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RESEARCH ARTICLE

Optimizing Inventory Management Using The EoQ Model: Case Study In One Of The Banks In Indonesia

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Abstract

Efficient inventory management is essential for maintaining operational excellence, particularly in the banking sector, where stock imbalances can disrupt workflows and impact service quality. This study examines inventory practices in of the Indonesia banking sector focusing on challenges like overstock and understock. Using the Economic Order Quantity (EOQ) model, the research determines optimal order quantities, safety stock, and reorder points for selected items. Analysis reveals that 27% of items were overstocked, incurring high holding costs, while understock situations disrupted operations. Root Cause Analysis (RCA) identified issues such as inefficient procurement processes and limited warehouse capacity. Recommendations include automation of inventory systems, improved procurement strategies, and optimized stock levels to enhance operational efficiency. These solutions contribute to reducing costs, improving service quality, and ensuring seamless operations.

Keyword: Inventory Management, EOQ Model, Banking Sector, Operational Efficiency

Introduction

The importance of efficient inventory management has been widely recognized across industries as organizations seek to optimize their resources, reduce costs, and improve operational performance. Inventory management goes beyond merely tracking stock levels; it involves a strategic approach to ensuring that necessary resources are available precisely when needed without incurring excess costs from overstocking or risking operational delays due to understocking.

The modern banking industry demands operational efficiency, with inventory management playing a pivotal role in ensuring uninterrupted services. Supplies like office stationery and operational tools are indispensable for daily banking activities, from administrative tasks to customer services. However, inventory mismanagement, characterized by overstocking or understocking, can lead to service disruptions, increased costs, and reduced customer satisfaction. Despite its importance, inventory optimization in the banking sector remains an underexplored area of research compared to other industries like retail or manufacturing.

In Indonesia's banking sector, inventory management plays a crucial role in maintaining operational efficiency and reducing costs. Banks handle a diverse range of inventories, from everyday office supplies to critical IT infrastructure. The relationship between inventory management and firm financial performance interests a wide audience, including shareholders, investors, and the general public (De Felice, 2014). Banks need to be both efficient and effective in their operations.Efficiency means doing something at the lowest possible cost, while effectiveness means doing the things that will create the most value for the customer (Jacobs & Chase, 2018).Value in banking can be defined as the attractiveness of the products and services relative to their price. The need for efficient and effective inventory management in the Indonesian banking sector is further underscored by the industry's dynamic growth and increasing competition.

One such strategy that has proven invaluable in optimizing inventory management within diverse industries is the Economic Order Quantity (EOQ) model. The EOQ model is a powerful tool that helps businesses calculate the optimal quantity of inventory to order at any given time, taking into account factors such as demand, holding costs, and ordering costs. By implementing the EOQ model, businesses can minimize the total cost of inventory, reduce the risk of stockouts and obsolescence, and ensure that the right amount of inventory is available at the right time to meet customer demand (Jacobs & Chase, 2018).

The evolution of inventory management has introduced several methodologies, including the Economic Order Quantity (EOQ) model, which calculates optimal order sizes to balance ordering and holding costs. Additionally, frameworks like Root Cause Analysis (RCA) provide a systematic approach to identifying inefficiencies, while tools like ABC classification enable prioritization based on item value and demand frequency. Despite the availability of these tools, many organizations face challenges in integrating them into their operations due to limited resources, lack of automation, or inefficiencies in procurement.

Method

This research employs a data collection technique that incorporates both primary and secondary data. By using both types, the study aims to enhance the reliability of the information. Data collection included detailed inventory records, procurement logs, and interviews with key personnel involved in inventory management at the bank. To achieve the research objectives, several analytical tools were employed. The Economic Order Quantity (EOQ) model was applied to determine the optimal order sizes for key inventory items, balancing ordering and holding costs. Safety stock and reorder points were calculated to ensure sufficient stock availability during demand fluctuations or procurement delays. Furthermore, Root Cause Analysis (RCA) was conducted to identify and address systemic inefficiencies in inventory processes. These methods were designed to provide actionable

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insights into the bank's inventory challenges and offer robust solutions to optimize stock management practices.

Results and Discussion

In the context of inventory management at the Bank, one of the primary challenges is finding an optimal balance between avoiding overstock and understock situations, a crucial aspect addressed by inventory management methods. The chart in figure 1 shows the total monthly demand for all items combined from January to October. The demand starts high in January at 814, then drops sharply in February to 261. The values fluctuate moderately from March to August, with no dramatic changes. However, September sees a significant dip to 210, followed by a sharp increase in October, reaching the highest demand of 1140.

