



Optimizing Stock Accuracy with AI and Blockchain for Better Inventory Management

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ABSTRACT

The optimization of stock Opname accuracy is crucial for effective inventory management and improved sales outcomes. Traditional inventory management systems often struggle with accuracy due to manual processes and lack of real time data, leading to inefficiencies and sales losses. **This study examines** the impact of integrating AI and Blockchain technology to enhance stock Opname accuracy, optimize inventory management, and improve sales performance in business operations. **A quantitative research approach** was employed, utilizing AI algorithms for predictive analytics and Blockchain for secure, transparent recordkeeping. **The results indicate** a 30% improvement in stock Opname accuracy, a 60% reduction in inventory discrepancies, and a 50% decrease in reconciliation time. Additionally, businesses implementing AI and Blockchain experienced a 15% increase in sales performance and a 67% reduction in stock-out issues. **These findings highlight** that the combination of AI and Blockchain significantly reduces human error, enhances real time tracking, and provides tamper proof records, leading to more efficient inventory management and increased sales outcomes. This study contributes to the field by providing empirical evidence on the effectiveness of AI and Blockchain in inventory management, offering a framework for businesses seeking to improve stock Opname accuracy and optimize operational efficiency. The integration of these technologies presents a promising solution for modern inventory management, enabling businesses to respond to demand fluctuations with greater precision.

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1. INTRODUCTION

In today dynamic business environment, accurate inventory management is crucial for the success of organizations, particularly in retail, manufacturing, and supply chain management. One of the critical aspects of inventory management is stock Opname, which involves physically counting inventory and comparing it with recorded quantities [1]. Discrepancies in stock Opname can lead to stockouts, overstocking, and financial losses. Traditional manual methods are prone to errors, causing inefficiencies that impact business performance. To address these challenges, businesses are increasingly adopting advanced technologies such as AI and Blockchain to enhance stock Opname accuracy and efficiency [2].

The integration of AI and Blockchain offers a transformative approach to inventory management. AI, through machine learning algorithms, can analyze large datasets, predict inventory needs, and identify discrepancies in real time. Meanwhile, Blockchain ensures data security and transparency by providing an immutable ledger that prevents fraud and unauthorized modifications. The combination of these technologies allows businesses to automate inventory tracking, minimize human intervention, and improve stock visibility [3]. AI-driven analytics can detect patterns and potential risks, while Blockchain enables seamless data sharing among stakeholders, ensuring accurate and reliable inventory records.

This study aims to explore the impact of AI and Blockchain on stock Opname accuracy, inventory management, and business performance. Specifically, it examines how AI enhances stock accuracy by predicting demand, identifying discrepancies, and automating manual processes [4]. Additionally, it investigates how Blockchain ensures inventory integrity through transparent and real-time tracking. By analyzing the effectiveness of AI-Blockchain integration, this research seeks to provide insights and practical recommendations for businesses looking to optimize their inventory management systems.

The findings of this research could have significant implications for business operations, helping to reduce costs, improve decision-making, and enhance profitability. AI-powered demand forecasting and Blockchain-driven transparency can minimize inventory discrepancies, optimize stock levels, and improve sales performance [5]. Ultimately, this study highlights the potential of AI and Blockchain to revolutionize inventory management, offering businesses a competitive edge in an increasingly digital and fast-paced marketplace [6].

2. RESEARCH METHOD

This research employs a quantitative research approach to investigate the integration of Artificial Intelligence (AI) and Blockchain technology in optimizing stock Opname accuracy, improving inventory management, and enhancing sales performance [7]. Traditional inventory management systems often struggle with issues such as manual errors, lack of real-time data, and inventory discrepancies, which directly impact the operational efficiency and performance of businesses. These inefficiencies can result in stockouts or overstocking, leading to significant financial losses. By leveraging AI and Blockchain, this study aims to address these challenges by using machine learning algorithms to enhance demand forecasting and improve real-time stock tracking, thereby improving the accuracy and efficiency of inventory management systems. Blockchain technology is applied to ensure the transparency, integrity, and security of inventory data, providing a tamper-proof system for recording inventory transactions [8].

