Journal of Basics and Applied Sciences Research (JOBASR)
ISSN (print): 3026-9091, ISSN (online): 1597-9962
Volume 3(5) September 2025
DOI: https://dx.doi.org/10.4314/jobasr.v3i5.5

Economic Order Quantity Approach to Optimizing Inventory Management: Evidence from a Nigerian Fertilizer Company

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ABSTRACT
Inventory inefficiencies remain a major challenge for manufacturing firms in developing economies, often resulting in excessive holding costs, shortages, and production delays. This study applies the Economic Order Quantity (EOQ) and Reorder Point (ROP) models to optimize inventory management at Hamdala Fertilizer and Chemical Company Limited, Nigeria. The company currently employs a fixed-ordering schedule of 12 purchases annually, without adjustments for demand fluctuations, leading to stock imbalances and unnecessary costs. Using company data and EOQ analysis, optimal order quantities and safety stock levels were computed for nitrogen, phosphorus, and potassium, the main raw materials for fertilizer production. A comparative analysis between the existing system and EOQ-based inventory management shows significant potential cost reductions and efficiency improvements. Sensitivity analysis further demonstrates the robustness of EOQ under fluctuating demand and holding costs. The findings confirm that structured, data-driven inventory models can provide reliable, scalable, and cost saving solutions for resource-intensive industries in developing economies.

Keywords:
Economic Order Quantity; Reorder Point; Inventory Optimization; Fertilizer Industry; Supply Chain Management

INTRODUCTION

Effective inventory management is essential for manufacturing firms, as it directly influences operational efficiency, production continuity, and profitability. In many industries, inventory costs account for 30–40% of total operational costs, making optimization a key driver of competitiveness (Rabta, 2020). Classical models such as the Economic Order Quantity (EOQ) and Reorder Point (ROP) remain widely applied due to their simplicity and effectiveness. However, in resource-intensive industries, particularly in developing economies, inventory inefficiencies continue to cause significant losses.

In Nigeria, fertilizer companies are critical to agricultural productivity and food security. Yet, many of these companies still rely on outdated inventory practices, often placing orders on rigid schedules that do not account for demand fluctuations or supply uncertainties. This leads to overstocking, shortages, and inflated costs. Hamdala Fertilizer and Chemical Company Limited which is situated at No. 3, Dawakin Dakata Industrial Area, Nasarawa Local Government Area of Kano State Nigeria exemplify this challenge, as its current fixed-ordering strategy results in imbalances and inefficiencies.

Inventory management has attracted considerable scholarly attention, with models ranging from classical EOQ to advanced machine learning-based forecasting. Recent scholarship has emphasized that while the classical EOQ model remains a useful starting point, modern inventory management increasingly requires data-driven, adaptive and technology-enabled replenishment strategies. Alnahhal *et al.* (2024) provide a comprehensive review of EOQ model extensions in uncertain supply chain environments, highlighting how digital analytics, real-time tracking, and fuzzy decision frameworks can augment or replace the traditional fixed-order-quantity policy to better cope with demand variability and lead time disruption.

A parallel thread of research on inventory-pooling strategies (Deng *et al*. 2024) shows that sharing inventory across locations and coordinating ordering decisions can significantly reduce overall safety stocks and ordering costs without hurting service levels, effectively "borrowing scale" to smooth out demand uncertainty. In another recent approach, Rajnikant and Khanna (2025) develop so-called SMART EOQ models where machine learning algorithms dynamically adjust order quantities in response to observed demand trends and supply chain disruptions.

How to cite this article: Mansur N. A., Harisu Y. S. & Shamsi A. I. (2025). Economic Order Quantity Approach to Optimizing Inventory Management: Evidence from a Nigerian Fertilizer Company. *Journal of Basics and Applied Sciences Research*, *3*(5), 41-45. https://dx.doi.org/10.4314/jobasr.v3i5.5

The EOQ model determines the optimal order size that minimizes total inventory costs, balancing ordering and holding costs. Despite its simplicity, EOQ remains relevant due to its adaptability across industries (Yung *et al*., 2021).

ROP complements EOQ by determining the inventory level at which new orders should be placed, ensuring continuity during lead times. Modern studies have integrated EOQ and ROP with stochastic models to address demand uncertainty (Tan & Sidhu, 2022).

Recent works have expanded classical inventory models. For instance, (Rane *et al.* 2024) explored postponement strategies, while (Saracoglu & Mifdal, 2024) applied DEA models for supply chain efficiency. Machine learning approaches have also been proposed, offering real-time predictive insights (Meherishi *et al.*, 2019).

