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Brief Research Report

Analysis of ship food inventory control using the economic order quantity (EOQ) method

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ABSTRACT

This study analyzes the control of food inventory aboard vessels operated by Bernhard Schulte Shipmanagement (BSM) using the Economic Order Quantity (EOQ) model. Employing a quantitative approach, the research examines 12 months of food procurement and consumption data from the PIS SMT vessel. Data were collected through documentation review and direct observation and analyzed using QM Software to calculate key EOQ parameters, including optimal order quantity, ordering frequency, reorder point, safety stock, and maximum inventory level. The results indicate that implementing the EOQ method significantly optimizes onboard food inventory management. The optimal ordering frequency was reduced from 12 to 3 times per year for perishable items and to 2 times per year for non-perishable items. Furthermore, the total annual inventory cost under the EOQ model is USD 1,517.83—a 62.71% reduction compared to the current policy cost of USD 4,927.85. These findings demonstrate that the EOQ method offers a substantially more cost-effective and efficient system for managing shipboard food provisions.

Keywords: Inventory control, Economic Order Quantity (EOQ), Ship food supplies

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Abstrak

Penelitian ini bertujuan untuk menganalisis pengendalian persediaan bahan makanan kapal pada Bernhard Schulte Shipmanagement (BSM) menggunakan metode Economic Order Quantity (EOQ). Pendekatan kuantitatif digunakan dengan menganalisis data pembelian dan pemakaian bahan makanan selama 12 bulan di kapal PIS SUMATERA. Metode pengumpulan data meliputi dokumentasi dan observasi langsung. Analisis data dilakukan menggunakan Software QM untuk menghitung EOQ, frekuensi pemesanan optimal, titik pemesanan ulang, persediaan pengaman, dan persediaan maksimum. Hasil penelitian menunjukkan bahwa penerapan metode EOQ dapat mengoptimalkan pengendalian persediaan bahan makanan kapal. Frekuensi pemesanan optimal berkurang dari 12 kali menjadi 3 kali per tahun untuk bahan makanan basah dan 2 kali per tahun untuk bahan makanan kering. Total biaya persediaan dengan metode EOQ adalah $1,517.83, jauh lebih rendah dibandingkan kebijakan saat ini sebesar $4,927.85, menghasilkan penghematan 62,71%.

***Kata Kunci**:* Pengendalian persediaan, Economic Order Quantity (EOQ), Bahan makanan kapal

1. Introduction

In an era of intensifying global competition, operational efficiency has emerged as a critical determinant of success across all sectors, including the shipping industry. A fundamental component influencing this efficiency is inventory management (Kumar et al., 2024). Effective inventory control can reduce operational costs, enhance productivity, and ensure smooth operations. Conversely, poor management may lead to wastage, operational disruptions, and a decline in competitiveness. The shipping industry faces particular challenges in this regard, as operations often span diverse geographical regions and involve extended voyages, complicating logistics and supply stability (Purwantini, 2021).

A vital aspect of maritime inventory management is the provisioning of food onboard. Inadequate or improper food supplies can adversely affect crew morale and health, thereby compromising operational safety. On the other hand, excess inventory results in unnecessary waste and increased costs. Achieving an optimal balance among availability, quality, and cost efficiency, therefore, requires a systematic and measured approach (Setyawan, 2022). The Economic Order Quantity (EOQ) model presents a promising solution to these inventory challenges. As noted by Pragiwani (2021), EOQ is designed to determine the order quantity that minimizes total inventory costs by balancing holding and ordering expenses. Its application can optimize stock levels, reduce operational costs, and improve overall logistical efficiency (Kurniawan, 2022).

This study aims to analyze food inventory control aboard the PIS SUMATRA vessel using the Economic Order Quantity method. Focusing on operations managed by BSM on the Taiwan–Singapore route from July 2023 to July 2024, the research will utilize twelve months of inventory data. The findings are expected to yield practical recommendations for optimizing inventory management, improving operational efficiency, and strengthening BSM's competitive position in the global shipping industry.