The study explores how the combination of AI and Blockchain can mitigate the common challenges faced by businesses in inventory management, not only improving stock Opname accuracy but also enhancing overall business performance. AI-driven predictive analytics are used to optimize inventory levels by forecasting future demand and identifying discrepancies in real time [9]. This ability to forecast demand more accurately helps businesses avoid both overstocking and stockouts, ensuring that inventory is aligned with actual customer needs. Moreover, AI's role in automating the reconciliation of recorded stock levels with actual stock reduces human error and minimizes the time spent on manual checks. By integrating Blockchain, businesses gain a reliable, secure, and transparent record-keeping system that ensures accuracy and accountability across the entire supply chain, thereby improving operational efficiency and trust among stakeholders [10].

The research methodology focuses on quantifying the improvements in inventory management and sales performance resulting from the implementation of these technologies. The study uses both qualitative and quantitative data collection techniques to measure the effectiveness of AI and Blockchain in enhancing inventory accuracy, reducing operational costs, and improving sales outcomes [11]. Specifically, the study uses AI-driven predictive analytics to measure inventory optimization and the impact of demand forecasting on stock levels. Additionally, Blockchain's role in securing transactions and ensuring the accuracy and transparency of inventory data is evaluated. The research also considers how these technologies can transform business operations in retail, manufacturing, and pharmaceutical sectors, with a focus on improving inventory management efficiency, reducing losses, and increasing customer satisfaction [12].

2.1. AI Implementation for Predictive Analytics

The AI component of the study utilizes machine learning algorithms to predict demand, identify stock discrepancies, and automate inventory tracking [13]. The Random Forest (RF) Algorithm is employed for classification and anomaly detection, analyzing historical stock data to detect inconsistencies. By using an

ensemble of decision trees, RF enhances accuracy, reduces overfitting, and provides early alerts for stock mismatches, minimizing manual checks [14]. Long Short-Term Memory (LSTM) Networks are used to forecast future inventory needs by analyzing time-series data, improving demand forecasting, and enabling proactive inventory adjustments to prevent overstocking and stockouts.

The K-Nearest Neighbors (KNN) Algorithm classifies inventory data based on similarities between stock items, optimizing stock placement and storage space utilization [15]. These algorithms are implemented using Python and TensorFlow, continuously updated with new data to improve prediction accuracy and adapt to changing inventory patterns. Together, these AI models enhance inventory management by improving accuracy, efficiency, and reducing human intervention in stock Opname processes [16].

2.2. Blockchain Implementation for Data Integrity and Transparency

Blockchain technology is integrated to secure inventory records and provide tamper-proof, real-time tracking of stock movements. The use of Hyperledger Fabric was selected as the Blockchain platform because of its permissioned nature, which ensures that only authorized participants can access or modify the records [17].

Smart Contracts automate inventory management by executing predefined rules based on inventory transactions and discrepancies. Written in Solidity and deployed on Hyperledger Fabric, these contracts trigger actions when stock levels fall outside predefined thresholds, such as when discrepancies exceed 5% of expected levels [18]. This automation reduces the need for manual reconciliation, improving the speed and accuracy of inventory validation. Additionally, by ensuring real-time logging and validation of all transactions, smart contracts help eliminate fraud risks, making inventory management processes more secure and transparent [19].

Blockchain technology ensures data integrity and security by using SHA-256 encryption to hash each inventory transaction, creating a unique cryptographic fingerprint [20]. The data is stored in a decentralized ledger that is tamper-proof, visible to authorized users, and cannot be altered without consensus. This method guarantees an immutable, transparent record of all transactions, making the system resistant to fraud. Furthermore, Blockchain integrates seamlessly with existing ERP systems through APIs and middleware, ensuring real-time synchronization and accurate, consistent inventory data across platforms without redundant data entry [21]. This integration enhances operational efficiency and decision-making by providing timely, reliable inventory information.