Fig 1. Total Monthly Demand Graph

Economic Order Quantity (EOQ)

The Economic Order Quantity (EOQ) model is a fundamental tool used to determine the optimal order size that minimizes the total inventory costs, including ordering and holding costs. It is especially useful in banking inventory management, where operational efficiency and service continuity are paramount. By calculating EOQ, we ensure that the Bank maintains adequate inventory levels to meet demand without incurring excessive costs associated with overstocking or stockouts, This model is applied to historical data, such as the past ten months of inventory records, to provide actionable insights into ordering and stocking practices. In total there are 82 items in the Bank warehouse that categorized as stationary with a total demanded quantity of 4.964 from January 2024 to October 2024. Below is a portion of the item that's going to be analyzed.

Table 1. Portion of Inventory item from January to October 2024

Item Name	Average Monthly Demand
AMPLOP BANK	1.5
AMPLOP KACA KIRI	25.2
AMPLOP NO 1 PANJANG 42 CM X LEBAR 29 CM	4.8
AMPLOP NO 2 PANJANG 29 CM X LEBAR 21 CM A4	1
AMPLOP NO 3 PANJANG 31 CM X LEBAR 17 CM	7.3
AMPLOP NO 4 PANJANG 31CM X LEBAR 13 CM	7.3
AMPLOP PRIORITAS 1 PACK ISI 100	0.5

Fixed Order Quantity Inventory Model (Q-Model)

Effective inventory management enables a company to maintain the appropriate quantity and types of stock, ensuring smooth operations. By monitoring inventory from procurement to sales, businesses can identify trends, address potential issues, and ensure sufficient stock to meet customer demands while minimizing the risk of shortages. Consequently, selecting the right inventory control strategies is essential for accurately determining the required safety stock. This section provides examples to demonstrate how the author develops an optimized inventory management system for the Bank. Taken from one of the item example which is "AMPLOP KACA KIRI" using the fixed order quantity model (Q-model) :

1. Average Monthly Demand (d)

The average order demand is a key input in EOQ calculations, providing an estimate of the monthly demand for inventory items. This is calculated using the demand data collected over the last ten months.The average order demand reflects the typical quantity of stock needed to meet demand over a given period. This value provides the baseline for understanding regular consumption and helps in planning future inventory levels

With the calculation :

Total 10 month demand = 252 Unit

Average monthly demand = 252/10=25.2 Unit/Month

2. Standard Deviation (σ),

The standard deviation of demand is essential for calculating safety stock, as it indicates the variability in monthly demand. Higher variability suggests a greater risk of stockouts, which safety stock helps mitigate. The calculation for the standard deviation will be performed for each invidual item.Standard deviation is defined by using the actual data from January 2024 to October 2024 and using the Excel formula STDEV. Which gives result of 71.52

Table 2. Example of Calculation Standard Deviation

Item Name	Average Monthly Demand
Amplop Bank	6.07
Amplop Kaca Kiri	71.52
Amplop No 1 Panjang 42 Cm X Lebar 29 Cm	13.73
Amplop No 2 Panjang 29 Cm X Lebar 21 Cm A4	3.82
Amplop No 3 Panjang 31 Cm X Lebar 17 Cm	20.49
Amplop No 4 Panjang 31cm X Lebar 13 Cm	20.2
Amplop Prioritas 1 Pack Isi 100	1.7

3. Safety Stock (SS)

Safety stock acts as a buffer against demand variability and potential delays in lead time, ensuring inventory availability even when actual demand exceeds average demand. This additional inventory reduces the risk of stockouts, which is especially crucial in service-oriented industries like banking, this study aims for 95% service level of demand from item in stock, therefore the value of z is 1.65.

