction

The global outbreak of Coronavirus Disease 2019 (COVID-19) has had a significant influence on many fields of life. The pandemic has terrified billions of people in various regions of the world with lockdown and social distancing regulations, even though this is done to slow the rate of transmission of the COVID-19 virus. In practice, everyone is expected to follow health procedures and provide immunizations to those who fit the criteria. As a result, the demand for medical equipment such as syringes, masks, and pharmaceuticals skyrockets.

As during epidemic, the health industry has played a leading role. This is because the growing demand for medical equipment and medications to treat COVID-19 has caused the healthcare industry to expand. Industrial sector growth is intricately bound to the strength of the supply chain (Natalia 2021). Inventory management is a critical component of supply chain management to satisfy customer demand (Kim et al. 2015). In order to meet consumer demands, raw material inventory management plays a critical role. Inventory management is the act of planning and controlling inventory to balance supply and demand and satisfy customer demands while reducing overall inventory investment (Singh and Verma, 2018). According to this definition, inventory is an item offered by the corporation that may be utilized to satisfy future demand.

Inventory management necessitates an examination of each item's properties. This is done to decide the best inventory policy for each item based on its characteristics. The ABC method (the level of importance of each group of goods) and XYZ (demand variation) are used in this study to classify raw materials and components, and the relationship between the classification approach and inventory control applied to each of the resulting characteristics are proven through performance. The entire system is dependent on the combination of the two (Conceico et al. 2015; Lolli et al. 2017). Several previous studies discuss inventory management in the health industry. Hovav and Tsadikovich (2015) researched the development of an inventory management model in managing vaccine distribution.

Meanwhile (Stecca et al. 2016) analyzed network design and drug inventory management. Cappanera et al. (2019) analyzed the inventory control system for drugs considering the impact of healthcare stakeholders. Several types of research on classification analysis on inventory management with ABC-XYZ have been conducted meanwhile, including (Scholz-Reiter et al. 2012; Chichulina and Skryl, 2018; Konikov, 2019; Stevic and Merima, 2021), although few cover this analysis in the healthcare industry.

1.1 Objectives

Given the importance of inventory management in the health care industry, the purpose of this research is to develop inventory management strategies for raw materials and components used in the manufacture of medical equipment in this sector. The decision is made based on the features of each item in order to acquire the best inventory policy.

2. Literature Review

2.1 Inventory Management

Inventory is a resource that is idle and awaiting further processing. The term "additional processes" refers to the manufacturing system's production process, marketing operations in the distribution system, or consumption in houses, offices, and so on (Bahagia, 2006, in Fauziah, et al. 2016). Inventory control is a strategy that guarantees that all consumer demands are satisfied at the lowest possible cost. The quantity of operational and safety stock is determined by inventory policy, which includes the amount to be ordered, the time of order, and the amount of safety stock. In order to carry out an inventory policy, inventory control procedures that conform with the company's conditions are required (Bahagia, 2006).

2.2 Form and Type of Inventory

According to their existence, there are at least three types of inventory in manufacturing: (Bahagia, 2006).

1. Raw materials are inputs from the manufacturing process converted into final goods. The availability of raw materials has a significant impact on the manufacturing process. Thus, it must be controlled carefully and accurately. This inventory is often imported from outside the manufacturing firm and held in receiving storage.
2. Work in Process is a transition from raw materials to finished products. Because the transformation process takes a long time in make-to-order manufacturing enterprises, an inventory of semi-finished items cannot be avoided. Meanwhile, in a make-to-stock manufacturing system, an inventory of semi-finished items may arise due to process features or an imbalanced production line.
3. Finished Goods are the ultimate result of the manufacturing transformation process that is ready to be sold to customers. The finished items are held at the finished goods warehouse before being given to needy clients. In manufacturing companies that make to stock, finished goods are stored first until consumers come to buy, whereas in manufacturing companies that make to order, if the finished goods have been produced, consumers will take them immediately, so there is rarely a finished goods inventory warehouse in the area.

