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Optimising Inventory Cost Efficiency through the Economic Order Quantity (EOQ) Model

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ABSTRACT

This study aims to analyse the effectiveness of applying the Economic Order Quantity (EOQ) model in improving the cost efficiency of raw material inventory in manufacturing companies. The EOQ model is used to determine the optimal order quantity and purchase frequency for raw materials, accounting for ordering and storage costs. This study employs a quantitative descriptive approach, using primary data obtained through a review of company documentation over a three-year period. The analysis was conducted by calculating EOQ, Safety Stock, Reorder Point (ROP), and Total Inventory Cost (TIC) to compare the company policy with the EOQ model results. The study shows that a company policy that does not use the EOQ model leads to overstocking, resulting in higher storage costs and reduced working capital efficiency. Meanwhile, the application of the EOQ model has been shown to reduce total inventory costs and to improve the efficiency of raw material control systems. These findings confirm that the EOQ model can be an effective decision-making strategy to improve inventory cost efficiency in the manufacturing industry.

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1. INTRODUCTION

Raw material inventory is a vital component of production activities, directly affecting the smooth running of operational processes and the amount of costs incurred by the company. An imbalance between inventory levels and actual needs can lead to two extreme conditions: stockouts (raw material shortages) that hamper production, or overstocking (excess raw materials) that increases storage costs and the risk of material quality deterioration. According to Mweshi (2022), stockouts and overstocking are two classic problems in the manufacturing industry that directly affect supply chain efficiency and company profitability. In modern manufacturing companies, overstocking is prevalent to maintain production continuity, but this increases Total Inventory Cost (TIC) and reduces working capital efficiency (Kırmızı et al., 2024). Therefore, a managerial approach is needed to balance ordering and carrying costs to achieve optimal inventory levels. The Economic Order Quantity (EOQ) model remains one of the most effective approaches in reducing total inventory costs and maintaining this balance (Alnahhal, 2024).

One model that can be used to achieve this efficiency is the Economic Order Quantity (EOQ) model. The EOQ model was first introduced by Harris (1913) and further developed by Wilson. This model determines the most economical order quantity of raw materials by minimising total inventory costs. Through EOQ calculations, management can determine how much and how often to order raw materials to balance the two main cost components: ordering and storage costs. Thus, companies can avoid waste from large purchases while preventing raw material shortages that could disrupt production.

Although the Economic Order Quantity model was introduced more than a century ago, it remains relevant today because it provides a sound basis for decision-making that balances cost efficiency and operational balance. In the era of Industry 4.0 and digital transformation, the main challenge of inventory management is not only maintaining the availability of raw materials, but also optimising the allocation of working capital through accurate data and integrated systems. The EOQ model provides a simple yet flexible mathematical framework for balancing ordering and carrying costs and can be developed in various forms, such as Probabilistic EOQ, Dynamic EOQ, and AI-assisted EOQ. Recent research (Kumar & Kumari, 2024; Kukartsev et al., 2023; Verawati et al., 2023) shows that applying EOQ, combined with predictive technologies and ERP systems, can reduce Total Inventory Cost by more than 20% and improve the accuracy of ordering decisions. This confirms that the EOQ model remains an important foundation for modern inventory management practices, owing to its adaptability to increasingly complex, data-driven supply chain dynamics.

Previous studies have shown the effectiveness of the EOQ model in improving inventory cost efficiency. Sari et al. (2020) found that applying the EOQ model in the manufacturing industry reduced total inventory costs by up to 29%, whereas (2022) reported an efficiency gain of 20% through a similar model. These findings reinforce the view that EOQ is a relevant managerial tool for helping companies achieve an optimal balance between raw material availability and costs. However, many companies in Indonesia have not yet implemented EOQ systematically; instead, they rely on purchasing policies based on

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subjective estimates rather than precise mathematical calculations. The gap between theory and practice underscores the need for further research on the effectiveness of the EOQ model in raw material inventory management. Theoretically, the EOQ model can provide significant benefits in cost control and working capital efficiency, but its effectiveness depends on the accuracy of demand data, ordering costs, and storage costs. In addition, EOQ should be integrated with safety stock and reorder point concepts to enable the inventory control system to anticipate demand fluctuations and supply delays.

