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Blockchain and AI synergies for effective supply chain management

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Abstract
In supply chain management, the combination of Blockchain and Artificial Intelligence (AI) offers innovative solutions to address critical challenges, particularly in safeguarding financial transactions and reducing fraud. Blockchain's decentralized and immutable nature, coupled with AI's ability to analyze vast data sets and detect patterns, can create tamper-proof financial records and enhance trust in supply chain operations. Blockchain-backed smart contracts can automate processes, ensuring transparency, accountability, and efficiency in trade finance. These smart contracts execute predefined actions based on agreed conditions, and the integration of AI allows for real-time monitoring, risk assessment, and anomaly detection. This synergy enhances the security and reliability of trade finance transactions, significantly reducing the potential for fraud, errors, or disputes. AI can continuously analyze blockchain transaction data to identify fraudulent activities, unauthorized access, and discrepancies, further bolstering security. By leveraging these technologies together, supply chain networks can achieve greater operational efficiency, minimize financial risks, and ensure the integrity of financial records. This review explores the potential of blockchain and AI synergies in creating secure, transparent, and fraud-resistant trade finance ecosystems, highlighting their impact on reducing fraud and increasing overall supply chain reliability. The integration of these advanced technologies holds great promise for transforming global trade by enabling more secure, efficient, and trustworthy financial operations across interconnected supply chains.

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1. Introduction

Supply chains form the foundation of global commerce, encompassing a vast network of transactions, operations, and financial exchanges (Wang *et al.*, 2020). However, these networks face a number of challenges, particularly in terms of financial transparency and fraud risk reduction in trade finance (Adegoke *et al.*, 2022). Traditional methods of tracking transactions and financial records frequently use centralized systems that are susceptible to manipulation, errors, and fraud. The increasing complexity of supply chains, combined with growing concerns about financial security, necessitates innovative solutions to ensure the integrity of financial data across transactions (Asante *et al.*, 2021). This has prompted the development of advanced technologies such as Blockchain and Artificial Intelligence (AI) to provide more secure, transparent, and tamper-proof financial record-keeping systems.

Trade finance plays a critical role in facilitating the movement of goods and services across borders, yet it remains prone to significant risks, particularly fraud (Sapian *et al.*, 2021). Fraudulent activities such as invoice manipulation, counterfeit documentation, and financial misreporting not only threaten the security of financial transactions but also erode trust within the

global supply chain ecosystem (Mahtani, 2022). In addition to fraud risks, there are concerns about inefficiencies and lack of visibility in the tracking and verification of financial data. The complex nature of supply chain networks further exacerbates these issues, as multiple stakeholders are involved in the process, often relying on manual, paper-based systems for record-keeping (Henninger and Mashatan, 2021). Given these challenges, the need for secure, tamper-proof financial records has never been more pressing. Supply chain actors require reliable solutions that enhance trust, transparency, and accountability while reducing fraud risks and improving operational efficiency (Saeed *et al*., 2022). The integration of emerging technologies, such as Blockchain and AI, presents an opportunity to address these issues effectively.

Blockchain is a decentralized digital ledger that records transactions across multiple computers, ensuring that no single entity has control over the data. The key feature of blockchain is its immutability: once a transaction is recorded, it cannot be altered or deleted (Politou *et al*., 2022). This feature makes blockchain particularly effective for securing financial records, as it guarantees the integrity of the data while enhancing transparency. Smart contracts, a significant application of blockchain, are self-executing contracts where the terms of the agreement are written directly into lines of code (Dutta, 2020). These contracts automatically trigger actions when predefined conditions are met, eliminating the need for intermediaries and reducing the risk of fraud. Artificial Intelligence (AI), on the other hand, refers to technologies such as machine learning, predictive analytics, and pattern recognition that enable systems to learn from data, detect anomalies, and make informed decisions. In the context of supply chains, AI can analyze large datasets in real time to identify suspicious activities, predict potential risks, and optimize operations. By combining AI with blockchain, the accuracy and security of financial transactions can be significantly enhanced. AI's ability to identify fraudulent behavior, combined with blockchain's immutable ledger, forms a powerful synergy that addresses key challenges in trade finance (Tyagi *et al*., 2020).