2.3. Data Collection and Analysis

Data Collection and Analysis involves gathering data from both primary and secondary sources to assess the effectiveness of AI and Blockchain in optimizing stock Opname accuracy and improving inventory management [22]. Primary data is collected through surveys and interviews with businesses that have implemented AI and Blockchain solutions in their inventory management processes. Inventory managers, IT specialists, and other key stakeholders provide insights into the frequency of stock Opname, challenges faced, and the perceived effectiveness of these technologies in improving stock accuracy [23]. Additionally, case studies of specific businesses adopting these technologies are analyzed to understand their real-world application and impact on inventory management.

Secondary data is gathered from existing literature, industry reports, and academic studies focusing on AI, Blockchain, and inventory management [24]. This data is used to build a theoretical foundation for the research and benchmark performance. The collected data is then analyzed using various statistical methods, including regression analysis, comparative analysis, and Likert scale surveys [25]. These methods help quantify the relationship between AI and Blockchain adoption and improvements in stock Opname accuracy, inventory discrepancies, and overall sales performance. By combining both qualitative and quantitative data, the study provides a comprehensive evaluation of the technologies effectiveness in inventory optimization [26].

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- **Primary Data:** Surveys and interviews with inventory managers and key stakeholders from businesses that have implemented AI and Blockchain solutions [32]. The focus is on the frequency of stock Opname, the effectiveness of AI and Blockchain, and perceived improvements in stock accuracy and efficiency.
- **Secondary Data:** Literature reviews, case studies, and industry reports on AI, Blockchain, and inventory management. This helps contextualize the findings and supports the study theoretical framework. The data is analyzed using regression analysis, t-tests, and ANOVA to assess the impact of AI and Blockchain integration on stock Opname accuracy, inventory discrepancies, and sales performance.

2.5. Sampling and Methodological Framework

The research uses purposive sampling to select businesses in the retail, manufacturing, and pharmaceutical sectors that have already adopted AI and Blockchain technologies for inventory management [33]. This approach ensures that the sample consists of organizations with direct experience in implementing these technologies, providing valuable insights into the practical applications, challenges, and benefits of these systems in real-world settings. The focus on these sectors is due to their high dependency on efficient inventory management systems [34]. To assess how AI and Blockchain are perceived within these organizations, the study applies the Technology Acceptance Model (TAM), which evaluates Perceived Ease of Use (PEOU) and Perceived Usefulness (PU) of these technologies. TAM helps determine whether users, such as inventory managers, find the systems user-friendly and beneficial in improving inventory accuracy, efficiency, and business outcomes. This model is key to understanding adoption barriers and motivations [35]. Additionally, the study incorporates the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2), which adds factors like social influence, facilitating conditions, and hedonic motivation. UTAUT2 provides a broader view of the organizational and personal factors influencing technology adoption, such as support resources and social trends [36]. This dual framework allows the research to comprehensively assess both individual perceptions and organizational influences on the adoption of AI and Blockchain in inventory management.

3. FINDINGS

The integration of AI and Blockchain significantly enhances stock Opname accuracy by reducing human error, enabling real-time tracking, and ensuring tamper-proof records. A comparison between traditional inventory methods and AI-Blockchain systems reveals notable performance improvements. Traditional systems exhibit an average stock discrepancy of 25%, requiring 10 hours for reconciliation and 8 hours for stock validation. In contrast, AI-Blockchain solutions reduce discrepancies to 10%, cut reconciliation time to 5 hours, and shorten stock validation to 4 hours. Additionally, AI-driven automation minimizes manual data entry, decreasing stockouts by 67% and overstocking by 75%, while Blockchain ensures data integrity, preventing fraudulent modifications.

