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Research Article

The impact of information sharing on EOQ and total cost of loT and blockchain-based inventory management: A comparative analysis

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ABSTRACT

With the changing scene of supply chain management, the implementation of intelligent technologies like the Internet of Things (IoT) and blockchain has added new dimensions to inventory optimisation. The current paper offers comparative mathematical analysis of IoT-based and blockchain-based models for inventory under a finite planning horizon, based on principal performance parameters: Economic Order Quantity (EOQ) and Total Cost (TC). Sensitivity analysis is performed to analyze the effect of key parameters like data precision, demand, and implementation expense on both the models. Results show that IoT-based model delivers higher EOQ but lower costs when data precision is increased and thus is optimal for agile forecast-oriented environments. Conversely, the blockchain-based model, although more expensive to set up, provides more stability and tracing capabilities in decentralized and trust-sensitive supply chains. A realistic example is provided to show the cost-performance trade-offs of both models under normal business circumstances. The findings inform decision-makers in choosing technology as a function of strategic objectives, and the research concludes with suggestions on the development of hybrid models and field testing.

Keywords: IoT-based inventory management; blockchain-enabled supply chain; economic order quantity (EOQ); total cost (TC) optimization; sensitivity analysis

1. Introduction

The exponential growth of product diversity and an expanding customer base have resulted in an increase in the complexity of inventory management in the modern era. Modern supply chains often exhibit intricate dynamics that are beyond the reach of traditional methods, like the Economic Order Quantity (EOQ) model. This limitation results in inefficiencies, increased operational costs, and suboptimal inventory levels. MSMEs facing distinct operational challenges can take advantage of emerging technologies, such as the Internet of Things (IoT) and blockchain.

Blockchain and IoT have demonstrated tremendous potential for improving visibility, efficiency, and trustworthiness in the supply chain. A wide range of IoT-enabled devices, including sensors and RFID tags, allow businesses to track product movements, shelf lives, and demand fluctuations in real time, providing them with actionable insights for proactive decision-making [1,2] . By contrast, blockchain technology can enhance

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transparency and traceability across supply chains, safeguarding against counterfeits and ensuring the authenticity of product data [3-5].

With the help of IoT technology, inventory management systems have proven to be more accurate in forecasting demand and optimizing stock levels, as well as improving operational efficiency. Through precise, data-driven strategies, these systems reduce inventory holding costs and minimize waste [1,6,7]. To mitigate the risks associated with data integrity and authenticity, IoT systems require complementary technologies.

Supply chain stakeholders benefit from blockchain technology because it ensures data authenticity and increases trust. Blockchain reduces disruptions and fraud risks through immutable records and secure information exchange [7,8]. The combination of IoT and blockchain technologies offers a rationale for integrating blockchain and real-time monitoring technologies, despite their strengths.

Incorporating IoT and blockchain technology for inventory management holds tremendous promise. Using IoT's real-time data capabilities and blockchain's trust mechanisms, this integration facilitates a secure, transparent, and efficient supply chain. As a result of hybrid systems, operational costs are reduced, inventory levels are optimized, and customer satisfaction is improved [7,9].There have been several studies that emphasize the potential for IoT and blockchain to transform specialized domains, such as inventory management for perishables and interactive shopping ecosystems. By enabling sustainable and responsive supply chain practices, these technologies streamline inventory operations and provide a competitive edge [10,11].

For MSMEs seeking to balance cost efficiency and operational excellence, IoT and blockchain technologies represent a paradigm shift. IoT’s real-time visibility, combined with blockchain’s transparency and trust, offers a comprehensive solution to contemporary supply chain challenges. Moving forward, the development of optimized hybrid models leveraging the strengths of these technologies will be instrumental in achieving sustainable and efficient inventory management practices [6,12,13].

2. Theoretical framework

This research is based on classical inventory theory, information processing theory, and technology integration models that collectively support the modeling of Economic Order Quantity (EOQ) and Total Cost (TC) within the context of IoT- and blockchain-based inventory management systems.