The purpose of this review is to investigate the use of Blockchain and AI technologies to create tamper-proof financial records in supply chains and reduce fraud in trade finance via smart contracts. Organizations can create more secure and efficient financial systems by combining blockchain's decentralization and transparency with AI's ability to predict and identify anomalies. Smart contracts powered by blockchain ensure that all terms of a financial agreement are met, automating the process and lowering the risk of human error or fraud. AI improves this process by analyzing transaction data, identifying suspicious behavior, and providing actionable insights for decision-making. Together, these technologies hold the potential to revolutionize trade finance, creating more reliable, transparent, and fraud-resistant financial ecosystems in global supply chains. This review will examine the role of blockchain and AI integration in improving financial transparency and reducing risks, highlighting their transformative potential for the future of supply chain management.

2. Understanding the Role of Blockchain in Supply Chains

Blockchain technology has rapidly emerged as a game-changer in the field of supply chain management due to its ability to provide secure, transparent, and tamper-proof systems for managing information and financial transactions (Centobelli *et al*., 2022). Its decentralized nature, immutability, and transparency offer distinct advantages over traditional centralized systems, making it particularly valuable in mitigating risks associated with fraud, errors, and inefficiencies in global supply chains. This will explore the key features of blockchain technology, its various applications in supply chain management, and its potential for ensuring tamper-proof financial records.

At its core, blockchain is a distributed ledger technology that runs on a decentralized network of computers known as nodes (Komalavalli *et al*., 2020). Unlike traditional centralized systems, in which a single authority controls data, blockchain distributes data among multiple parties, ensuring that no single entity can manipulate or control the system. This decentralization improves security because there is no single point of failure that cybercriminals or malicious actors can exploit. Furthermore, each transaction or record added to a blockchain is encrypted and linked to the previous one, resulting in a continuous chain of blocks. This feature is known as immutability: once data is recorded on a blockchain, it cannot be altered or erased, making the system highly resistant to tampering and fraud (Al Hasan Politou *et al*., 2019). In addition to decentralization and immutability, blockchain offers transparency. Every participant in the network has access to the same data, and any changes made are visible to all stakeholders. This transparency enables all participants in a supply chain to track and verify transactions in real time, which fosters trust and accountability among parties (Dubey *et al*., 2020). For supply chain management, this level of transparency ensures that every step in the movement of goods and financial transactions can be traced, offering a complete and unalterable record of events.

The applications of blockchain in supply chain management are numerous and varied. One of the most common applications is for the traceability of goods. Blockchain allows for the tracking of products at every stage of the supply chain, from raw material extraction to final delivery to customers (Hastig and Sodhi, 2020). Companies can ensure product provenance by recording every movement and transaction associated with it on a blockchain. This is especially important in industries that require product authenticity and origin, such as pharmaceuticals, luxury goods, and food safety. This level of traceability not only ensures product safety and regulatory compliance, but it also enables consumers to make more informed purchasing decisions Qian *et al*., 2020). Similarly, in the pharmaceutical industry, blockchain can be used to combat counterfeit drugs, as it allows stakeholders to verify the authenticity of drugs before they reach consumers. Blockchain also plays a crucial role in improving the transparency and efficiency of financial transactions in supply chains. Traditionally, financial transactions in supply chains are processed through intermediaries, which can lead to delays, errors, and additional costs. Blockchain allows for the automation of financial transactions through the use of smart contracts self-executing contracts with predefined conditions written directly into code (Unsworth, 2019). When certain conditions are met, such as the receipt of goods or payment, the contract automatically executes, reducing the need for manual intervention and minimizing the risk of errors or fraud. This automation streamlines the financial processes and increases

the efficiency of transactions across supply chains (Cole *et al*., 2019).