With the calculation :

Z = 1.64

σ = 71.52

Lead time (L) = 14 Days = 0.47 Month (14/30)

$$\text{Safety Stock (SS)} = z \times \sigma\sqrt{L} = 1.64 \times 71.52\sqrt{0.47}$$

Safety Stock (SS) = 81 Unit

Table 3. Example of Calculation Standard Deviation

Item Name	Safety Stock
AMPLOP BANK	7
AMPLOP KACA KIRI	81
AMPLOP NO 1 PANJANG 42 CM X LEBAR 29 CM	15
AMPLOP NO 2 PANJANG 29 CM X LEBAR 21 CM A4	4
AMPLOP NO 3 PANJANG 31 CM X LEBAR 17 CM	23
AMPLOP NO 4 PANJANG 31CM X LEBAR 13 CM	23
AMPLOP PRIORITAS 1 PACK ISI 100	2

4. Reorder Point (ROP)
The Reorder Point (ROP) signals when it is time to place a new order, accounting for the average demand during the lead time and the safety stock, the ROP can be calculated using this formula

ROP = (d x L) + Safety Stock
ROP = (25.2 x 0.47) + 81

Table 4. Example of Calculation Reorder Point

Item Name	ROP
AMPLOP BANK	8
AMPLOP KACA KIRI	92
AMPLOP NO 1 PANJANG 42 CM X LEBAR 29 CM	18
AMPLOP NO 2 PANJANG 29 CM X LEBAR 21 CM A4	5
AMPLOP NO 3 PANJANG 31 CM X LEBAR 17 CM	27
AMPLOP NO 4 PANJANG 31CM X LEBAR 13 CM	26
AMPLOP PRIORITAS 1 PACK ISI 100	2

5. Economic Order Quantity (EOQ)
The EOQ formula determines the optimal order quantity that minimizes the total cost of ordering and holding inventory. The calculation of Economic Order Quantity (EOQ) will be conducted by the author, using all the calculation said before to ensure a balance in the banking inventory management

With the calculation :
Monthly demand (d) = 25.2
Set up cost (S) = IDR 500,000
Holding Cost (H) = 10% of the unit Price
H = IDR 6,128.30 (10% x 61,283.00)
$EOQ = \sqrt{(2 \times (d \times 12) \times S)/H}$
$EOQ = \sqrt{(2 \times (25.2 \times 12) \times 500{,}000)/6{,}128.3}$ = 222Unit

Table 5. Example of Calculation EOQ

Item Name	EOQ
AMPLOP BANK	51.56
AMPLOP KACA KIRI	222.14
AMPLOP NO 1 PANJANG 42 CM X LEBAR 29 CM	73.47
AMPLOP NO 2 PANJANG 29 CM X LEBAR 21 CM A4	36.02
AMPLOP NO 3 PANJANG 31 CM X LEBAR 17 CM	108.07
AMPLOP NO 4 PANJANG 31CM X LEBAR 13 CM	111.87
AMPLOP PRIORITAS 1 PACK ISI 100	18.79

6. Average Inventory Level (AIL)
The average inventory level reflects the amount of inventory typically on hand, considering the EOQ and safety stock. It helps manage storage costs and space requirements.

With the calculation :
Average Inventory Level (AIL) = EOQ/2+SS
Average Inventory Level (AIL) = 222/2+81=192Unit

Based on the calculated actual stock in the bank warehouse, actual AIL can be calculated. The comparison between calculated and actual AIL highlights inventory performance:

(a) If Actual AIL > Calculated AIL:
- Indicates overstocking.
- Potential causes:
  - Demand was overestimated.
  - Orders arrived too early or in excess quantities.
  - Poor coordination in inventory replenishment.

(b) If Actual AIL < Calculated AIL:
- Indicates understocking.
- Potential causes:
  - Demand was underestimated.
  - Replenishment delays or lower order quantities.
  - Inventory shrinkage

(c) If Actual AIL ≈ Calculated AIL:
- Indicates optimal inventory management.
- Suggests the company's assumptions and models align well with real-world conditions

Table 6. Example of Calculation AIL

Item Name	AIL
AMPLOP BANK	33
AMPLOP KACA KIRI	192
AMPLOP NO 1 PANJANG 42 CM X LEBAR 29 CM	52
AMPLOP NO 2 PANJANG 29 CM X LEBAR 21 CM A4	22
AMPLOP NO 3 PANJANG 31 CM X LEBAR 17 CM	77
AMPLOP NO 4 PANJANG 31CM X LEBAR 13 CM	79
AMPLOP PRIORITAS 1 PACK ISI 100	11

Next is to determine which item is categorized as understock,overstock or in an optimal state. By comparing the AIL Actual (unit) and the calculated AIL (unit) the number of differences of an item will be obtained, next is to calculated how much in perchantage the gap is. The Author use this number to determine it. The values were obtained from the results of interviews with the warehouse staff.