Inventory management has long been influenced by the classical Economic Order Quantity (EOQ) model, which provides a benchmark for balancing ordering and holding costs under deterministic demand conditions. However, scholars have continued to refine and extend the model in order to address the complexities of modern supply chains. For instance, (Chilkapure & Pillai, 2019) emphasize the role of supply chain collaboration in optimizing inventory decisions. They argue that approaches such as vendor-managed inventory (VMI) become more effective when suppliers and buyers engage in collaborative planning and information sharing. Through joint forecasting and the exchange of real-time data, firms are able to reduce uncertainty, lower safety stock requirements, and align more closely with EOQ-based policies in practice. Their work highlights the practical importance of integrating coordination mechanisms with classical models to enhance responsiveness and reduce costs.

Building on this perspective, Altekar (2023) stresses that the classical EOQ framework, while foundational, must be adapted to the realities of modern supply chains characterized by volatile demand, fluctuating lead times, and frequent disruptions. He argues for the integration of real-time analytics, flexible replenishment policies, and data-driven decision support systems to ensure that EOQ remains a useful guide in dynamic environments. In such contexts, EOQ serves not as a rigid formula but as a baseline around which firms design adaptive and resilient replenishment strategies.

Similarly, Kong *et al*. (2018) explore extensions of the EOQ model to multi-echelon inventory systems, stochastic demand environments, and scenarios with quantity discounts. Their analysis demonstrates that departures from the simplifying assumptions of constant demand and instantaneous replenishment often lead to materially different optimal order quantities. As a result, they suggest that firms should calibrate EOQ-based policies using empirical data or simulation models to capture the true dynamics of their operating environments. By doing so, managers can balance the theoretical elegance of EOQ with the practical realities of supply chain operations.

However, empirical applications in developing economies remain scarce. Adeniran *et al*. (2024) emphasized the importance of inventory management for manufacturing efficiency in Africa, yet few studies apply EOQ in fertilizer industries. Given the agricultural significance of fertilizers in Nigeria, this research fills a critical gap by providing context-specific evidence.

Although numerous studies have examined inventory optimization globally, applications focusing on fertilizer production in developing economies remain limited. This study addresses that gap by applying EOQ and ROP to a Nigerian fertilizer company and comparing outcomes against its existing system, Akano et al. (2024)

MATERIALS AND METHODS

2.1 Source of Data Collection

Quantitative data were obtained from Hamdala Fertilizer and Chemical Company Limited, including demand, ordering costs, and holding costs for major raw materials (Nitrogen, Phosphorus, and Potassium). Where company records were incomplete, plausible values consistent with industry reports were applied.

2.2 Notations

Table 1: Notations and their meanings

Symbol	Definition
D	Annual demand for supplies (tons)
S	Order fee for each order (N)
C	Holding cost or storage cost per unit of inventory
Q^*	Economic Order Quantity
TIC	Total Inventory Cost
D	Average daily demand (tons/day)
L	Lead time (days)
SS	Safety stock (tons)
ROP	Reorder Point (tons)
Z	Desired service level factor
σ_d	Standard Deviation of demand
C_b	Holding cost or storage cost per unit of inventory

2.3 Economic Order Quantity Model

The EOQ formula is given as:

$$Q^* = \sqrt{\frac{2DS}{C}} \quad (1)$$

$$TIC = \frac{D}{Q}S + \frac{Q}{2}H + C_b \times E(Z) \quad (2)$$

$$SD = \sqrt{\frac{\sum(X-\bar{X})^2}{N}} \quad (3)$$

$$SS = Z \times \sigma_d \times \sqrt{LT} \quad (4)$$
$$ROP = d \times L + SS \quad (5)$$

2.4 Comparative Analysis

To evaluate the benefits of the EOQ model, a Comparative Analysis was conducted between the company's existing inventory system and the proposed EOQ-based system.

2.4.1 Current System (Fixed Ordering Policy)

The company currently orders 12 times annually, irrespective of fluctuations in demand

$$TIC_{current} = \frac{D}{12} \times C + 12(S) \quad (6)$$

2.4.2 Proposed System (EOQ model)

Order size is determined by using the EOQ formular;

$$TIC_{EOQ} = \frac{Q^*}{2} \times C + \frac{D}{Q^*} \times (S) \quad (7)$$

For each raw material (Nitrogen, Phosphorus, Potassium), total inventory costs were computed under both systems.