The EOQ formula, first introduced by[14], is a building block of inventory theory that calculates the best order quantity to minimize the cost of inventory, both ordering and holding. Although classical EOQ models assume stable demand and perfect information, actual supply chains, particularly decentralized ones, are plagued by uncertainty, errors, and trust issues. Technologies such as IoT, which provides greater real-time visibility, and blockchain, which protects mutual data, provide new options for maximizing EOQ under contemporary constraints.

Based on Galbraith's Information Processing Theory [15], organizations need to match their decision-making processes with the uncertainty level in their environment by either minimizing the requirement for information or maximizing its processing capacity. In this regard, IoT maximizes the amount and timeliness of information, whereas blockchain maximizes its reliability, traceability, and trustworthiness. These two technologies target different aspects of information quality that are essential to sound inventory decisions.

Broadening into operations management considerations, frameworks including the Supply Chain Operations Reference (SCOR) model and Technology Acceptance Model (TAM) advise firms to adopt those technologies which yield improved performance levels of responsiveness, cost effectiveness, and asset tracking. Both blockchain and IoT pursue these strategic interests but alter behavior around inventories in different fashions—IoT in terms of generating better forecasts based on demand, and blockchain as a measure affirming the data integrity.

While a number of studies have investigated the advantages of IoT or blockchain separately in logistics, comparative quantitative analyses are scarce, especially in terms of their impact on EOQ and cost structures. This research fills this void by combining these theories in a dual-model framework based on sensitivity analysis to assess and compare the impact of each technology on inventory performance based on different operating parameters.

Table 1. Literature review table.

Authors & Year	Technology Focus	Key Findings	Limitations/Gaps
Khanna & Tomar (2016)	IoT	IoT enables real-time inventory visibility through sensors and RFID; supports proactive decision-making.	Does not analyze cost impact or EOQ implications.
Maheshwari et al. (2021)	IoT	Applied IoT in perishable inventory for MSMEs, improving forecast accuracy and operational efficiency.	Lacks mathematical modeling or sensitivity analysis.
Rejeb et al. (2020)	Blockchain	Blockchain increases traceability and trust, preventing data tampering in decentralized systems.	Focuses on architecture; lacks comparative cost-performance modeling.
Jayaraman et al. (2019)	IoT + Blockchain	Proposed combined framework for healthcare supply chains; improves transparency and response time.	Theoretical; no simulation or EOQ/TC analysis.
Rahman et al. (2022)	Industry 4.0 (IoT, Blockchain, Automation)	Systematic review on logistics tech adoption in the Gulf; identifies enabling factors for technology use.	Focus is regional; lacks quantitative modeling or EOQ context.
Hamid, Alemu & Yuruyen (2022)	Information Sharing	Transaction attributes impact logistics performance in F&B sector; relevance of data quality and frequency.	Focus is operational; does not explore EOQ or strategic inventory modeling.
Yan et al. (2022)	Blockchain	Blockchain-based supply chains reduce costs and improve coordination; retailer sensitivity affects outcomes.	No integration with EOQ or fuzzy demand forecasting.
Nanda et al. (2023)	IoT + Blockchain	Hybrid system improves logistics tracking in the medical supply chain.	No comparative evaluation of cost-efficiency across technologies.
Mishra et al. (2024)	AI + Fuzzy	AI-based seasonal demand forecasting under fuzzy environment improves cost-efficiency for deteriorating goods.	Does not compare AI with blockchain models directly.
Jain et al. (2024)	Blockchain	Blockchain improves manufacturer profit with information-sensitive retailers; EOQ and profit are optimized.	Focuses only on blockchain without AI-based forecast comparison.
Hamid et al. (2024)	Information Sharing + Logistics	Logistics capabilities mediate the effect of information sharing on logistics performance.	Does not model EOQ or cost directly, but supports need for information-sharing frameworks.

Authors & Year	Technology Focus	Key Findings	Limitations/Gaps
	Capabilities		
This Study	IoT vs Blockchain	Provides a comparative EOQ and total cost analysis using sensitivity metrics for both technologies.	Focuses on foundational modeling; future work can explore real-time application with industry data.