1. Understock: Gap (%) < 0%
2. Optimal (Balanced): 0% ≤ Gap (%) ≤ +10%
3. Overstock: Gap (%) > +10%

With a calculation of :
Gap (Unit) = AIL Actual (Unit)- AIL (Unit)
Gap (%) = (Gap (unit))/(AIL Actual (unit))×100%
So the results are obtained in the table 1 below

Table 7. Inventory Status

Number of Items	Status	%	Total Value (IDR)
22	Overstock	27%	104,428,260
58	Understock	71%	205,870,665
2	Optimal	2%	3,135,740

Fig 2. Status Perchantage

Based on the analysis, it can be observed that out of a total of 82 items, 22 items (27%) are categorized as "overstock." Overstock in the banking context indicates excess inventory, such as office supplies or materials, which ties up financial resources unnecessarily and could result in increased storage costs and inefficiencies. On the other hand, 58 items (71%) fall under the "understock" category. In a banking environment, understock can lead to operational disruptions, such as delays in processing customer requests or inefficiencies in service delivery. This could negatively impact customer satisfaction, damage the institution's reputation, and ultimately result in loss of revenue due to unmet demands.Lastly, only 2 items (2%) are categorized as "optimal," indicating that they are maintained at appropriate levels to meet operational needs without incurring excess costs

ABC Classification

The ABC inventory classification is a method used to organize inventory to minimize errors. This approach divides inventory into three categories: high-dollar volume (A), moderate-dollar volume (B), and low-dollar volume (C). Dollar volume is utilized as a criterion to determine an item's significance. This system implies that items with lower costs but higher quantities may be more critical than items with higher costs but lower quantities. (Jacobs & Case, 2018).

The next step is to determine the value-based classification. Class A items have a high annual dollar volume, accounting for 80% of the total dollar usage. Class B items, with a moderate annual dollar volume, represent 15% of the total dollar utilization. Lastly, Class C items, characterized by a low annual dollar volume, contribute to only 5% of the overall dollar usage (Chopra & Peter, 2013).After analyzing the inventory data and the price of each item in the the Bank from the past 10 month, the ABC calculation obtain by using the IF and COUNT formula within the excel. the ABC classification can be seen in table below.

Table 8. ABC Classification Analysis

Class	Number of Items	Value (IDR)	Perchentage
A	26	250,046,303.70	80%
B	24	47,155,429.10	15%
C	32	16,232,931.77	5%
Total	82	313,434,664.57	100%

From the table, the following conclusions can be drawn:

1. For class A, the total items contribute approximately 80% of the total inventory value. The total quantity of category A items is 26, and their overall value amounts to 250,046,303.70 IDR.
2. For class B, the total items account for roughly 15% of the total inventory value. The total quantity of category B items is 24, with their cumulative value reaching 47,155,429.10 IDR.
3. For class C, the total items contribute to only about 5% of the total inventory value. The total quantity of category C items is 32, with a combined value of 16,232,931.77 IDR.

These classifications illustrate the application of the ABC analysis, where the majority of the inventory value is concentrated in a small portion of items (class A), while the larger quantity of items (class C) contributes minimally to the overall value. Next, the author groups how many items there are in each category and their status. The table below explains the number and status of each category

Table 9. Total Value For Each Class and Status

Class	Status	Number of Items
A	Understock	18
	Overstock	8
	Optimal	0
B	Understock	21
	Overstock	2
	Optimal	1
C	Understock	19
	Overstock	12
	Optimal	1

Based on the table the data reveals that overstocked items are more prominent in the lower Categories (C), indicating inefficiencies in managing lower-priority items. While for the understocked items are more in Category A and B, posing risks to service quality and operational efficiency. Therefore it's crucial to analyze the causes of understock to minimize further risk.

Root Cause Analysis For Understock (RCA)

In the context of bank operations, understock inventory significantly impacts service quality, institutional reputation, and operational efficiency. While it does not directly affect financial aspects, such as revenue or profit, understock disrupts service to customers and internal coordination across divisions. Thus, Root Cause Analysis (RCA) is employed as the primary approach to understand the fundamental causes of understock and develop strategic actions to address it. This sub-chapter presents the RCA analysis based on interviews with warehouse and procurement teams.