Percentage savings were then calculated as:

$$\%Savings = \frac{TIC_{current} - TIC_{EOQ}}{TIC_{current}} \times 100 \quad (8)$$

2.5 Sensitivity Analysis

To assess robustness of the EOQ model under uncertain business conditions, a sensitivity analysis was conducted by varying two critical parameters: annual demand (D) and holding cost (C). These parameters were selected because they are most affected by market fluctuations in the Nigerian fertilizer industry, where demand patterns and inflation-driven costs are unstable.

2.5.1 Baseline Scenario

EOQ and total inventory costs (TIC_{EOQ}) were computed using the actual company data for 2024.

3.5.2 Demand Variation Scenarios

Demand (D) was increased and decreased by 10% from the baseline.

New EOQ values were recalculated using:

$$Q^*_{new} = \sqrt{\frac{2D_{new}S}{C}} \quad (9)$$

$$TIC_{EOQ_{new}} = \frac{Q^*_{new}}{2} \times C + \frac{D_{new}}{Q^*_{new}} \times (S) \quad (10)$$

Holding Cost (C) was also increased and decreased by 10% from the baseline and new EOQ values were recalculated.

RESULTS AND DISCUSSION

3.1 Economic Order Quantity and Reorder Point Calculations

The Economic Order Quantity and Reorder Point calculations for 2024 are presented in Table 2. The results show that the optimal order quantities (EOQ) for nitrogen, phosphorus, and potassium are 26,563 tons, 28,397 tons, and 33,082 tons respectively. The corresponding reorder points (ROP), considering a lead time of 7 days and safety stock requirements, are 598,999 tons for nitrogen, 684,570 tons for phosphorus, and 929,059 tons for potassium. These values provide structured guidelines for timely reordering while preventing both overstocking and shortages.

Table 2: EOQ and ROP Results for 2024

Raw Material	EOQ (Tons)	Reorder Point (Tons)	Safety Stock (Tons)	Lead Time (Days)
Nitrogen	26,563	598,999	35,163	7
Phosphorus	28,397	684,570	40,185	7
Potassium	33,082	929,059	54,539	7

Results from Table 2 above shows structured guidelines for optimal order size and timely reordering.

3.2 Comparative Analysis

A comparative analysis between the company's existing system (fixed 12 orders annually) and the EOQ-based system is shown in Table 3 and illustrated in Figure 1. The findings indicate that EOQ-based inventory management yields significant cost savings across all raw materials. For nitrogen, the total cost decreases from ₦145.2 million to ₦128.5 million (11.5% savings). Phosphorus shows a reduction from ₦161.7 million to ₦142.8 million (11.7% savings), while potassium records the highest savings at 13.4%, reducing costs from ₦236.9 million to ₦205.3 million. Overall, the company could achieve an estimated 12.4% reduction in total inventory-related costs by adopting the EOQ model.

Table 3: Comparative Inventory Costs (Current System vs EOQ System)

Raw Material	Current System Cost (₦ million)	EOQ System Cost (₦ million)	Savings (%)
Nitrogen	145.2	128.5	11.5%
Phosphorus	161.7	142.8	11.7%
Potassium	236.9	205.3	13.4%
Total	543.8	476.6	12.4%

EOQ yields cost savings of 11.5 – 13.4% across raw materials, with overall savings of 12.4%

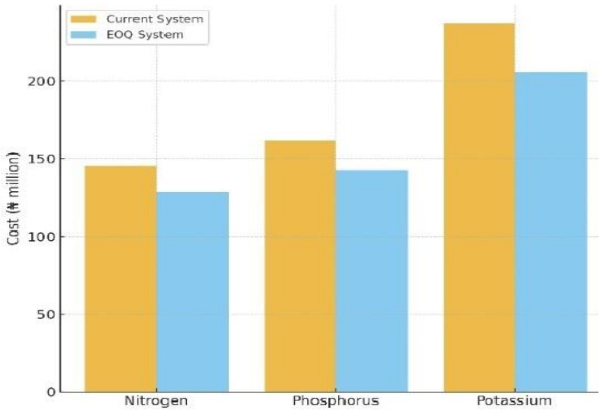

Figure1: Comparative Inventory Costs (Current system vs. EOQ system)

To test the robustness of EOQ under uncertain conditions, a sensitivity analysis was conducted by varying demand and holding costs by ±10%. The results summarized in Table 4 and illustrated in Figure 2, show that EOQ consistently delivers cost savings, ranging from 9.2% under reduced demand to 13.8% under increased demand. Similarly, variations in holding costs still produce positive savings, between 10.3% and 12.7%. These findings confirm that the EOQ approach remains effective even when external conditions fluctuate.