One of the most valuable features of blockchain in supply chains is its ability to create tamper-proof records. As previously mentioned, blockchain's immutability ensures that once data is recorded, it cannot be altered or erased (Moin *et al*., 2019). This is particularly important when it comes to maintaining the integrity of financial records. In traditional financial systems, there is always the risk of unauthorized changes being made to transaction records, whether by internal actors or external threats. These changes can be difficult to detect, especially when the records are stored centrally and are accessible by a limited number of parties. Blockchain eliminates this problem by making all financial records transparent and available to all authorized participants (Laroiya *et al*., 2020). Each financial transaction is verified through consensus mechanisms, ensuring that all parties agree on the validity of the transaction before it is added to the blockchain. Once a transaction is confirmed, it becomes part of the immutable ledger, providing a secure and unalterable record. This feature is especially useful in trade finance, where secure financial transactions are vital to maintaining trust between buyers, sellers, and financial institutions (Jain and Sedamkar, 2020). Blockchain ensures that all transaction data is accurate, consistent, and tamper-proof, providing a level of security that is not achievable with traditional record-keeping systems. The ability to prevent unauthorized changes in financial records not only reduces the risk of fraud but also enhances compliance with regulatory standards. For example, blockchain's transparent and immutable nature can help companies demonstrate their compliance with anti-money laundering (AML) and know-your-customer (KYC) regulations by providing a clear and auditable trail of financial transactions. This level of transparency and accountability is particularly valuable in global supply chains, where multiple stakeholders across different jurisdictions are involved, each with their own regulatory requirements (Gardner *et al*., 2019).

Blockchain technology has the potential to revolutionize supply chain management by providing secure, transparent, and tamper-proof solutions for tracking goods and financial transactions (Iftekhar *et al*., 2020). Its key features decentralization, immutability, and transparency address many of the challenges associated with fraud, inefficiencies, and errors in traditional supply chain systems. Blockchain not only ensures traceability and visibility in the movement of goods but also enables the creation of tamper-proof financial records, thereby reducing the risk of fraud and ensuring data integrity. As supply chains become increasingly complex and interconnected, the adoption of blockchain technology will play a crucial role in building more secure, efficient, and trustworthy systems for global trade (Rejeb *et al*., 2019; Koh *et al*., 2020).

2.1 The Role of AI in Supply Chains

The incorporation of Artificial Intelligence (AI) into supply chains is revolutionizing how businesses manage operations, increase efficiency, and secure financial transactions (Dash *et al*., 2019). AI technologies such as machine learning (ML), predictive analytics, and natural language processing (NLP) are increasingly being used to detect fraud, predict potential financial discrepancies, and automate key trade finance processes. As supply chains become more complex and interconnected, using AI to complete these tasks is critical to improving the overall security and efficiency of financial transactions within these systems (Sobb *et al*., 2020). This investigates the role of AI in supply chains, with a particular emphasis on advanced analytics for fraud detection, predictive modeling for fraud prevention, and process automation to streamline financial transaction workflows.