Identification of Understock Impact

The interviews revealed several key symptoms resulting from understock conditions:

1. Disruption to Division Operations:
   - Stock shortages lead to delays in internal projects, including services to other divisions.
   - Customer requests cannot be fulfilled on time, affecting service quality.
2. Operational Efficiency Challenges:
   - Warehouse staff face additional workloads to handle urgent requests.
   - Manual systems slow down inventory management processes.
3. Long-term Reputation Impact:
   - The inability to meet internal needs affects the perception of divisions and the bank's reputation among customers.

RCA Visualization

The Current Reality Tree (CRT) analysis identified root causes of understock issues, including delays in procurement, lack of real-time inventory tracking, and limited warehouse capacity. These problems lead to disruptions in operational efficiency and service quality.

To address these challenges, the Economic Order Quantity (EOQ) model was proposed as a systematic solution. EOQ directly addresses inefficiencies by determining the optimal order quantity, minimizing both holding and ordering costs. Moreover, the integration of EOQ with safety stock calculations ensures a buffer for demand variability, preventing further understock issues.

For example:

- Delays in Procurement: By calculating the optimal reorder point (ROP) and integrating automated reorder alerts, EOQ minimizes the risk of delayed orders.
- Manual Inventory Tracking: EOQ leverages historical demand data to establish precise inventory thresholds, reducing errors in stock replenishment.
- Limited Warehouse Capacity: EOQ aids in planning optimal procurement quantities, ensuring efficient use of storage space without overstocking.

The CRT and EOQ integration present a comprehensive approach to transitioning from reactive inventory management to a proactive system, ensuring operational stability and cost efficiency.

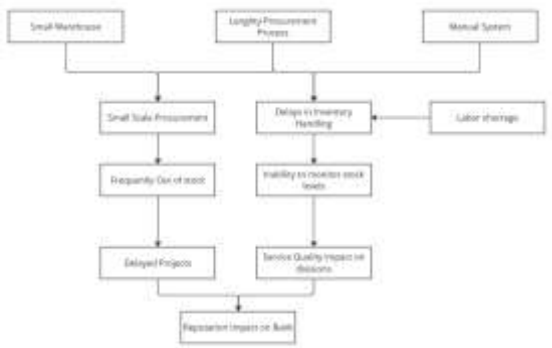

Fig 3. CRT Analysis

Based on interview analysis, the primary causes of understock are summarized into the following categories:

1. Human Resources:
   - Insufficient warehouse staff.
   - High workload slows down inventory handling.
2. Methods (Processes):
   - Lengthy procurement procedures with prolonged circulation processes.
   - Lack of automation or digitalization in inventory management, causing inefficiencies.
3. Material (Warehouse Capacity):
   - Limited warehouse capacity forces procurement in smaller quantities, increasing the risk of stock shortages.
   - Rarely requested items are often out of stock for extended periods.
4. Systems:
   - Manual inventory systems reduce the ability to monitor stock levels in real-time.
   - No contingency plans, such as purchasing from external vendors when stock is unavailable

Based on the ABC analysis and the results of the RCA discussed earlier, the business solution must focus on addressing the challenges of inventory mismanagement—both overstock and understock—while enhancing operational efficiency and service quality. These solutions focus on optimizing inventory processes, improving communication, and leveraging technology to enhance efficiency and service quality.

The primary root causes of inventory management issues identified are:

1. Limited warehouse capacity, leading to restricted procurement quantities.
2. Manual inventory management systems, resulting in inefficiencies and lack of real-time monitoring.
3. Lengthy procurement processes with extended lead times.
4. Lack of emergency procurement plans for understock scenarios.
5. Disproportionate focus on low-priority (Category C) items, causing overstock and unnecessary costs.

To address these root causes, the following solutions are proposed, categorized by aspects of improvement:

1. Technology Integration
   i. Automated Inventory Management System: Implement a digital system to monitor inventory levels in real-time, reducing human error and improving forecasting accuracy.
   ii. Alerts for Critical Stock Levels: Enable automated alerts for Category A items nearing minimum stock levels to prioritize replenishment.
2. Warehouse and Procurement Process Optimization
   i. Expand Warehouse Capacity: Allocate additional storage for high-priority items (Category A) to reduce stockouts and procurement frequency.
   ii. Streamline Procurement Processes: Simplify approval workflows to shorten lead times, ensuring faster replenishment of critical items.
   iii. Emergency Procurement Plan: Develop contingency measures, including agreements with secondary suppliers, for rapid replenishment during shortages.
3. Enhanced Inventory Control
   i. ABC Prioritization:
      - Focus stricter monitoring on Category A items to ensure availability and prevent operational disruptions.
      - Minimize overstock in Category C by adopting lean management practices.
   ii. Cycle Count Audits: Conduct regular audits to identify discrepancies in stock records and ensure accuracy.
4. Staff Training and Development
   i. Training Programs: Provide training on inventory management best practices (e.g. EOQ Model, ABC Analysis, Forecasting,etc.)