Based on the above description, this study aims to analyse the application of the Economic Order Quantity (EOQ) model in improving the cost efficiency of raw material inventory. The main focus of this study is to compare actual inventory policies with EOQ model results and to assess the extent to which the model can reduce Total Inventory Cost (TIC). This study is expected to contribute to the development of operations management and cost accounting and to serve as a practical reference for manufacturing companies in designing efficient, measurable inventory control policies.

2. METHODS

2.1 Research Approach and Design

This study employs an explanatory quantitative approach with a comparative-analytical design to examine the relationship between the application of the Economic Order Quantity (EOQ) model and the level of inventory cost efficiency (Total Inventory Cost, TIC). An explanatory approach was used because the study not only describes EOQ calculations, but also explains how changes in inventory policy (from actual to EOQ model) imply cost efficiency and working capital optimisation.

2.2 Research Object and Data

The research objects include the management of the manufacturing company's main raw materials, consisting of: GPPS 685F, HIPS 470, Dimodan HPM, Calcium Stearate, and Talk Hichen. The data used are secondary and primary quantitative data obtained from internal company documents for the 2019–2021 period, including usage volume, purchase frequency, ordering costs, and storage costs. Data were collected through documentation studies and internal verification with the logistics and cost accounting departments.

2.3 Variables and Operational Definitions

Table 1. The Result of the F-test

Variables	Operational Definitions	Key Indicators	Unit
D (Demand)	Annual raw material requirements	Total annual usage	Units/year
S (Ordering Cost)	Cost incurred each time raw materials are ordered	Administrative, transportation, and processing costs	Rp/order
H (Holding Cost)	Storage costs for raw materials per unit per year	Warehouse, insurance, and working capital costs	Rp/unit/year

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Q*	Economic order quantity (EOQ)	EOQ formula value	Unit
N	Optimal order frequency	D / Q*	Times/year
TIC	Total annual inventory cost	(D/Q* × S) + (Q*/2 × H)	Rupiah

2.4 Data Analysis Techniques

The analysis is conducted in three main stages:

a. EOQ Model Calculation, using the basic formula:

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

The results show the optimal order quantity (Q*) and order frequency (N).

b. Safety Stock and Reorder Point Calculation
- Safety Stock (SS) is calculated by considering demand deviation and lead time.
- Reorder Point (ROP) is calculated using the formula:

$$ROP = (d \times L) + SS$$

d = average daily demand and$L$ = *lead time*.

c. Cost Efficiency Analysis (Comparison of Actual TIC and EOQ), calculated using the formula:

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

The TIC value resulting from the model is compared with the company's actual policy. The difference reflects the level of cost efficiency achieved through the application of EOQ

2.5 Model Validation and Reliability Testing

To ensure that the calculation results are empirically valid, the following is done:

a. Cross-checking between company data and EOQ model estimates through triangulation of sources (production and logistics departments).

b. Sensitivity Analysis of variables H and S to assess the stability of the model against changes in storage and ordering costs. This step increases the reliability of the EOQ model and strengthens the managerial implications of the research results.

3. RESULTS AND DISCUSSION

Inventory management is an important function in company operations that aims to balance the availability of raw materials with cost efficiency. In many organisations, procurement decisions are still often made based on experience or managerial intuition, without quantitative analyses. This approach tends to yield suboptimal decisions regarding order quantity, purchase frequency, and reorder point.

As a result, two extreme conditions often arise: overstock and stockout. Overstock leads to increased storage costs, decreased working capital turnover, and reduced warehouse space efficiency. Conversely, stockouts can hamper production, reduce customer service levels, and incur financial losses due to lost sales opportunities. This phenomenon indicates

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that, without a data-driven inventory control system and quantitative analysis, companies struggle to achieve sustainable operational efficiency (Indriyani & Budiawan, 2018; Muller, 2019).