2.3 ABC Analysis

ABC analysis classifies each item depending on yearly investment absorbed in inventory acquisition. By utilizing the Pareto principle, commodities may be categorized into three types (Bahagia 2006):

1. Category A (80-20) consists of the types of products that absorb 80 per cent of total capital, with the number of goods accounting for around 20 per cent of all types of goods handled.
2. Category B (15-30), Kinds of goods that absorb about 15% of total capital given for inventory (after category A), with the number of types of goods accounting for approximately 30% of all types of goods handled.
3. Category C (5-50) consists of the kinds of goods that absorb just about 5% of total capital and the number of types of goods that absorb approximately 50% of all types of goods managed.

In ABC analysis, the Pareto diagram is organized based on the cumulative proportion of capital absorption and the percentage of different categories of commodities. Several pieces of information are required for this study, including the number of uses of each kind of good in one year and the price per unit of products.

2.4 XYZ Analysis

XYZ analysis is an analysis that categorizes each object depending on the variation of its use. This analysis divides the product into three categories:

1. X-class is an item with constant demand that has very little change and can be forecasted with high accuracy.
2. Y-class goods with variable demand with modest changes and a medium level of predicting accuracy.
3. Z-class, the number of requests for various commodities varies greatly from time to time and is impossible to estimate.

Based on the Variation Coefficient (CV), the parameters that have been set are XYZ analysis classification ranking (Sommerer, 1998) in (Stojanovic and Regodik, 2017):

- Class X with Coefficient of Variation less than 0.5.
- Class Y with a Coefficient of Variation between 0.5 and 1.
- Class Z with Coefficient of Variation greater than 1.

2.5 Integration of ABC and XYZ Analysis

Combining these two analyses is accomplished by first completing an ABC analysis and then an XYZ analysis. This integration yields nine criterion features in the form of a matrix (Schönsleben, 2016) as shown in Table 1.

Table 1. Integration of ABC and XYZ Analysis

Demand Variation	**Consumption Value**		
	A	**B**	**C**
X	High Value Very little variation	Medium Value Very little variation	Low Value Very little variation
Y	High Value Some variation	Medium Value Some variation	Low Value Some variation
Z	High Value The most variation	Medium Value The most variation	Low Value The most variation

According to (Buliski et al., 2013), when defining inventory policy based on the ABC-XYZ categorization findings, it is separated into two groups, the first of which includes classes AX, AY, AZ, BZ, and CZ. The second group includes BX, BY, CX, and CY classes. The first category must be purchased based on stock information since it contains high-value items with variable demand. Category 2 should be regularly inspected since it comprises moderate to low-value items and less variable demand.

3. Methods

Research data were obtained by direct observation and interviews with the inventory department. Data on inventory and usage of equipment and raw materials in one year and their corresponding costs are required for this research. After all the data is collected, the calculations are performed using ABC analysis first, followed by XYZ analysis. The formula utilized in this study is as follows:
The following are the steps in the classification of goods using ABC analysis by describing a Pareto diagram,

a. Calculate the amount of absorption of funds for each type of goods per year (Mi), namely by multiplying the amount of use of each type of goods per year (Di) with the unit price of goods (Pi), mathematically it can be stated:
$M_i = D_i \text{ x } P_i$ (1)
b. Calculate the total absorption of funds for all types of goods.
$M = \sum Mi$ (2)
c. Calculate the percentage of absorption of funds for each type of goods (Pi)
$P_i = \frac{Mi}{M} \text{ x } 100\%$ (3)
d. Calculate the percentage of each type of item.
e. Sort the percentage of absorption of funds according to the order of the percentage of absorption of funds, starting from the percentage of absorption of funds from the largest to the smallest.
f. Calculate the cumulative value of the percentage of absorption of funds and the cumulative value of the percentage of types of goods based on the order obtained in step e.
g. Determine the categorization of goods

Then, XYZ analysis is performed by determining the value of coefficient of variation (CV) equation is as follows,

$$CV = \frac{\sigma}{\overline{x}} \quad (4)$$

Where is the standard deviation with the following equation,

$$\sigma = \sqrt{\frac{\Sigma(x-\bar{x})^2}{N}} \quad (5)$$

And $\bar{x}$ is the average of each of these categories with the equation below,

$$\bar{x} = \frac{\Sigma x}{N} \quad (6)$$

Where x is the number of the use of raw materials and components and N is the number of period.