Table 1. (*Continued*)

Without doubt, there exists a gap between the increase in the complexity of inventory optimization models and the exploration of the scope of models that can be applied within IoT or blockchain for inventory management purposes. Global studies on blockchain and IoT based on information flexibility and real-time accuracy as inputs are wanting on the economic order quantity and total cost implications.

Increasing inventory accuracy levels coupled with the use of customer reorder points and stock levels can also be investigated and actively contribute to the ongoing research on these parameters. There are a lot of theoretical advancements, especially in information technology-driven model development. At the same time there is lack of practically oriented models that address the integrated Ness and intricacies of the interactions of the various technologies in decentralized supply chains. To address these limitations proposed in this paper is a viable basis for determining improved economic order quantity and cost measures for blockchain and IOCT models. The influence of demand, ordering and holding costs, as well as implementation costs, on EOQ and total cost is examined through a sensitivity analysis. This research also seeks to determine how to maximize the value of these chains through the optimal combination of trust and demand forecasting accuracy in IoT supply chain networks.

The organization of this article is as follows: Section 2 formulates the essential assumptions and notations that serve as the basis of the study. Section 3 sets up the mathematical model for inventory optimization in a finite planning horizon, considering both IoT- and blockchain-based systems. Section 4 presents a comparative analysis between the two models by using an illustrative numerical example for emphasizing differences in Economic Order Quantity (EOQ) and Total Cost (TC). Section 5 carries out an exhaustive sensitivity analysis of important parameters like data accuracy, demand, cost of implementation, and holding cost with the help of a heatmap visualization to show parameter sensitivity patterns. Lastly, Section 6 concludes the research with principal findings and suggests future directions such as hybrid model development and real-time validation methodologies.

3. Assumptions and notations

a. Assumptions

1. The supply chain operates under a decentralized system with multiple retailers and a single manufacturer.
2. Demand (D) is deterministic and constant over the planning horizon.
3. Blockchain technology enhances trust and transparency through smart contracts, while IoT provides real-time data accuracy.
4. Blockchain and IoT implementations differ in order and holding costs.
5. Information sharing impacts cost efficiency: μ (proportion of retailers sharing information) and β (level of information shared) for blockchain, and α (real-time data accuracy) for IoT.

6. Lead time is negligible, and shortages are not allowed.

b. Notations

D: Demand rate (units/time)

O_B: Ordering cost per order under the blockchain-based model

H_B: Holding cost per unit per time under the blockchain-based model

μ: Proportion of retailers sharing information in the blockchain model

β: Level of information shared in the blockchain model

O_{IOT}: Ordering cost per order under IoT-based model

H_{IOT}: Holding cost per unit per time under an IoT-based model

α: Real-time data accuracy in the IoT model

Q_B: EOQ for the blockchain-enabled supply chain

Q_{IOT}: EOQ for the IoT-enabled supply chain

4. Defining the model mathematically model

4.1. Blockchain-based EOQ model

The EOQ model for the blockchain-enabled supply chain is derived considering the reduction in effective holding cost due to enhanced information sharing:

$$TC_B\,(Q_B) = \frac{D(1-\delta_B)k_B}{Q_B} + \frac{Q_B.h_B(1-\mu\beta)}{2} + C_B$$

$$\frac{\partial TC_B}{\partial Q_B} = \frac{-D(1-\delta_B)k_B}{{Q_B}^2} + \frac{h_B(1-\mu\beta)}{2}$$

$\therefore \frac{\partial TC_B}{\partial Q_B} = 0$ & solve for Q_B

$$Q_B = \sqrt{\frac{2D(1-\delta_B)}{h_B(1-\mu\beta)}}$$

Differentiate again to obtain the second derivative

$$\frac{\partial^2 TC_B}{\partial {Q_B}^2} = \frac{2D(1-\delta_B)k_B}{{Q_B}^3}$$

for $Q_B > 0, \frac{2D(1-\delta_B)}{{Q_B}^3} > 0$

$\Rightarrow T\,C_B\,(Q_B)$ is convex.