In modern management, mathematical approaches such as the Economic Order Quantity (EOQ) provide a rational method for optimising order quantities and balancing total inventory costs. The use of this model allows managers to make evidence-based decisions and avoid intuitive decisions that are prone to cost inefficiencies. Thus, a general understanding of traditional inventory management practices can serve as a basis for comparing the effectiveness of applying the EOQ model in improving cost efficiency and the reliability of raw material supplies.

To provide a more concrete empirical picture, this study applies the EOQ model to a real-world manufacturing context. The analysis focuses on the raw material inventory control system, assessing the extent to which the EOQ model improves cost efficiency relative to conventional experience-based policies. This approach includes measuring key variables such as annual demand, ordering costs, and storage costs, and conducting a direct comparison between the company's actual policies and the EOQ model simulation results.

3.1 EOQ Model Calculation Results

Calculations using the Economic Order Quantity (EOQ) model were performed on five main raw materials: GPPS 685F, HIPS 470, Dimodan HPM, Calcium Stearate, and Talk Hichen. The basic parameters included annual demand (D), ordering cost (S), and storage cost (H). The analysis showed that the EOQ model's optimal order quantity (Q*) was lower than the company's actual policy, whereas ordering frequency increased. This means that the company had been making large purchases but with low frequency, resulting in inflated carrying costs. Conversely, with EOQ, the company can balance these two cost components. This is consistent with the findings of Jiraruttrakul et al. (2017), who reported cost savings of up to 50% following EOQ simulation in Thailand's import industry. For example, the calculation results show that:

- The optimal ordering frequency increased by 15–25%, resulting in a slight increase in ordering costs but offset by a reduction in carrying costs of more than 30%.
- In aggregate, the TIC using the EOQ model is 18–25% lower than the actual policy throughout the study period (2019–2021).

These findings reinforce Sari et al. (2020), who found that applying EOQ in retail and manufacturing companies can reduce total average inventory costs by 29%. The Economic Order Quantity (EOQ) calculations for five main raw materials—GPPS 685F, HIPS 470, Dimodan HPM, Calcium Stearate, and Talk Hichen—show a significant discrepancy between the company's actual policy and the mathematical model results. Based on data from 2019–2021, the EOQ model's optimal order quantity (Q*) is, on average, 15–28% lower than the actual policy.

Current company policies tend to focus on reducing ordering costs by placing large, infrequent orders. This approach actually increases carrying costs due to the long storage time

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of raw materials in the warehouse. The EOQ model offers a new balance point: although the order frequency increases by approximately 20%, total annual costs decrease.

This reduction is consistent with the findings of Rao & Mangal (2018), who reported that EOQ re-optimisation can save 5–10% of TIC per year in the manufacturing sector, and with Jiraruttrakul et al. (2017), who reported savings of up to 50% after EOQ simulation in a Thai import company.

A comparison of actual TIC and model results indicates average annual savings of 21–25%. Specifically, ordering costs rose by around 8–12% due to increased order frequency, while carrying costs fell by 30–35%, resulting in a significant net reduction in TIC. This phenomenon reflects the classic EOQ principle—the trade-off between ordering costs and storage costs—and shows that the "order less but more often" strategy is more efficient when storage costs are relatively high. These results are consistent with those of Sari et al. (2020), who reported a 29% efficiency gain at the Muslim fashion retailer CV Rafhanah following implementation of the EOQ model.

To assess the model's stability, a sensitivity analysis was conducted for the variables H (holding cost) and S (ordering cost). A change in H of ± 10% changed Q* by approximately ± 5%, while a change in S of ± 10% changed Q* by ± 4%. This indicates that the EOQ model has moderate sensitivity—it is responsive but remains stable under cost fluctuations. These findings are consistent with the analysis by Bah et al. (2023), which shows that EOQ remains effective even when cost parameters change by up to ± 15% from their initial values.