2. Material and methods

This study employs a quantitative descriptive case study approach to analyze the food inventory control system at Bernhard Schulte Shipmanagement (BSM). The Economic Order Quantity (EOQ) model is applied to optimize inventory management for perishable food items. Data analysis was performed using QM 5.2 software to calculate optimal order quantities and associated cost parameters.

Population and sample

As a focused case study on BSM's inventory system, this research does not utilize a traditional population or sampling method. The sole unit of analysis is the food inventory control process implemented by BSM for its vessel operations.

Research variables

Operational management encompasses the comprehensive activities undertaken by a company to generate value through the production of goods or services, thereby creating outputs with distinct competitive advantages (Purnomo & Astuningsih, 2021). Inventory, or stock, constitutes an asset that includes goods held for sale, items in the process of production, and raw materials awaiting use. Effective control of these assets is essential for operational and financial efficiency (Nugraha Kusuma & Syahrur, 2023). The EOQ model is a cornerstone of inventory management, determining the most cost-effective purchase quantity by balancing ordering and holding costs (Prastya et al., 2019). The standard formula is:

$EOQ = \sqrt{(2SD / H)}$

Where: S = Ordering cost per order, D = Annual demand, H = Holding cost per unit per year (Andiana & Pawitan, 2019).

Safety Stock and Reorder Point

To mitigate stockout risks, safety stock (SS) is maintained, calculated as **$SS = Sd \times Z \times \sqrt{LT}$** (Katiandagho, 2021). The Reorder Point (ROP), the inventory level triggering a new order, is calculated as **$ROP = (T \times LT) + SS$** (Siboro & Nasution, 2020). Lead Time (LT) is the total duration from order placement to receipt (Slamet Kerans, 2024).

Operational definitions and measurement scales

Key variables are defined and measured as follows:

a. Ship's Food Inventory: Quantity of stock to meet crew consumption, measured in kilograms (ratio scale).
b. Economic Order Quantity (EOQ): Optimal order quantity minimizing total cost, measured in kilograms (ratio scale).
c. Ordering Cost (S): Cost incurred per order placed, measured in US Dollars (ratio scale).
d. Holding Cost (H): Cost of storing inventory per unit per period, measured in US Dollars per kilogram per year (ratio scale).
e. Annual Demand (D): Total food requirement for one year, measured in kilograms (ratio scale).

Data analysis technique

Analysis was conducted in two stages:

1. Descriptive Analysis: To outline the current state of food inventory control practices.
2. Quantitative EOQ Analysis: To calculate optimal inventory parameters using the EOQ formula (**√(2SD / H)**). The QM 5.2 software facilitated this computation. A comparative analysis between the current inventory policy and the EOQ model results was then performed to evaluate potential efficiency gains and cost savings.

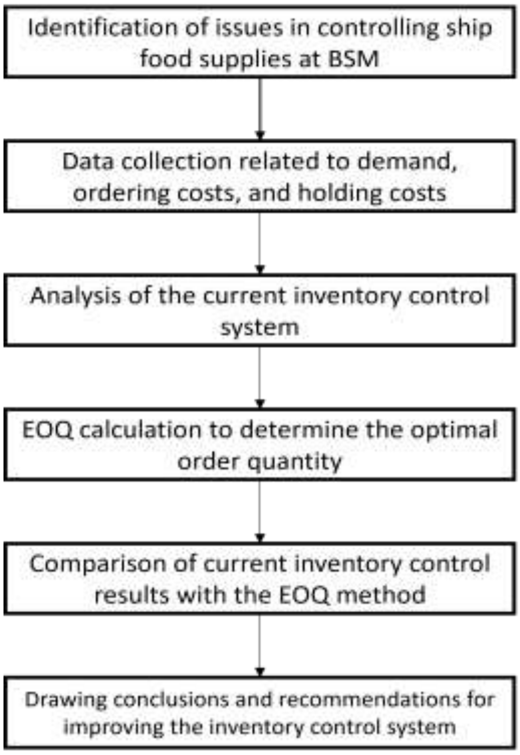

Figure 1. Problem-Solving Framework
Source: Research (2024)

3. Results

3.1 Analysis of Food Inventory Data

Purchase and Consumption Data

The following data details the purchase and consumption of food supplies aboard vessel over 12 months.