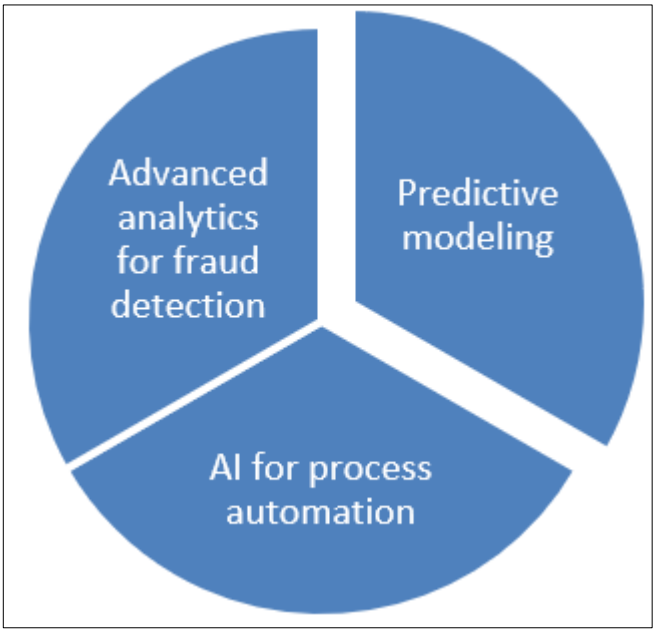

Fig 1: The importance of AI in supply chains

One of the most promising applications of AI in supply chains is in advanced analytics for fraud detection (Hassija *et al*., 2020). Fraudulent activities, including financial discrepancies, document falsification, and unauthorized transactions, pose significant risks to organizations in trade finance. Traditional fraud detection methods often rely on rule-based systems, which are limited in their ability to adapt to new or evolving fraudulent techniques (Aparício *et al*., 2020). AI, particularly machine learning, can improve upon these methods by leveraging data-driven approaches to identify patterns and anomalies in trade finance data. Machine learning algorithms are particularly effective in analyzing large volumes of data in real-time. These algorithms can examine transactional records, shipping logs, invoices, payment histories, and more, to detect irregularities that may indicate fraudulent activities. For example, AI-powered systems can analyze trends in pricing, shipment times, or payment terms, and flag unusual patterns that could suggest fraudulent behavior. In the context of trade finance, such systems can detect fraudulent financial transactions, such as false invoice payments or fictitious trade deals, before they result in significant financial losses (Nicholls *et al*., 2021). One of the key advantages of using AI for fraud detection is its ability to continuously learn and improve its performance over time. As AI systems are exposed to more data, they become better at recognizing subtle fraud indicators, which might be overlooked by human analysts or traditional rule-based systems. This adaptive capability enhances the ability to detect new forms of fraud, even those that have not yet been encountered in prior data.

Another critical role of AI in supply chains is its application in predictive modeling to anticipate potential fraud or financial discrepancies before they occur. Predictive modeling leverages historical data, trends, and patterns to

forecast future events or behaviors (Zhao, 2021). In the context of trade finance, predictive modeling can be used to anticipate fraudulent activities or financial risks based on past occurrences and other relevant factors. By analyzing historical financial data and transaction records, AI systems can build models that predict which transactions or business relationships are most likely to result in fraud. For example, AI models can analyze the relationship between suppliers and buyers, taking into account factors such as payment history, shipment times, and product quality. If certain characteristics are identified as predictive of fraud, the model can flag these transactions as high-risk, allowing businesses to take preventative measures before the transaction is completed. These predictions can be invaluable for risk management, as they allow organizations to proactively address potential threats before they cause significant financial damage. Moreover, predictive models can be used to identify early signs of financial discrepancies, such as payment delays, irregular billing, or inconsistencies in contract terms (Peters *et al*., 2019). By detecting these discrepancies early on, AI can help businesses mitigate risks and avoid costly disputes. Predictive analytics also enables supply chain managers to better allocate resources, prioritize high-risk transactions, and develop targeted strategies to address emerging threats.

AI's role in automating supply chain processes includes streamlining workflows for financial transaction approvals and dispute resolution. Traditional trade finance systems' approval processes for transactions like invoices and payments can be slow, error-prone, and labor-intensive (Eggers *et al*., 2021). By using AI technologies to automate these workflows, organizations can significantly reduce the time and cost associated with manual processing. AI-powered systems can automate the review and approval of financial transactions by verifying invoice accuracy, identifying discrepancies between purchase orders and shipment receipts, and comparing payment terms to contract agreements. This automation speeds up the approval process, reduces the risk of human error, and ensures that financial transactions are consistent with agreed-upon terms. AI can also play a key role in dispute resolution by automatically identifying potential issues, such as payment delays or contract violations, and offering solutions based on predefined rules or historical data (Alessa, 2022). AI systems can analyze the context of the dispute, such as communication between parties, contract terms, and past transaction history, to recommend appropriate actions for resolving the issue. This can include triggering automatic notifications to stakeholders, proposing alternative payment schedules, or even suggesting adjustments to contract terms. By automating the dispute resolution process, AI can help businesses avoid costly delays and legal complications (Zeleznikow, 2021). In addition to automating financial transaction approvals, AI can also streamline the broader supply chain management process. For example, AI systems can optimize inventory management, shipment scheduling, and demand forecasting, leading to more efficient supply chain operations. These improvements not only enhance operational efficiency but also reduce the likelihood of errors or fraudulent activities that can arise due to miscommunication or delayed transactions (Omar *et al*., 2020).