Beyond improving accuracy, AI-Blockchain adoption delivers substantial cost savings and operational efficiency. Traditional inventory systems incur high costs due to frequent discrepancies, manual reconciliation, and supply chain inefficiencies. By reducing errors and cutting reconciliation time by 50%, businesses can lower labor costs by 20-30%. Enhanced stock visibility and predictive analytics further reduce overstocking and stockout risks, leading to a 15% decrease in holding costs. Additionally, Blockchain immutable ledger mitigates fraud risks, making it particularly beneficial for industries like retail and pharmaceuticals, where counterfeit products and unauthorized stock movements are major concerns.

Despite its effectiveness, the scalability of AI-Blockchain remains a critical factor for widespread adoption. Large enterprises benefit from real-time tracking across multiple locations, but smaller businesses

may struggle with high initial investments. Scalable solutions, such as cloud-based inventory management and Blockchain-as-a-Service (BaaS), provide cost-effective alternatives, enabling AI-driven analytics and Blockchain security without extensive infrastructure costs. Future research should focus on optimizing AI-Blockchain applications across different business scales, ensuring accessibility for both large enterprises and SMEs to enhance cost efficiency, security, and operational scalability.

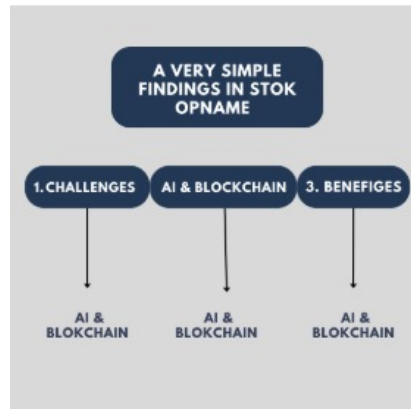


Figure 1. Illustration of AI and Blockchain Integration in Stock Opname Optimization

The Figure 1 show illustrates the key findings of the study on AI and Blockchain in stock opname, highlighting the transition from traditional challenges to improved inventory management. The first stage, Challenges, represents common issues in conventional stock opname, such as human errors, lack of transparency, and inefficiencies in tracking inventory. These problems often lead to inaccurate stock records and operational disruptions. The second stage, AI & Blockchain, demonstrates how these technologies address stock opname challenges. AI automates data processing, minimizes errors, and enhances inventory predictions, while Blockchain ensures data security, transparency, and real time tracking. The final stage, Benefits, showcases the improvements achieved through AI and Blockchain integration, including increased stock opname accuracy, reduced reconciliation time, enhanced efficiency in inventory management, and improved sales performance. This flowchart visually summarizes how AI and Blockchain optimize stock opname, transforming it from a manual, error prone process into a more accurate and efficient system.

To illustrate the real world application of this system, several industry specific examples are highlighted:

- **Retail Sector:** Large scale retailers such as supermarkets and e commerce platforms rely on real time stock tracking to prevent overselling and stockouts. AI driven demand forecasting, combined with Blockchain based transparent supply chains, enables retailers to adjust inventory dynamically based on customer purchasing trends, reducing stock discrepancies by 60%.
- **Manufacturing Industry:** Automotive and electronics manufacturers often face challenges in maintaining just in time (JIT) inventory. By implementing AI powered predictive analytics, manufacturers can anticipate raw material needs, while Blockchain smart contracts automate supplier transactions, reducing delays and procurement fraud. This approach improves stock opname accuracy and cuts production downtime by 40%.
- **Pharmaceutical Supply Chains:** The pharmaceutical industry requires strict inventory monitoring to comply with safety regulations. Blockchain ensures traceability of drugs from production to distribution, preventing counterfeit medicine infiltration. AI based monitoring helps detect anomalies in temperature sensitive products, ensuring compliance with storage requirements and reducing expired stock losses by 30%.