Table 1. Monthly Food Purchase and Consumption (Kilograms)

Month	Perishable Food Purchase	Perishable Food Used	Non-Perishable Food Purchase	Non-Perishable Food Used
JUL	950	920	620	580
AUG	900	890	580	590
SEP	880	870	560	570
OCT	900	890	580	575
NOV	930	920	600	590
DEC	880	870	560	570
JAN	890	880	570	565
FEB	860	850	550	560
MAR	880	870	560	565
APR	900	890	580	575
MAY	1050	1030	680	670
JUN	1050	1040	680	675
Total	**11070**	**10920**	**7120**	**7085**

Source: Primary Research Data (2024)

Inventory Cost Parameters

Key cost parameters were established for the EOQ model based on operational data:

- Ordering Cost (S): Fixed at $200 per order, comprising administrative ($50), communication ($30), and transportation ($120) costs.
- Holding Cost (H): Calculated at 4% of the food value per annum, including storage (2%), handling (1%), and spoilage risk (1%). Given average prices of $5/kg for perishable food and $3/kg for non-perishable food, the holding costs are:
  - Perishable Food: $0.20 per kg/year
  - Non-Perishable Food: $0.12 per kg/year

3.2 Current Inventory Policy Analysis

The existing policy involves monthly orders (12 times per year). The Total Inventory Cost (TIC) under this policy is calculated as follows:

For Perishable Food:

$TIC = [(D/Q) \times S] + [(Q/2) \times H] = [(10920/922.5) \times \$200] + [(922.5/2) \times \$0.20] = \$2,492.25$

For Non-Perishable Food:

$TIC = [(7085/593.33) \times \$200] + [(593.33/2) \times \$0.12] = \$2,435.60$

Total Current Annual Inventory Cost: $4,927.85

3.3 EOQ Model Calculation and Results

Applying the EOQ formula **EOQ = √(2SD/H)**, the optimal order quantities are:

- Perishable Food**:** EOQ = √((2 × 10920 × 200) / 0.20) = 4,673 kg
- Non-Perishable Food**:** EOQ = √((2 × 7085 × 200) / 0.12) = 4,859 kg

These optimal quantities lead to the following revised operational parameters:
Optimal Order Frequency (N):

- Perishable: 10920 / 4673 = 3 times per year
- Non-Perishable: 7085 / 4859 = 2 times per year

Total Inventory Cost (TIC) with EOQ:

- Perishable Food: $934.66
- Non-Perishable Food: $583.17
- Total EOQ Annual Inventory Cost: $1,517.83

This represents a potential cost reduction of 62.71% ($3,410.02**)** compared to the current policy.
Safety Stock (SS) and Reorder Point (ROP):
To mitigate stockout risks, safety stock was calculated assuming a 95% service level (Z=1.65) and a lead time of 7 days.

- Perishable Food: SS = 97.61 kg; ROP = 306.05 kg
- Non-Perishable Food: SS = 62.25 kg; ROP = 198.97 kg

Maximum Inventory Level:

- Perishable Food: Safety Stock + EOQ = 4,770.61 kg
- Non-Perishable Food: Safety Stock + EOQ **=** 4,922.10 kg

Table 2. Comparison of Current Policy vs. EOQ Model Recommendations

Parameter	Current Policy	EOQ Model
Perishable Food Order Frequency	12 times/year	3 times/year
Non-Perishable Food Order Frequency	12 times/year	2 times/year
Perishable Food Order Quantity	922.5 kg	4,673 kg
Non-Perishable Food Order Quantity	593.33 kg	4,859 kg
Perishable Food Reorder Point	Not Defined	306.05 kg
Non-Perishable Food Reorder Point	Not Defined	198.97 kg
Perishable Food Safety Stock	Not Defined	97.61 kg
Non-Perishable Food Safety Stock	Not Defined	62.25 kg
Total Annual Inventory Cost	**$4,927.85**	**$1,517.83**

Source: Data Analysis (2024)

Based on Table 2, the previous company's policy calculations using the EOQ method over 12 months show significant potential savings in inventory costs. This method reduces the frequency of orders and increases the quantity per order, while providing guidance on reorder points, safety stock, and maximum inventory limits, thereby helping the company manage food inventory on the company ship more efficiently.