With the reduction in TIC value, companies gain two direct benefits: 1) Working capital optimisation, as the decrease in average inventory improves inventory turnover and cash flow liquidity; 2) More efficient warehouse space, which means that fixed costs per unit decrease due to increased utilisation. Empirically, this shows a shift in the EOQ function from merely an inventory optimisation tool to a financial instrument for managing capital costs.

The EOQ results are validated by comparing operational indicators before and after the simulation:

a. Inventory Turnover Ratio increased from 3.2 times to 4.5 times per year;
b. Days of Inventory Outstanding decreased by approximately 27 days.
c. Cost Saving Ratio (TIC efficiency / actual TIC) averaged 24%.

This indicator indicates that the EOQ model not only reduces inventory costs but also improves the company's operational resilience, consistent with the study by Gokhale & Kaloji (2018), which found a positive correlation between the application of EOQ and profitability in the Indian foundry industry.

3.2 Safety Stock and Reorder Point Analysis

The Economic Order Quantity (EOQ) model applied in this study is augmented with Safety Stock (SS) and Reorder Point (ROP) components to ensure the continuity of raw material supply amid demand uncertainty and fluctuations in delivery times. This integrative approach makes the inventory control system more realistic and adaptive to the operational dynamics of manufacturing companies.

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Conceptually, Safety Stock is a reserve provided to anticipate variations in demand and delivery delays (lead time uncertainty). In this study, SS calculations are based on the standard deviation of daily demand and delivery waiting times, with the desired service level accounted for. This means that the greater the demand fluctuations or the greater the uncertainty in raw material delivery, the greater the SS value required to maintain smooth production. According to Kırmızı et al. (2024), SS functions as "operational insurance" against the risk of stockouts, and its amount must be adjusted to the company's risk profile and tolerance policy for supply delays.

Meanwhile, the Reorder Point (ROP) is determined by multiplying the average daily demand (d) by the lead time (L), then adding the SS value, as per the formula:

$$ROP = (d \times L) + SS$$

This approach ensures that new raw material orders are placed when remaining stock approaches the minimum level that can still cover demand during the lead time. In other words, ROP functions as an early-warning system to prevent companies from experiencing material shortages during production.

The analysis shows that applying Safety Stock and ROP with this approach yields a safer order time tolerance, particularly during sudden demand surges or supplier distribution disruptions. With more accurate SS and ROP calculations, companies can reorder on time without having to stockpile excessive amounts of inventory. This directly improves storage space efficiency and reduces carrying costs.

For example, during 2020–2021, when demand fluctuations increased amid post-pandemic economic uncertainty, simulation results showed that this model-based ROP policy maintained production continuity without incurring significant additional storage costs. These findings align with Kadafi & Delvina (2021), which emphasises that the balance between cost efficiency and supply reliability is central to modern inventory control systems. They argue that integrating EOQ–SS–ROP is superior to the single EOQ model because it maintains operational performance even when demand or lead time is variable.

Furthermore, empirical studies by Jiraruttrakul (2017) in the automotive industry support these findings—that applying a combination of EOQ, SS, and ROP can reduce Total Inventory Cost (TIC) by up to 18% while increasing the average service level from 92% to 97%. From a managerial perspective, this means that companies not only achieve cost efficiency but also strengthen operational resilience through better supply readiness.

From a strategic perspective, the integration of EOQ–SS–ROP represents a paradigm shift from a purely cost-minimisation approach to cost–service optimisation, in which inventory decisions consider two key dimensions: economic efficiency and operational reliability. This model encourages managers to no longer simply reduce costs, but rather balance them with the company's ability to meet customer demand without disruption.

As concluded by Arani et al. (2021), effective inventory control in the digital era must be based on adaptive calculations, in which SS and ROP are regularly updated using actual demand data and changes in lead time. In the context of this study, this approach has been shown to maintain the continuity of raw materials at PT Trimitra Kemasindo without causing overstocking, while optimising the company's working capital liquidity.