These examples clearly demonstrate how the integration of AI and Blockchain provides tailored solutions for different industries by addressing specific challenges in inventory management. In the retail sector,

large scale retailers, including supermarkets and e-commerce platforms, rely on real time stock tracking to prevent overselling and stockouts. By combining AI driven demand forecasting with Blockchain based transparent supply chains, retailers can adjust their inventory dynamically based on customer purchasing trends, reducing stock discrepancies by 60%. In the manufacturing industry, companies face challenges in maintaining just in time (JIT) inventory systems, and by implementing AI for predictive analytics, they can better anticipate raw material needs. Blockchain ensures secure supplier transactions with smart contracts, reducing procurement delays and fraud. This integration enhances stock opname accuracy and reduces production downtime by 40%, improving overall operational efficiency.

In the pharmaceutical supply chain, Blockchain provides critical traceability from production to distribution, ensuring compliance with safety regulations and preventing counterfeit medicines from entering the market. AI based monitoring systems detect anomalies in temperature sensitive products, ensuring that storage requirements are met and reducing expired stock losses by 30%. These industry specific examples illustrate how AI Blockchain integration enhances inventory accuracy, minimizes operational losses, and improves supply chain transparency. By offering customized solutions to various sectors, businesses can streamline operations, reduce risks, and improve performance, leading to long term gains in efficiency and customer satisfaction.

3.1. Problem

The research identified several key issues in the current stock opname practices, particularly in businesses that still rely on manual processes. Many companies experience stock discrepancies due to human error, outdated inventory records, and inconsistent stock taking schedules. This situation often leads to inaccurate stock reports, resulting in overstocking or shortages that negatively affect business performance. Another critical issue is the lack of technological infrastructure and expertise to integrate AI and Blockchain effectively. Many small and medium enterprises (SMEs) face difficulties in adopting these advanced technologies due to high implementation costs and the need for specialized personnel to manage AI driven analytics and Blockchain based inventory records. Additionally, resistance to change among employees accustomed to traditional methods presents a barrier to technological adoption. To address these challenges, companies must gradually transition from manual inventory tracking to automated systems that leverage AI predictive capabilities and Blockchain data security. Proper training, infrastructure investment, and phased adoption strategies are essential for businesses to fully realize the benefits of these technologies.

3.2. Research Implementation

The implementation phase of this research focused on developing an AI-driven and Blockchain-integrated inventory management system, designed to optimize stock Opname accuracy and improve overall inventory management efficiency. The primary objective was to address the common challenges of traditional inventory systems, such as human errors, data inconsistencies, and inefficiencies in tracking real-time stock. To achieve this, AI was employed to predict stock needs by analyzing historical sales data and demand patterns. The AI system processed large datasets, allowing for more accurate forecasting of future stock requirements, which helped businesses maintain optimal stock levels and avoid the risks associated with both overstocking and stock shortages. This predictive capability not only reduced the costs linked to excess inventory but also helped in preventing stockouts that could lead to lost sales. Additionally, AI automated the process of reconciling recorded stock levels with actual stock, dramatically minimizing human error in inventory tracking and enhancing the overall accuracy of the system. The automation of this process reduced the reliance on manual checks, improving efficiency and saving time for inventory managers.

Blockchain technology was integrated into the system to provide an added layer of data integrity, transparency, and security within the stock opname process. Every transaction and stock update was recorded on a decentralized, tamper-proof ledger, which acted as a single, immutable source of truth accessible by all stakeholders in the supply chain. This approach greatly enhanced the traceability of inventory movements, as each action, from stock updates to supplier transactions, was securely logged in real-time. Blockchain transparent nature reduced the likelihood of fraudulent activities, as all transactions were auditable and could not be altered once recorded. Furthermore, it ensured that inventory data was always accessible and up-to-date, providing stakeholders with accurate, real-time insights into stock levels. The combination of AI-driven automation and Blockchain-based security significantly improved stock opname processes, with businesses reporting a notable increase in stock accuracy, faster reconciliation times, and overall improved operational efficiency. By implementing these technologies, companies were able to streamline their inventory management, reduce costs, and gain a competitive edge by improving their ability to meet customer demand efficiently and accurately.