The integration of AI into supply chain management offers significant advantages, particularly in the areas of fraud detection, predictive modeling, and process automation. Advanced analytics powered by AI can detect patterns and anomalies in trade finance data, improving the ability to identify fraudulent transactions and financial discrepancies (Sambrow and Iqbal, 2022). Predictive modeling allows organizations to anticipate risks and proactively address potential threats, while process automation streamlines workflows and reduces the time and costs associated with manual transaction approvals and dispute resolutions. As AI technology continues to evolve, its application in supply chains will likely expand, offering even greater capabilities for securing financial transactions and improving overall efficiency. By embracing AI, businesses can build more secure, efficient, and resilient supply chains that are better equipped to navigate the complexities of global trade finance.

2.2 Blockchain-Backed Smart Contracts with AI Integration

In recent years, blockchain technology has gained significant traction for its potential to disrupt traditional industries, including finance, supply chain management, and contract execution (Madhani, 2021). One of the most promising applications of blockchain is the concept of smart contracts self-executing agreements with predefined rules encoded on a blockchain. These contracts automatically enforce and execute the terms of agreements when certain conditions are met, minimizing the need for intermediaries and reducing human error. Integrating artificial intelligence (AI) into smart contracts has further enhanced their potential by adding real-time decision-making capabilities and improving fraud detection mechanisms.

Smart contracts are digital agreements that are programmed to automatically execute, enforce, or verify the terms of a contract when certain conditions are met (Hamledari and Fischer, 2021). These contracts are written in code and stored on a blockchain, ensuring transparency, security, and immutability. The decentralized nature of blockchain eliminates the need for intermediaries such as banks or legal representatives, as the code enforces the contract's rules. Smart contracts function by automating complex processes that would otherwise require human intervention. A blockchain-backed smart contract is automatically executed when the specified conditions, such as payment verification or delivery confirmation, are met. The contract ensures that once these conditions are fulfilled, the terms of the agreement are immediately carried out e.g., releasing funds to the seller upon receiving proof of goods delivery (Chou *et al*., 2021). In addition to automating the execution of contracts, smart contracts provide a high level of transparency and traceability, which is a critical feature in industries like trade finance, where trust and security are paramount. Since blockchain technology is decentralized and publicly accessible, it offers a tamper-proof record of all contract executions and transactions (Lavanya and Kavitha, 2022).

The integration of AI into smart contracts amplifies their potential by enabling the system to make real-time decisions based on live data and conditions that are beyond simple code execution. AI can analyze vast amounts of information, such as financial data, market trends, shipment tracking, or even changes in regulations, to inform the contract’s execution (Handfield *et al*., 2019). In a trade finance scenario, an AI-powered smart contract could adjust the payment terms based on fluctuations in currency exchange rates or economic conditions, optimizing the transaction in real-time.

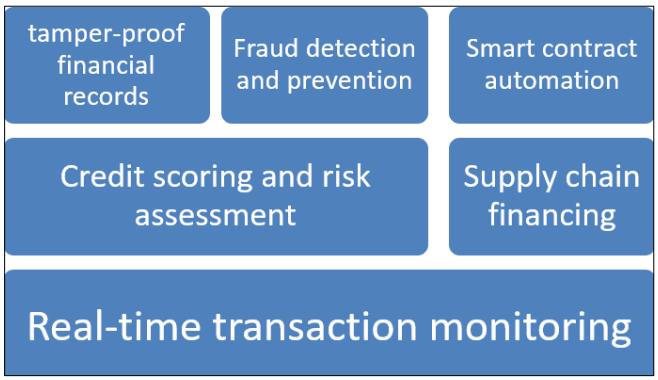

Fig 2: The transformative potential of blockchain and AI integration in trade finance and supply chain management

AI also facilitates decision-making by processing unstructured data, such as invoices, receipts, and emails, to identify discrepancies and ensure compliance with contract terms. Furthermore, AI enhances the adaptability of smart contracts, allowing them to respond to dynamic and evolving situations. In traditional contracts, changes in circumstances might require renegotiation or legal intervention. However, AI-enhanced smart contracts can autonomously adapt to these changes by analyzing patterns in data and updating contract terms as necessary (Moore, 2019). This reduces the need for intermediaries and the time-consuming process of renegotiating agreements.