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3.3 Comparison of Total Inventory Cost (TIC)

A comparison of the actual Total Inventory Cost with the EOQ model results indicates a significant difference. Although the actual policy yields relatively high TIC due to the dominance of storage costs, applying EOQ consistently reduces total costs. A comparison graph of TIC over the last three years shows a downward trend of approximately 20% per year, as indicated by the EOQ simulation.

Table 2. The Result of the F-test

Component	Actual Policy	EOQ Model	Efficiency Difference
Ordering Cost	Lower (low frequency)	Slightly increased	-
Storage Costs	Very high	Significantly decreased	↓ 30–35%
Total Inventory Cost (TIC)	High	Lower	↓ 20–25%

This efficiency reinforces the argument that the EOQ model functions not only as a quantitative calculation tool but also as a rational, data-driven cost control mechanism. These findings are consistent with studies by Arif et al. (2022) and Rao & Mangal (2018), which emphasise the positive correlation between EOQ model accuracy and operational efficiency.

3.4 Managerial Implications

The application of the Economic Order Quantity (EOQ) model in inventory management is not only about determining the optimal order quantity but also about contributing to a strategic transformation in working capital management, customer service, and digital system integration. Based on the results of this study and the latest empirical findings, several important implications can serve as managerial guidelines.

The EOQ model requires a paradigm shift from an orientation toward excessive safety stock to an emphasis on efficient use of working capital. By calculating the economic order quantity (Q*), companies can significantly reduce carrying costs without disrupting the smooth supply of raw materials. Studies by Alnahhal et al. (2024) show that applying EOQ can reduce Total Inventory Cost by 20–30% within two to three years. Furthermore, a state-of-the-art review by Sharma and Kaur (2024) confirms that EOQ remains relevant in an era of supply chain uncertainty, as it is flexible in the face of variations in ordering and storage costs.

Discussion

The modern approach to inventory management emphasises the importance of linking stock decisions to service levels rather than merely to minimum stock levels. By setting service targets (e.g., 95% availability), managers can calculate Safety Stock (SS) and Reorder Point (ROP) that are aligned with demand variability and lead time. According to Rezaei and Kargar (2023), probabilistic-based optimisation of SS and ROP improves cost efficiency by up to 17% without reducing supply reliability. Thus, EOQ is no longer just a mathematical model, but also an instrument for achieving customer service excellence.

Recent research by Sudarmi & Sunaryo (2024) highlights the importance of integrating EOQ into Enterprise Resource Planning (ERP) and Manufacturing Execution System (MES) systems. This integration enables the automatic calculation of Q*, SS, and ROP using real-time

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data. Additionally, a study by Badakhshan & Ball (2023) emphasises that implementing digital twins in the supply chain improves demand forecasting accuracy and order decision efficiency by up to 25%. Therefore, companies should treat EOQ as a dynamic digital decision-support system rather than a static Excel calculation.

EOQ performance is greatly influenced by the accuracy of demand projections. When organisations adopt machine learning forecasting, demand variability can be reduced, thereby lowering SS and ROP without compromising service levels. Avi et al. (2024) found that combining EOQ and AI-based demand forecasting can reduce Total Inventory Cost by up to 22% in the FMCG industry. This means that EOQ functions optimally when supported by an intelligent, data-driven demand forecasting system.

Deterministic assumptions about lead times are often unrealistic in global supply chains. A study by Mohammed & Mandal (2023) shows that lead-time variability has the greatest impact on cost inefficiency, compared with demand variability. Therefore, managers need to update the ROP by accounting for the actual lead-time distribution and conducting sensitivity simulations to anticipate supply delays (e.g., due to weather or logistical disruptions). The safety stock optimisation approach has been proven to improve cost efficiency and reduce the risk of stockouts in multilevel supply chains (Arasteh, 2022).
Financial and operational managers need to have a sensitivity playbook for three key variables:

a. H (Holding Cost) – if it increases, Q* must be lowered so that average inventory decreases.
b. S (Ordering Cost) – if it decreases due to automation, Q* can be increased to reduce carrying costs.
c. L (Lead Time) – if it increases, SS and ROP are temporarily adjusted to maintain service levels.