The categorization of each raw material and component is then obtained by combining the two analyses. After understanding each attribute, the best form of policy, whether continuous or periodic, will be chosen.

4. Data Collection

Data collection is done through the medical device company. The data needed include the amount of use of raw materials and components as well as the price per unit. Table 2, Table 3, and Table 4. below show the data used in this study.

Table 2. Data Collection of Raw Material

Item Code	Amount of Usage (Unit)	Price (Rp/ unit)
PPSCG	607225	Rp27.070
PP	446700	Rp27.070
EPOXY	3131	Rp543.226
PPM	60000	Rp27.070
ETO90	12005	Rp130.000
SILOIL	1797	Rp615.306
INKCT	1356	Rp468.000
SOLVENTNH	13228	Rp28.000
SILCOM	239	Rp1.523.962
PPHY	11475	Rp27.070
ETO30	4000	Rp58.000
PIGV	1567	Rp129.000
RCT	1878	Rp86.000
PPHO	5150	Rp27.070
ETO80	420	Rp120.000
RFCT	150	Rp86.000
PIGG	25	Rp129.000

Table 3. Data Collection of Components

Item Code	Amount of Usage (Unit)	Price (Rp/ unit)
BJMI05MLK1	276240000	Rp89
GLY05MLK1	349526250	Rp41
NK24G05MLK1	72075000	Rp78
NBLY24G05MLK1	20960000	Rp78
PLJMI05MLK1	12440000	Rp74
CANPT23G05ML	36009000	Rp25
GPT5MLK1	15000000	Rp41
GPT005MLOJI2	14400000	Rp41
GPT05MLK1	14300000	Rp41
GPT3MLK1	9500000	Rp41
CANPT21G5ML	15000000	Rp25

Table 4. Data Collection of Components

Item Code	Amount of Usage (Unit)	Price (Rp/ unit)
CANPT22G1ML	15000000	Rp25
CANPT23G3ML	13600000	Rp25
GJMI05MLK1	4388200	Rp41
NPT24G05MLK1	2250000	Rp78
NSM24G05MLK1	2000000	Rp78
CANPT24G05ML	2625000	Rp25
PLLY05MLK1	616000	Rp74
CANPT27G005ML	1905000	Rp23

Tables 2, 3 and 4 provide statistics on the consumption of seventeen raw materials and nineteen components throughout one year, from January to December 2021. Then, using formulae 1-6, computations are performed. The ABC analysis generates a classification of raw materials and components based on the proportion of investment invested, whereas the XYZ analysis generates a classification based on fluctuations in demand based on the coefficient of variation value.

5. Results and Discussion

5.1 ABC Analysis

The ABC item analysis is based on a twelve-month investment consumption.

- A-items: 0-80 per cent of the cumulative consumption value.
- B-items: 80-95 per cent of the cumulative consumption value
- C-items: 95-100 per cent of the cumulative consumption value.

Table 5 and 6 displays data for ABC analysis for 17 different types of raw materials, including the quantity of usage, price per unit, and consumption value, which are sorted in the fourth column from the largest to the smallest and computed based on the unit price and the number of goods utilized. The derived value serves as the foundation for calculating the proportion of consumption of specific product investments in sales volume and the percentage of the cumulative value of consumption of products.