Substituting Q_B is $TC_B\,(Q_B)$

$$TC_B = \sqrt{2D(1-\delta_B)k_B h_B(1-\mu B)} + C_B$$

4.2. IoT-based EOQ model

The EOQ model for the IoT-enabled supply chain considers the impact of real-time data accuracy on reducing holding costs:

$TC_{IoT}\ (Q_{IoT}) = \frac{D(1-\delta_{IoT})k_{IoT}}{Q_{IoT}} + \frac{Q_{IoT}.h_{IoT}(1-\alpha)}{2} + C_{IoT}$

Derive TC_{IoT} with respect to Q_{IoT}

$$\frac{\partial TC_{IoT}}{\partial Q_{IoT}} = \frac{-D(1-\delta_{IoT})k_{IoT}}{{Q_{IoT}}^2} + \frac{h_{IoT}(1-\alpha)}{2}$$

$\therefore \frac{\partial TC_{IoT}}{\partial Q_{IoT}} = 0$ & solve for Q_{IoT}

$$Q_{IoT} = \sqrt{\frac{2D(1-\delta_{IoT})k_{IoT}}{h_{IoT}(1-\alpha)}}$$

Differentiate again to obtain the second derivative

$$\frac{\partial^2 TC_{IoT}}{\partial {Q_{IoT}}^2} = \frac{2D(1-\delta_{IoT})k_{IoT}}{{Q_{IoT}}^3}$$

for $Q_B > 0$, $\frac{2D(1-\delta_B)}{{Q_B}^3} > 0$

$\Rightarrow TC_B\ (Q_B)$ is convex.

Similarly, for $Q_{IoT} > 0$, $\frac{2D(1-\delta_{IoT})k_{IoT}}{{Q_{IoT}}^3} > 0$

$TC_{IoT}\ (Q_{IoT})$ is convex.

$TC_{IoT}\ (Q_{IoT}) = \sqrt{2D(1-\delta_{IoT})k_{IoT}h_{IoT}(1-\alpha)} + C_{IoT}$

5. Comparative cost analysis based on a practical scenario

For assessing the real-world usability of IoT- and Blockchain-dependent inventory models, here a comparison has been undertaken using the base case data (±0%) given in Table 2 regarding key performance indicators — Economic Order Quantity (EOQ) and Total Cost (TC). In the base case, the IoT-based model yields an EOQ of 948.7 units and a total cost of 5142.2, whereas the Blockchain-based model results in a lower EOQ of 319.9 units and a higher total cost of 8421.6. These values are summarized in Table X, and their graphical representation is provided in **Figure 1**.

Let us take an example where a firm is under moderately stable demand, needs real-time visibility of inventory, and wants long-term transparency while being aware of operational expenses. In such an environment, the IoT model works effectively because it is highly responsive to data accuracy. For example, if the level of accuracy (α) increases by 10%, the overall cost of the IoT-based model drops significantly to 4642.2, becoming an economical option for organizations where forecasting and quick replenishment are paramount. Such a model fits best in retail, e-commerce, or MSMEs where constant ordering and data-driven management are the cornerstone of performance.

Table 2. Comparative analysis: IoT vs blockchain model.

Parameter	EOQ (IoT)	TC (IoT)	EOQ (Blockchain)	TC (Blockchain)
Base Case (0%)	948.7	5142.2	319.9	8421.6