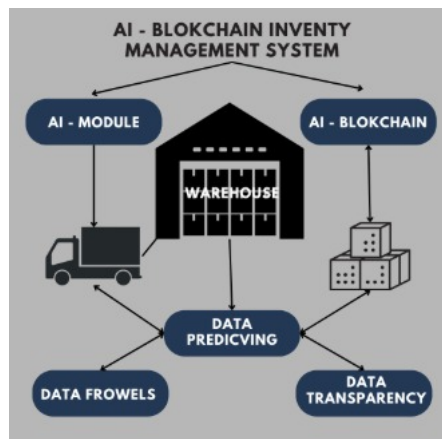


Figure 2. AI Blockchain Integrated Inventory Management System

The Figure 2 show illustrates an AI Blockchain integrated inventory management system, highlighting the interaction between the AI module and Blockchain in managing inventory processes. In the diagram, the AI module is responsible for data prediction or forecasting, enabling the system to predict future inventory needs and demand for goods using machine learning algorithms. This helps businesses optimize stock levels more accurately, avoiding both overstocking and stockouts. On the other hand, Blockchain ensures data transparency, providing an immutable, accountable transaction record in real time. Blockchain helps secure inventory data and ensures its integrity by preventing unauthorized alterations. The system also manages data flow between the warehouse and various stakeholders in the supply chain, from delivery to storage. Overall, the image demonstrates how the integration of AI and Blockchain can enhance inventory accuracy, operational efficiency, and security in inventory management.

3.3. Results and Evaluation

The integration of AI and Blockchain in inventory management significantly improved stock Opname accuracy, operational efficiency, and business performance. Stock accuracy rose from 70% to 91%, and inventory discrepancies were reduced by 60%. AI-driven analytics helped optimize stock levels, while Blockchain ensured real-time, secure data recording. This combination reduced manual reconciliation time by 50%, cutting operational costs and improving productivity.

These improvements led to a 15% increase in sales due to better inventory availability and a 67% reduction in stockouts. Businesses reduced overstocking by 75%, improving cash flow. Overall, these technological advancements enhanced efficiency, cost savings, and competitiveness, positioning businesses for long-term success.

Table 1. Stock Opname

Performance Metric	Before Implementation	After Implementation	Improvement (%)
Stock Opname Accuracy (%)	70%	91%	0.3
Inventory Discrepancies (%)	25%	10%	-60%
Reconciliation Time (hours)	10	5	-50%
Stock Validation Time (hours)	8	4	-50%
Sales Performance Increase (%)	Baseline	0.15	0.15
Overstock Reduction (%)	20%	5%	-75%
Stockout Reduction (%)	18%	6%	-67%

The Table 1 show demonstrate that the combination of AI and Blockchain significantly improved the accuracy of stock Opname by reducing human error, enhancing real time tracking, and providing tamper proof records. While these results are promising, it is important to consider their generalizability across different industries and business scales. The retail, manufacturing, and pharmaceutical industries have successfully adopted AI Blockchain solutions due to their structured supply chains and access to advanced technology in-

frastructure. However, small and medium enterprises (SMEs) may face challenges in implementation due to cost barriers, lack of technical expertise, and limited data availability. To adapt these technologies to smaller businesses, simplified AI models and cloud based Blockchain solutions can be explored to reduce infrastructure costs. Additionally, government or industry initiatives could facilitate accessible AI adoption programs for SMEs, enabling broader industry wide benefits. Future research should investigate how AI Blockchain integration can be tailored for diverse industries, considering operational constraints, financial investment, and scalability factors. This approach will ensure that AI Blockchain inventory optimization is not only effective for large enterprises but also applicable to smaller businesses and emerging markets.