Table 5. Result ABC Analysis of Raw Materials

Item Code	Amount of Usage (Unit)	Price (Rp/ unit)	Consumption Value	% Consumption Value	% Cumulative	Group
PPSCG	607225	Rp27.070	Rp16.437.580.750	44,4%	44,4%	A
PP	446700	Rp27.070	Rp12.092.169.000	32,7%	77,1%	A
EPOXY	3131	Rp543.226	Rp1.700.840.606	4,6%	81,7%	B
PPM	60000	Rp27.070	Rp1.624.200.000	4,4%	86,1%	B
ETO90	12005	Rp130.000	Rp1.560.650.000	4,2%	90,3%	B
SILOIL	1797	Rp615.306	Rp1.105.705.763	3,0%	93,3%	B
INKCT	1356	Rp468.000	Rp634.608.000	1,7%	95,0%	C
SOLVENTNH	13228	Rp28.000	Rp370.384.000	1,0%	96,0%	C
SILCOM	239	Rp1.523.962	Rp364.226.947	1,0%	97,0%	C
PPHY	11475	Rp27.070	Rp310.628.250	0,8%	97,8%	C
ETO30	4000	Rp58.000	Rp232.000.000	0,6%	98,5%	C
PIGV	1567	Rp129.000	Rp202.143.000	0,5%	99,0%	C

RCT	1878	Rp86.000	Rp161.508.000	0,4%	99,4%	C

Table 6. Result ABC Analysis of Raw Materials

Item Code	Amount of Usage (Unit)	Price (Rp/ unit)	Consumption Value	% Consumption Value	% Cumulative	Group
PPHO	5150	Rp27.070	Rp139.410.500	0,4%	99,8%	C
ETO80	420	Rp120.000	Rp50.400.000	0,1%	100,0%	C
RFCT	150	Rp86.000	Rp12.900.000	0,0%	100,0%	C
PIGG	25	Rp129.000	Rp3.225.000	0,0%	100,0%	C

Three product groupings may be identified based on the accumulation of selling points:
Group A contains two raw material items with an accumulated investment value of 77.1 per cent; Group B contains four products with an accumulated investment value of 16.2 per cent, and Group C contains eleven products with an accumulated investment value of 6.7 per cent.

Table 7. Result ABC Analysis of Components

Item Code	Amount of Usage (Unit)	Price (Rp/ unit)	Consumption Value	% Consumption Value	% Cumulative	Group
BJMI05MLK1	276240000	Rp89	Rp24.585.360.000	47,3%	47,3%	A
GLY05MLK1	349526250	Rp41	Rp14.330.576.250	27,6%	74,9%	A
NK24G05MLK1	72075000	Rp78	Rp5.621.850.000	10,8%	85,8%	B
NBLY24G05MLK1	20960000	Rp78	Rp1.634.880.000	3,1%	88,9%	B
PLJMI05MLK1	12440000	Rp74	Rp920.560.000	1,8%	90,7%	B
CANPT23G05ML	36009000	Rp25	Rp900.225.000	1,7%	92,4%	B
GPT5MLK1	15000000	Rp41	Rp615.000.000	1,2%	93,6%	B
GPT005MLOJI2	14400000	Rp41	Rp590.400.000	1,1%	94,7%	B
GPT05MLK1	14300000	Rp41	Rp586.300.000	1,1%	95,9%	C
GPT3MLK1	9500000	Rp41	Rp389.500.000	0,8%	96,6%	C
CANPT21G5ML	15000000	Rp25	Rp375.000.000	0,7%	97,3%	C
CANPT22G1ML	15000000	Rp25	Rp375.000.000	0,7%	98,1%	C
CANPT23G3ML	13600000	Rp25	Rp340.000.000	0,7%	98,7%	C
GJMI05MLK1	4388200	Rp41	Rp179.916.200	0,3%	99,1%	C
NPT24G05MLK1	2250000	Rp78	Rp175.500.000	0,3%	99,4%	C
NSM24G05MLK1	2000000	Rp78	Rp156.000.000	0,3%	99,7%	C
CANPT24G05ML	2625000	Rp25	Rp65.625.000	0,1%	99,8%	C
PLLY05MLK1	616000	Rp74	Rp45.584.000	0,1%	99,9%	C
CANPT27G005ML	1905000	Rp23	Rp43.815.000	0,1%	100,0%	C