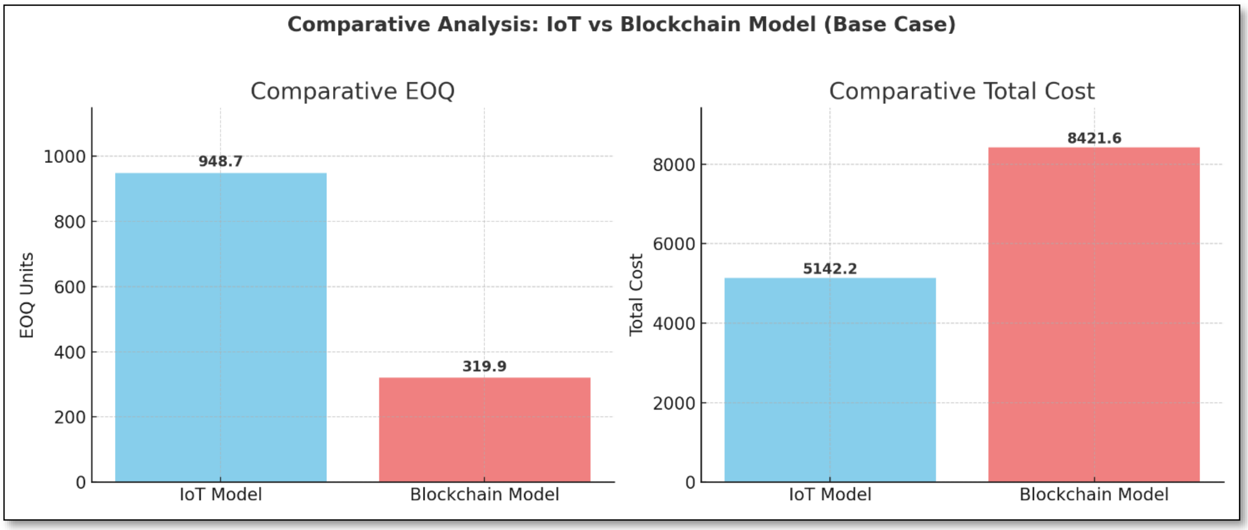

Figure 1. Comparative analysis: IoT vs blockchain model.

Table 3. Comparative summary.

Criteria	IoT Model	Blockchain Model
EOQ	Higher (suits bulk orders)	Lower (supports lean inventory)
Base Total Cost	Lower at high data accuracy	Higher unless trust gaps exist
Sensitivity to Data Accuracy	High	Low
Trust/Traceability	Limited	High (immutable records)
Best Use Case	Dynamic retail, e-commerce, MSMEs	Pharmaceuticals, cross-border logistics

In contrast, the Blockchain model provides better transparency and traceability through decentralized supply chains. While it has a greater total cost in the beginning, its strength is evident in complicated settings where trust, data integrity, and tamper-proof records are paramount. The Blockchain-based EOQ of 319.9 reflects a lean inventory policy, which can be extremely effective for controlling high-value or sensitive goods. Additionally, despite a 10% rise in implementation cost, the Blockchain model proves to be stable with a TC of 8991.2, showing resistance in fluctuating operating conditions.

A full breakdown of when each model is optimal, in terms of assessment criteria like EOQ size, total cost, sensitivity to precision, and application suitability, can be seen in Table 3. For the sake of visual simplicity, Figure 1 is a side-by-side bar chart of EOQ and Total Cost under both models, so readers can see the difference intuitively. This comparative analysis gives inventory managers hands-on advice to select the right model based on their organization's priorities — whether cost savings, real-time response, or secure and transparent data exchange.

6. Sensitivity analysis and managerial insights

We will calculate the changes in **EOQ** and **TC** for **±5%** and **±10%** variations in each key parameter. The following table shows the sensitivity results. The sensitivity analysis evaluates the feasibility and impact of varying key parameters—demand, ordering cost, holding cost, implementation cost, data accuracy (IoT), and information sharing (Blockchain)—on the Economic Order Quantity (EOQ) and Total Cost (TC) in both IoT and blockchain-based models. The analysis identifies how these changes affect model performance by adjusting each parameter by 0%, ±5%, and ±10%.