4. Discussion

The analysis shows that the current inventory control policy for the PIS SUMATERA is suboptimal, resulting in unnecessarily high costs. The EOQ model offers a clear framework for optimization, recommending a significant reduction in order frequency and a substantial increase in order quantity.

The dramatic reduction in total inventory cost—from $4,927.85 to $1,517.83—highlights the substantial financial efficiency gains achievable through EOQ implementation. Furthermore, the model introduces critical management parameters currently missing, such as reorder points and safety stock levels, thereby enhancing operational reliability and preventing stockouts that could disrupt crew morale and vessel operations.

However, successful implementation must account for practical constraints. The much larger order quantities require adequate onboard storage and robust inventory management to prevent spoilage, especially for perishable items. Furthermore, the model's application must be flexible, accommodating variable voyage schedules and port availability for reprovisioning. Despite these considerations, the EOQ method provides a data-driven, cost-effective foundation for transforming food inventory management, directly enhancing operational efficiency and cost competitiveness for Bernhard Schulte Shipmanagement.

Practical Implications

The findings of this study offer several actionable implications for Bernhard Schulte Shipmanagement (BSM) and the broader maritime logistics sector. Primarily, the projected 62.71% reduction in annual inventory costs presents a compelling financial case for adopting the EOQ model. The significant savings achieved could be reallocated to other critical operational areas, such as fleet maintenance or crew training, thereby directly enhancing the company's competitive position.

From an operational standpoint, implementing the calculated reorder points and safety stock levels would transform inventory management into a more proactive and reliable system. This shift would minimize the risk of stockouts that could disrupt crew welfare and voyage safety. Concurrently, the move toward larger, less frequent orders necessitates a strategic review of supplier relationships and procurement contracts, potentially allowing for more favorable terms due to increased order volumes.

However, this new model also introduces practical challenges, particularly regarding onboard logistics. The substantial increase in optimal order quantity requires a thorough assessment of storage capacity and conditions to ensure that larger inventory batches can be accommodated without risking spoilage or compromising safety standards. Successfully managing this will be crucial for reaping the model's benefits.

Furthermore, the framework developed here is not limited to a single vessel. It can be adapted and scaled across BSM's fleet by inputting specific demand and cost parameters for different ships and routes. To fully leverage this optimization, integrating the EOQ parameters into the company's existing digital logistics or ERP systems is a logical next step. Such integration would automate reorder alerts and facilitate real-time inventory tracking, bridging the gap between theoretical optimization and daily practice.

Ultimately, this case study demonstrates the tangible value of applying classical operations research models to contemporary maritime challenges. It provides a replicable methodology for achieving greater cost efficiency and operational reliability, offering a strategic pathway for BSM and the wider industry to enhance supply chain resilience through data-driven management.

5. Conclussion

The application of the Economic Order Quantity (EOQ) method for managing food inventory on the company ship has proven to be more effective than the current company policy. It provides an efficient guideline for determining the frequency and quantity of orders over 12 months. The total inventory cost using the EOQ method is $1,517.83, compared to $4,927.85 under the current policy, resulting in significant savings of $3,090.23, or approximately 62.71%. The optimal order frequency based on the EOQ is three times per year for wet food and two times for dry food, which is far more efficient than the current monthly orders (12 times a year). The EOQ method also establishes clear reorder points: 306.05 kg for wet food and 198.97 kg of dry food, considering a 7-day delivery lead time. Additionally, safety stock calculations of 97.61 kilograms of damp food and 62.25 kg for dry food help prevent stock shortages that could disrupt ship operations.

Limitations

It is recommended that the company implement the EOQ method in its food procurement policy, as it yields a more efficient total cost than the current approach. The company will need to adjust the ship's storage and inventory management system to accommodate the suggested changes in order frequency and quantity. Implementing an integrated inventory management information system is also advised to facilitate real-time monitoring of inventory levels and ensure that orders are placed on time in accordance with the reorder points. Moreover, training staff on the principles of EOQ and its benefits is essential for effective implementation. The company should also conduct periodic evaluations of the EOQ method's implementation, considering that operational conditions and food prices may change.

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