Table 7 above presents data from ABC analysis on 19 different sorts of components. According to the calculation findings, two types of components fit into group A, six goods in category B, and eleven types of components in category C. Each group earned 74.89 per cent, 19.8 per cent, and 5.3 per cent of the total investment value in components, respectively. The ABC analysis and the data obtained allowed for the categorization of items. The results give the basis for setting the priority level in issue solving decisions to obtain optimal inventory management outcomes by identifying and evaluating the relevance of the problems examined. According to (Silver et al., 2017), the proper inventory policy for class A is the periodic system (R, s, S) and continuous (s, S), but for classes B and C, the periodic system is (R, S) and (R, s, Q), and the continuous system is (s, S) (s, Q). It is up to the company to decide between periodic and continuous inventory practices, which may be evaluated through the overall inventory expenses incurred.

5.2 XYZ Analysis

The XYZ categorization was applied, with diverse product items classified into three groups:

- Group X contains things with a high usage rate, where CV < 0,5
- Group Y contains goods with an average usage rate, where 0,5 < CV < 1; and
- Group Z contains items with a low usage rate (occasionally), where CV > 1.

The findings of the XYZ analysis on 17 raw materials are shown in Table 8. In this approach, the group is determined by the coefficient variation of the commodities' consumption. The coefficient of variation (CV) is calculated by dividing the standard deviation by the average of raw material consumption.

Table 8. Result of XYZ Analysis of Raw Material

Item Code	Value of Coefficient Variation	Group
PPSCG	0,8	Y
PP	1,2	Z
EPOXY	0,3	X
PPM	2,2	Z
ETO90	0,8	Y
SILOIL	0,4	X
INKCT	1,8	Z
SOLVENTNH	0,4	X
SILCOM	0,7	Y
PPHY	3,3	Z
ETO30	1,1	Z
PIGV	0,6	Y
RCT	0,4	X
PPHO	3,3	Z
ETO80	3,3	Z
RFCT	0,8	Y
PIGG	3,3	Z

According to the findings of the XYZ analysis on the raw materials displayed in table 8, there are four types of raw materials that are classed as products with a large number of applications and minimal variation. There are five kinds of raw materials in group Y, and these features represent the average number of uses with numerous variants of usage. Group Z, which has eight goods, has a very high usage variance with a low level of use. The features of group z dominate the type of raw material, with over half of all raw materials falling into this category

Table 9. Result of XYZ Analysis of Components

Item Code	Value of Coefficient Variation	Group
BJMI05MLK1	2,4	Z
GLY05MLK1	2,0	Z
NK24G05MLK1	2,0	Z
NBLY24G05MLK1	2,0	Z
PLJMI05MLK1	2,4	Z
CANPT23G05ML	1,3	Z
GPT5MLK1	2,4	Z
GPT005MLOJI2	1,6	Z
GPT05MLK1	0,4	X
GPT3MLK1	1,3	Z
CANPT21G5ML	2,2	Z
CANPT22G1ML	3,3	Z

CANPT23G3ML	1,6	Z
GJMI05MLK1	2,4	Z
NPT24G05MLK1	3,3	Z
NSM24G05MLK1	2,4	Z
CANPT24G05ML	0,4	X
PLLY05MLK1	2,0	Z
CANPT27G005ML	2,0	Z

Table 9 presents the results of the XYZ analysis on 19 components. According to the statistics, practically all components fit into group Z, with the characteristics of a substantial change in the number of uses from time to time. There are only two types of components that fall into group X, but no types of components fit into group Y.

5.3 Integration of ABC and XYZ Analysis

Based on (Stojanović and Regodić 2017), XYZ analysis which classifies goods based on demand variability, can overcome the limitations of ABC analysis. The relationship between the classification approach and inventory control applied to each of the resulting characteristics is proven because the system's overall performance depends on the combination of the two (Conceiçąo et al. 2015; Lolli et al. 2017). After performing the ABC and XYZ analyses, a matrix is created to classify raw materials and components depending on the results of the two analyses. This matrix has nine groupings based on the integration of ABC and XYZ analysis. Tables 8 and 9 presents the ABC/XYZ categorization results.