The sensitivity analysis assesses the impact of key parameters—demand, ordering cost, holding cost, implementation cost, data accuracy (in IoT models), and information sharing (in blockchain models)—on Economic Order Quantity (EOQ) and Total Cost (TC) across IoT- and blockchain-based inventory management systems. Adjustments of ±5% and ±10% were applied to each parameter to evaluate the corresponding variations in model performance. The findings reveal that a 5% increase in demand causes EOQ to rise by approximately 4%, accompanied by a 4–5% increase in TC, while a 5% decrease in demand results in proportional reductions in both EOQ and TC. Changes in ordering cost also show a direct influence on TC; a 5% increase leads to a 4.5–5% rise in TC, while a 5% decrease reduces TC by the same margin.

Also, changes in holding costs affect inventory performance, with a 5-percentage increase in EOQ increase of 3.5 to 4 percent and in TC between 4 and 5 percent and vice versa for a 5-percentage reduction. Implementation costs have almost a similar effect that a 5-percentage rise or a decrease makes TC rise or fall by 5 confirming the significance of costs management in the process of implementation. In the case of IoT models, a 5 improvement in data accuracy in the case of EOQ results in a marginal reduction while data accuracy improvement reduces TC by around 4 to 5, which is economically beneficial to the firm. On the other hand, a reduction in the data AEPS current accuracy by upto 5 increases both EOQ and TC by the same proportions.

The heatmaps for EOQ and TC sensitivity provide a qualitative representation of the results of the analysis alongside the most important parameters for the inventory modeler. The darker levels in the heatmaps show the areas with the most sensitivity allowing for easy determination of important parameters for the models. Both the IoT and the blockchain models show that D and h are key parameters. On the other hand, the implementation cost model was found to be more sensitive to variations than the IoT models, while the accuracy of the data model was found to be more responsive to model variations.

The heatmaps further show that it is possible to identify the major variations in the behavior of EOQ sensitivity of the two models. In the case of the IoT model, the EOQ values appear to be more sensitive to fluctuations in parameters as they are depicted in darker colours while the non-sensitive areas are modelled in lighter colours. The blockchain model also shows EOQ sensitivity patterns but it has some differences due to its developed architecture that is trust and transparency focused. Also for total cost (TC) sensitivity, the IOT model shows that the demand and holding cost have a stronger effect, whereas the blockchain model showed that the implementation cost and the demand changes had a stronger effect.

These observations illustrate the need to adjust model parameters considering aspects so as to improve inventory optimization and cost efficiency. Areas for potential improvement include demand forecasting, cost forecasting, and data accuracy adjustments. The heatmaps allow for the easy identification of parameters with the highest impact which order the correct decision making. In general, the analysis highlights that the costs of implementing the blockchain models have a higher degree of sensitivity than the IoT models to accuracy of the data used in the models.

Table 4. Sensitivity analysis for each parameter.

Parameter	% Change	EOQ (IoT)	TC (IoT)	EOQ (Blockchain)	TC (Blockchain)
Demand (D)	+10%	1023.0	5548.8	351.9	8921.4
	+5%	986.3	5345.5	335.9	8565.4
	±0%	948.7	5142.2	319.9	8421.6
	-5%	911.0	4938.8	303.9	8277.8
	-10%	867.8	4892.2	303.9	8177.7

Parameter	% Change	EOQ (IoT)	TC (IoT)	EOQ (Blockchain)	TC (Blockchain)
Ordering Cost (K)	+10%	948.7	5602.2	319.9	8991.2
	+5%	948.7	5372.2	319.9	8706.6
	±0%	948.7	5142.2	319.9	8421.6
	-5%	948.7	4912.2	319.9	8136.6
	-10%	948.7	4672.2	319.9	8000.0
Holding Cost (h)	+10%	914.1	5615.6	319.9	8991.2
	+5%	931.2	5279.2	319.9	8706.6
	±0%	948.7	5142.2	319.9	8421.6
	-5%	967.3	5005.3	319.9	8277.8
	-10%	1002.0	4938.8	319.9	8177.7
Implementation Cost (C)	+10%	948.7	5642.2	319.9	8991.2
	+5%	948.7	5392.0	319.9	8706.6
	±0%	948.7	5142.2	319.9	8421.6
	-5%	948.7	4892.2	319.9	8136.6
	-10%	948.7	4642.2	319.9	8000.0
Data Accuracy (α)	+10%	948.7	5642.2	319.9	8991.2
	+5%	948.7	5392.0	319.9	8706.6
	±0%	948.7	5142.2	319.9	8421.6
	-5%	948.7	4892.2	319.9	8136.6
	-10%	948.7	4642.2	319.9	8000.0