The table below groups the proposed solutions by the aspects they address:

Table 10. Proposed Solution

Aspect	Proposed Solution
Technology	Implement automated systems; enable critical stock alerts; establish data dashboards.
Business Process	Expand warehouse capacity; streamline procurement processes; introduce cycle counts.
People/Human Resources	Conduct staff training for inventory performance evaluation

The proposed solutions are designed to systematically address the root causes of inventory management inefficiencies, ensuring a balance between operational demands and resource optimization. By leveraging technology, refining procurement processes, and enhancing workforce capabilities, these recommendations aim to create a robust inventory management framework that aligns with organizational goals while minimizing risks associated with overstock and understock. The integration of these strategies will not only improve operational efficiency but also enhance service quality, safeguard the organization's reputation, and establish a foundation for long-term sustainability in inventory practices.

Limitation Of The Study

The limitations of this study arise from its specific scope and focus. This research concentrates on analyzing the inventory management system at the Bank's Headquarters in Jakarta, utilizing historical inventory data from the last eight months, spanning January 2024 to October 2024. The scope is further narrowed to office stationery materials stored in the warehouse, specifically items categorized as small assets worth less than 2.5 million rupiah. While this focus allows for an in-depth analysis of the Bank's operations, it limits the generalizability of the findings to other branches or organizations with different inventory structures or broader asset categories. Additionally, the findings are specific to the Bank's current inventory management practices and operational constraints, making them less applicable to contexts outside the bank's framework. Future research could address these limitations by including a wider range of inventory materials, analyzing data over a longer time period, or incorporating practices from multiple locations to provide a more comprehensive understanding of inventory management in similar industries.

Conclusions

This study aimed to optimize inventory management at a Bank using the EOQ model to address overstock and understock challenges. The EOQ application on "AMPLOP KACA KIRI" provided benchmarks for Safety Stock, Reorder Point (ROP), and EOQ values, ensuring cost-efficient stock management and timely replenishment. Analysis revealed 27% of items were overstocked, valued at IDR 104,428,260, while 71% were understocked, amounting to IDR 205,870,665. The research concludes that inventory management at the studied bank faces significant challenges due to frequent understock and overstock situations. The Current Reality Tree (CRT) analysis identified the root causes of these issues, including delays in procurement, reliance on manual inventory tracking systems, and limited warehouse capacity. These inefficiencies have disrupted operational workflows, increased costs, and diminished service quality To address these issues, short-term solutions include redistributing excess stock, setting safety stock levels, and optimizing order schedules. Long-term strategies involve automating inventory systems, improving procurement coordination, and creating contingency plans. These measures aim to enhance efficiency, reduce costs, and strengthen inventory practices at the Bank.

Recommendations

To address the challenges of inventory management, the implementation of the Economic Order Quantity (EOQ) model is proposed, integrating safety stock calculations and reorder points to balance inventory levels systematically. By leveraging EOQ, the bank can minimize holding and ordering costs, ensure timely replenishment, and prevent stockouts or overstocking. The study recommends applying the EOQ model across a broader range of high-priority inventory items to standardize ordering processes and reduce costs. Additionally, implementing a real-time inventory monitoring system with reorder alerts will enable precise stock tracking and alignment with demand. Strengthening safety stock policies is essential to buffer against demand fluctuations and procurement delays, while simplifying procurement processes by reducing lead times and establishing reliable vendor agreements will enhance operational efficiency. Addressing overstock and understock issues requires targeted strategies, such as redistributing surplus inventory and setting minimum stock thresholds, supported by regular training programs for inventory staff to improve their understanding of advanced techniques like EOQ and ABC classification. Leveraging ABC analysis will further allocate resources effectively, prioritizing high-value or frequently used items, and integrating advanced technologies such as AI and machine learning can enhance inventory tracking and forecasting accuracy. These measures, combined with longitudinal studies on EOQ implementation, broader applications across industries, and a focus on employee training and change management, aim to create a more efficient, responsive, and cost-effective inventory management system for the bank.

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