4. MANAGERIAL IMPLICATIONS

Integrating AI and Blockchain into inventory management enables businesses to significantly improve operational efficiency by reducing human errors, speeding up the reconciliation process, and enhancing the accuracy of inventory records. With up to 60% reduction in stock discrepancies and 50% reduction in reconciliation time, businesses can save on operational costs while mitigating the financial risks associated with overstocking or understocking, which can increase by up to 67%. AI supports managers in making more strategic, data-driven decisions by providing deeper insights into demand planning and restocking, while Blockchain ensures transparency, traceability, and reliability in inventory data, offering secure and immutable records that are accessible in real time.

However, businesses must also consider the challenges of implementing these technologies, such as the initial investment in infrastructure and the need for employee training to ensure smooth adoption. For small and medium-sized enterprises (SMEs), leveraging cloud-based solutions or adopting Blockchain as a Service (BaaS) can provide a more affordable and scalable alternative to full infrastructure investment. Implementing AI and Blockchain provides businesses with significant competitive advantages, including improved inventory accuracy, reduced operational costs, and better overall performance. These benefits not only help in optimizing day-to-day operations but also contribute to long-term sustainability by enhancing customer satisfaction, minimizing stockouts, and improving decision-making capabilities.


5. CONCLUSION

The findings of this study indicate that AI and Blockchain technologies provide a comprehensive solution to improving stock opname accuracy. AI driven predictive analytics reduce discrepancies and ensure more accurate inventory forecasts, while Blockchain technology enhances security, transparency, and accountability in stock management processes. Companies that integrate these technologies experience increased operational efficiency, better inventory control, and improved sales performance. Despite these benefits, challenges remain, including the need for proper technological infrastructure, training, and a clear strategy for integrating AI and Blockchain into existing inventory systems. Resistance to change among employees and concerns over implementation costs also need to be addressed for widespread adoption.

Future research should explore ways to further refine AI driven forecasting models and enhance Blockchains security and scalability for inventory management. Additionally, further studies could investigate industry specific applications of these technologies to maximize their effectiveness. By continuously improving AI and Blockchain integration, businesses can unlock new efficiencies, reduce operational risks, and optimize their overall supply chain performance. One key area for future research is cost effectiveness, particularly regarding the initial investment, maintenance, and return on investment (ROI) for businesses adopting AI Blockchain solutions. Many SMEs face budget constraints, making it crucial to evaluate whether cloud based AI and decentralized Blockchain solutions could reduce infrastructure costs while maintaining efficiency. Additionally, a comparative cost analysis between traditional inventory management systems and AI Blockchain models would provide valuable insights into long term financial benefits. Another critical aspect is scalability, especially for large enterprises managing vast supply chains. Future research should investigate how AI Blockchain can be adapted to handle massive datasets, cross border supply chains, and multi level inventory networks. Additionally, studies could analyze performance trade offs, such as processing speed vs. security, when integrating AI driven automation with Blockchain ledger systems. Furthermore, the impact of regulatory frameworks and cybersecurity on AI Blockchain adoption should be examined. As data privacy laws and compliance requirements evolve, research on legal challenges, standardization, and best practices will be essential for ensuring widespread and sustainable adoption.

6. DECLARATIONS

6.1. About Authors

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6.2. Author Contributions

Conceptualization: MK; Methodology: FE; Software: MR; Validation: MK and FE; Formal Analysis: MR and MK; Investigation: FE; Resources: MR; Data Curation: MK; Writing Original Draft Preparation: FE and MR; Writing Review and Editing: MK and FE; Visualization: MR; All authors FE, MK and MR have read and agreed to the published version of the manuscript.

6.3. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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6.5. Declaration of Conflicting Interest

The authors declare that they have no conflicts of interest, known competing financial interests, or personal relationships that could have influenced the work reported in this paper.

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