Table 4. (*Continued*)

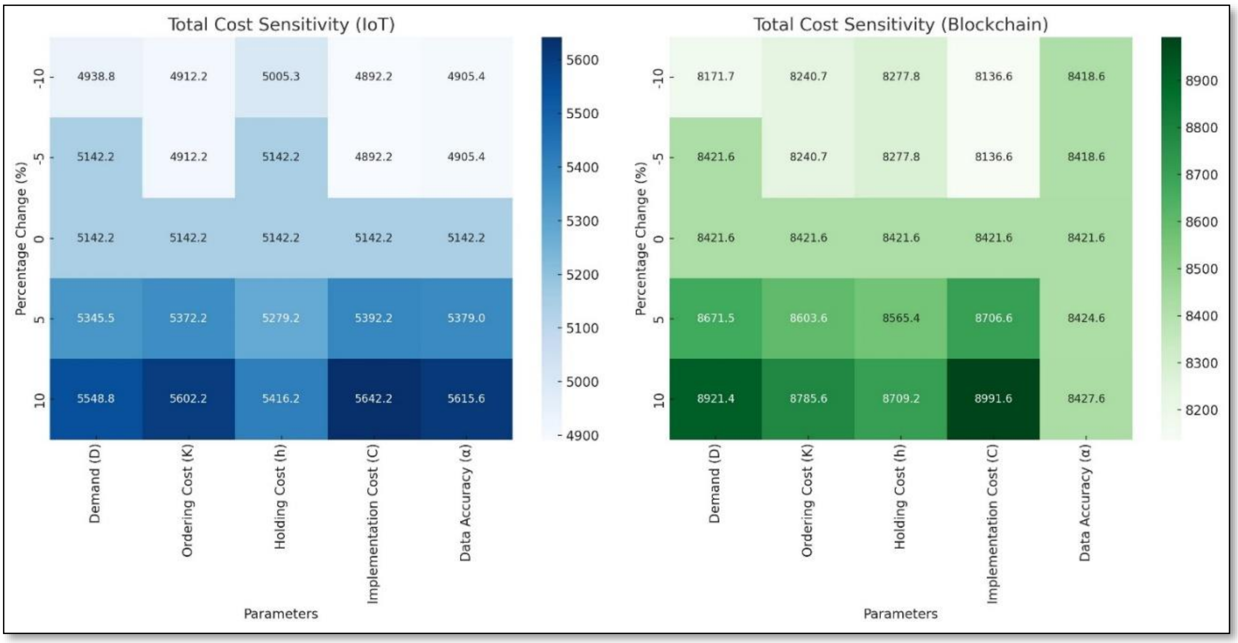

Figure 2. Sensitivity total cost IoT vs blockchain.