According to Arasteh (2022), inventory policies that are adaptive to cost parameters achieve 15–20% higher efficiency than static policies. This approach ensures that TIC remains minimal under dynamic cost and demand conditions.

For companies with a wide range of SKUs, managers should use ABC-XYZ classification and select inventory models according to item characteristics. The application of a hybrid policy—for example, EOQ (deterministic) for stable items and a service-level/variability-based (stochastic) approach for fluctuating items—has been shown to reduce inventory costs while maintaining service levels; these findings are demonstrated in the hybrid ABC–XYZ + service-level study (Kırmızı et al., 2024). In line with Nobil et al. (2020), the EOQ model requires modification to account for the characteristics of perishable goods. Adjustments based on shelf life and quality deterioration help reduce losses from expired stock and maintain inventory cost efficiency.

The implementation of EOQ will only be sustainable if it is integrated into organisational governance and culture. According to Kırmızı et al. (2024) and Alnahhal (2024), the success of inventory management transformation is strongly influenced by cross-functional collaboration among finance, procurement, and production departments, as well as by periodic audits of EOQ parameters to maintain system efficiency and responsiveness. In

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addition, Tian (2024) and Sinoimeri & Teta (2023) state that the effectiveness of inventory policies needs to be linked to Key Performance Indicators (KPIs) such as On-Time In-Full (OTIF) and Inventory Turnover Ratio so that the EOQ model does not stop at the calculation stage but becomes part of the organisation's performance management system. The integration of inventory control and KPIs enables companies to monitor the efficiency of logistics processes while maintaining the reliability of supply in a broader value chain.

Overall, the managerial implications of this study confirm that EOQ is not only a tool for calculating cost efficiency but also a managerial framework for building data-driven decision-making systems. The integration of EOQ with digital technology, AI-based forecasting, and cross-functional governance makes it a model that remains relevant amid the complexity of modern supply chains.

Conceptually, the results of this study show that EOQ functions as a mechanism for enhancing efficiency, not merely as a mathematical calculation. In the context of manufacturing, EOQ balances economic rationality (minimising costs) with operational reliability (stable supply). The integration of EOQ with the concepts of safety stock and reorder point makes this model relevant for companies facing demand fluctuations and cost efficiency pressures. Thus, the results of this study reinforce the position of EOQ as an integral part of lean inventory management strategies in the era of supply chain digitalisation.

4. CONCLUSION

This study confirms that applying the Economic Order Quantity (EOQ) model significantly improves inventory cost efficiency and raw material management effectiveness in manufacturing companies. The results of the analysis show that actual inventory policies oriented toward large purchase quantities, but not measured mathematically, tend to incur wasteful storage costs (carrying costs) and reduce working capital turnover.

Applying the EOQ model yields a smaller optimal order quantity (Q*) but more frequent orders, thereby balancing ordering and carrying costs. Average Total Inventory Cost (TIC) savings range from 20–25% relative to the actual policy. This finding is reinforced by integrating the EOQ model with the Safety Stock (SS) and Reorder Point (ROP) components, which serve as safety mechanisms against demand fluctuations and lead-time uncertainty. The combination of EOQ–SS–ROP has been proven to maintain raw material continuity without causing overstocking, while also improving operational indicators such as inventory turnover ratio and days of inventory outstanding.

From a managerial perspective, the EOQ model plays a strategic role in helping management achieve cost efficiency while improving supply chain reliability. EOQ not only functions as a static calculation tool but also as a decision-support framework that can be integrated with digital systems (e.g., ERP and AI forecasting) for data-driven decision-making (e.g., inventory management). This approach aligns with the manufacturing industry's transformation toward sustainable efficiency and adaptive working capital management.

Theoretically, the results of this study reinforce the relevance of the EOQ model in a modern context characterised by demand uncertainty and the complexity of global supply chains. Although developed more than a century ago, the EOQ principle remains valid

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because it is adaptable through digital modification and integration with artificial intelligence-based predictive systems.

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