Table 10. Result of ABC and XYZ Analysis Integration of Raw Material

	X	**Y**	**Z**
A		PPSCG	PP
B	EPOXY; SILOIL;	ETO90;	PPM;
C	SOLVENTNH; RCT;	SILCOM; PIGV; RFCT	INKCT; PPHY; ETO30; PPHO; ETO80; PIGG

Based on table 10 above, it can be seen that there is each one type of raw material that is included in the categories AY, AZ, BY, and BZ. Except for group AX with high value and little variation, which does not have a product in its group, the other groups comprise more than one type of raw material. Group CZ has the rawest materials in its category, with as many as six goods, implying that about one-third of raw materials have large consumption variations but low value.

Table 11. Result of ABC and XYZ Analysis Integration of Components

	X	**Y**	**Z**
A			BJMI05MLK1; GLY05MLK1
B			NK24G05MLK1; NBLY24G05MLK1; PLJMI05MLK1; CANPT23G05ML; GPT5MLK1; GPT005MLOJI2
C	GPT05MLK1; CANPT24G05ML		GPT3MLK1; CANPT21G5ML; CANPT22G1ML; CANPT23G3ML; GJMI05MLK1; NPT24G05MLK1; NSM24G05MLK1; PLLY05MLK1; CANPT27G005ML

The ABC and XYZ integration study results on the components are shown in Table 11. Like raw materials, the CZ category includes over half of the components, followed by the BZ category, which includes six different types of products. Moreover, the AZ and CX groups include two sorts of component goods included in the group. On the other hand, Groups AX, AY, BX, BY, and CY do not have any items in their category.

The characteristics of each raw material and component are derived from the two tables above based on the value of investment consumption and variation in their usage. Once this is determined, the firm may decide the best inventory policy based on the characteristics of each product. The features are split into nine groups with two major categories after merging these two analyses. Classes AX, AY, AZ, BZ, and CZ comprise the first category. This first category includes all Z groups with irregular demand kinds, such as having zero demand randomly over a lengthy period and having increased and reduced demand at any moment in a relatively short period. According to (Buliński et al., 2013; Conceiço et al., 2015), the first category must be based on stock information since it contains high-value items with changing demand. The second group includes BX, BY, CX, and CY classes. This group is distinguished by the presence of moderate to low-value items and less variable demand, resulting in inventory management carried out through periodic inspections (Buliński et al. 2013).

6. Conclusion

The integration of the accomplished ABC-XYZ analysis makes it easier to manage objects based on the criteria chosen. Activities performed by combining ABC/XYZ analysis allow for the identification of the company's goods based on the company's finances and the introduction of the amount of demand emergence. Businesses may use suitable and optimum strategies to predict inventory problems such as stockouts or missed sales with this connectivity. There are nine different categories of raw materials in all (PPSCG; PP; PPM; INKCT; PPHY; ETO30; PPHO; ETO80; PIGG) and 17 types of components (BJMI05MLK1; GLY05MLK1; NK24G05MLK1; NBLY24G05MLK1; PLJMI05MLK1; CANPT2300G05MLK1; GPT5MLK1; GPT5MLKML1; GPT5MLK1; CANPT21G5ML; CANPT22G1ML; CANPT23G3ML; GJMI05MLK1; NPT24G05MLK1; NSM24G05MLK1; PLLY05MLK1; CANPT27G005ML) which fall into the first category so that the right inventory policy for these products is a policy based on inventory stock information, where inventory reorder points are carried out or take into account the minimum limit for the amount of inventory that has been determined. The second category includes 8 raw materials (EPOXY; SILOIL; ETO90; SOLVENTNH; RCT; SILCOM; PIGV; RFCT) and 2 components (GPT05MLK1; CANPT24G05ML). The proper inventory policy for this group is to conduct periodic inspections depending on the time established by the firm.

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