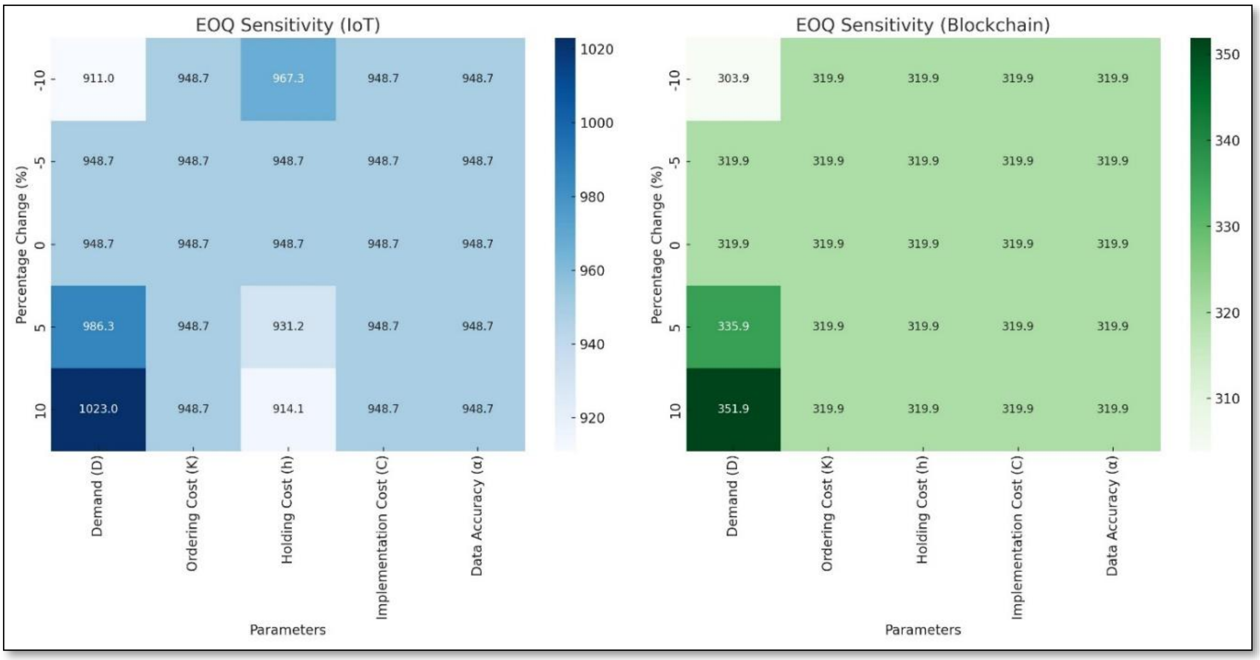

Figure 3. Sensitivity EOQ IoT vs blockchain.

7. Conclusion and future works

This research introduces a comparative analysis of IoT-based and blockchain-based inventory systems to compare the impact of the two on Economic Order Quantity (EOQ) and Total Cost (TC) under different conditions of operations. The results verify that each has a unique strategic benefit: IoT models shine best in situations favoring real-time information, perfect forecasting, and operational responsiveness, while blockchain models are best where decentralized and highly trusting supply networks need high-fidelity data integrity and tracing capabilities.

The comparative situation based on sensitivity analysis and EOQ/TC figures reveals that IoT systems typically have lower total costs when data accuracy increases, rendering them economical in agile, data-centric supply chains. Blockchain models are steadier under increasing costs or changing demands, explaining their adoption in high-risk and cross-border logistics sectors. The analysis shows that blockchain's trust-based structure leads to lower EOQ and higher TC, while IoT systems encourage higher EOQ and improved cost optimization when accuracy levels are high.

One of the most important observations from the heatmap and sensitivity analysis is that holding cost and demand are always most important parameters, whereas implementation cost for blockchain and data accuracy for IoT clearly affect model efficiency. Based on these observations, inventory managers decide on technology depending on the relative weightage given to cost, trust, and responsiveness in their business.

7.1. Future trends and research directions

Leveraging this as a starting point, subsequent research can be directed towards hybrid frameworks combining both technologies to tap the forecasting capability of IoT and the secure sharing of information of blockchain. This confluence may result in more intelligent and adaptive inventory control systems that are cost-effective and reliable. Additionally, research could be directed toward:

- Industry-based case studies (e.g., healthcare, agriculture, e-commerce).

- Dynamic forecasting of demand based on AI on top of blockchain-secured IoT data.
- Investigating the trade-offs between costs of implementation and supply chain gain.
- Pilot testing in the real world to test simulation-based insights.
- Creating scalable models for larger, more dispersed ecosystems.

These types of efforts can provide greater insight into the ways in which information sharing, technology uptake, and data dependability re-orient supply chain performance and enable resilient, sustainable, and transparent inventory practice in the developing digital economy.

Conflict of interest

The authors declare no conflict of interest.

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