3.3 Sensitivity Analysis

EOQ remained cost-effective under ±10% variations in demand and holding cost. Savings ranged between 9% and 14%, confirming robustness.

Table 4: Sensitivity Analysis of EOQ Savings

Scenario	Savings (%)
-10% Demand	9.2%
Baseline (Current Data)	11.5%
+10% Demand	13.8%
-10% Holding Cost	10.3%
+10% Holding Cost	12.7%

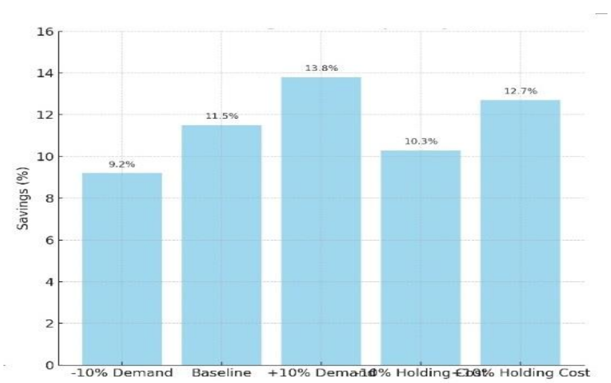

Figure 2: Economic Order Quantity Savings Sensitivity Analysis

The findings of this study demonstrate that the current fixed-ordering system employed by Hamdala Fertilizer and Chemical Company Limited is significantly less efficient compared to the EOQ-based inventory management approach. By adopting EOQ, the company can reduce inventory-related costs by more than 12% across its key raw materials, which represents a substantial financial saving in a capital-intensive industry such as fertilizer production. These results align with earlier studies which identified EOQ as an effective cost-minimization tool in manufacturing industries (Rabta, 2020; Yung *et al*., 2021). However, unlike generic applications, this study provides empirical evidence specific to Nigeria's fertilizer industry, thereby filling an important contextual gap in the literature.

The results also indicate that the highest relative savings were achieved for potassium (13.4%), followed by phosphorus (11.7%) and nitrogen (11.5%). This suggests that EOQ is particularly valuable for high-cost raw materials, as holding and ordering inefficiencies have greater financial implications in such cases. This finding corroborates the work of Saracoglu & Mifdal (2024), who argued that inventory models are most impactful when applied to high-value inputs.

Furthermore, the sensitivity analysis reveals that EOQ remains robust even under fluctuating demand and holding costs. Savings were consistently positive, ranging between 9% and 14%, indicating that the model is resilient in uncertain environments. This robustness is consistent with Tan and Sidhu (2022), who emphasized the adaptability of EOQ under variable demand conditions. Importantly, the confirmation of EOQ's resilience within the volatile Nigerian business environment highlights the model's practicality for firms operating in developing economies, where supply chain disruptions and inflation are common.

From a managerial perspective, the adoption of EOQ and ROP would allow fertilizer companies to avoid overstocking and stockouts, ensuring smoother production processes and reduced risk of operational disruptions. Beyond cost savings, this structured inventory management system enhances decision-making by introducing a scientific, data-driven approach to procurement. For academic research, the study contributes by validating the applicability of classical models such as EOQ and ROP in a contemporary, resource-intensive African context a domain where empirical evidence is still sparse.

Overall, the study shows that even in the era of advanced forecasting and machine learning models, traditional techniques such as EOQ remain highly relevant, especially in environments where simplicity, cost-effectiveness, and robustness are paramount. This reinforces the position that inventory optimization strategies must be context-sensitive: while advanced methods may suit developed economies with extensive data infrastructure, classical models remain invaluable in developing economies.

CONCLUSION

This study applied the Economic Order Quantity (EOQ) and Reorder Point (ROP) models to optimize inventory management at Hamdala Fertilizer and Chemical Company Limited, Nigeria. The results demonstrate that the company's existing fixed-ordering system is inefficient, leading to unnecessary holding costs and potential shortages. By contrast, EOQ-based inventory management reduces overall costs by more than 12%, ensures timely replenishment, and provides a structured framework for decision-making.

The sensitivity analysis further confirms the robustness of EOQ under fluctuating demand and holding costs, making it a practical and resilient tool for inventory management in volatile business environments. These findings establish that classical models such as EOQ remain highly relevant and valuable in modern supply chains, especially within developing economies where resource constraints and market uncertainties are prevalent.

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