In trade finance, where trust, security, and efficiency are crucial, blockchain-backed smart contracts with AI integration offer several advantages. One of the key benefits is the automation of payment processes, which is critical in international trade (Pramod, 2022). Typically, payments in trade finance involve multiple intermediaries, such as banks, lawyers, and customs authorities, leading to delays and potential errors. Smart contracts automate the entire process, reducing human error, speeding up transactions, and lowering costs. Upon shipment, the smart contract automatically verifies the delivery using real-time data from sensors, GPS, or third-party logistics providers. Once the contract verifies that the goods have been delivered and inspected, it automatically triggers payment to the seller. AI can assist in this process by analyzing factors such as the condition of the goods, compliance with contractual terms, or even analyzing market trends to ensure the price is fair. Additionally, AI can help monitor compliance with terms in real-time. Smart contracts can be designed to enforce compliance with regulations, such as trade tariffs, import/export laws, or tax regulations. AI can analyze relevant documentation, such as customs declarations or certificates of origin, to verify that the transaction complies with all applicable laws, preventing fraud or errors in the process (Matsudaira and Koh, 2022; Azcárraga and San, 2022).

One of the most powerful combinations in blockchain-backed smart contracts is the collaboration of AI-powered fraud detection with blockchain's inherent transparency and immutability. Blockchain creates a tamper-proof, decentralized ledger in which all transactions are recorded and cannot be altered once completed (Sarode *et al*., 2021). This ensures that all contract executions are fully auditable, which reduces the possibility of fraudulent activity. AI is critical for detecting suspicious or anomalous activity within smart contracts. AI systems use machine learning and advanced analytics to monitor financial transactions, identify unusual patterns, and flag potential fraudulent activities (Khurana, 2020). For example, AI algorithms can detect mismatches between the actual performance of a contract and the expected outcomes based on historical data. If a payment is triggered despite discrepancies in the delivery of goods, AI can raise an alert to notify the parties involved. AI can also analyze the behavior of participants in trade finance transactions, such as buyers, sellers, and intermediaries, to detect abnormal actions that may signal fraud. By studying transaction patterns and identifying deviations from the norm, AI can prevent fraud by alerting stakeholders before fraudulent transactions occur. Furthermore, the combination of blockchain's transparency and AI's fraud detection capabilities creates a comprehensive fraud reduction mechanism. Blockchain records every action taken under a smart contract, creating an immutable trail of actions that can be verified at any time. This transparency, coupled with AI's ability to detect and flag suspicious activity in real-time, significantly reduces the risk of fraud in trade finance transactions.

Blockchain-backed smart contracts with AI integration represent a transformative innovation for the trade finance sector (Zou *et al*., 2020). By leveraging the inherent advantages of blockchain, such as decentralization, transparency, and immutability, alongside AI's ability to analyze data and make real-time decisions, businesses can significantly improve the efficiency, security, and trustworthiness of financial transactions. These technologies enable the automation of payment processes, enhance compliance monitoring, and provide robust fraud detection mechanisms, all while reducing the need for intermediaries. As blockchain and AI technologies continue to evolve, their integration will further revolutionize trade finance and other industries by providing more secure, transparent, and efficient ways to conduct business (Arslanian and Fischer, 2019; Javaid *et al*., 2021).

2.3 Synergies Between Blockchain and AI in Supply Chains

The modern supply chain has grown in complexity, with stakeholders spread across multiple geographical regions. Ensuring the security, efficiency, and transparency of financial transactions on this network is critical. Blockchain and Artificial Intelligence (AI) are two transformative technologies that, when used together, can significantly improve supply chain management, particularly in trade finance (Golubev *et al*., 2020). The combination of blockchain's tamper-proof features and AI's advanced analytics can enhance the integrity of financial records, optimize processes, and provide real-time insights into supply chain activities.

One of the most critical aspects of managing financial transactions in supply chains is ensuring the integrity of the records. Blockchain technology, with its decentralized and immutable ledger, provides a robust solution for preventing unauthorized alterations to financial data (Habib *et al*., 2022). Each transaction recorded on the blockchain is cryptographically linked to previous transactions, making it nearly impossible for any party to tamper with or alter the records. This feature is especially important in industries like trade finance, where trust and transparency are essential for smooth operations (Bai *et al*., 2022). AI, on the other hand, plays a key role in monitoring and validating the authenticity of these transactions in real-time. By leveraging machine

learning algorithms, AI systems can analyze transaction patterns and detect anomalies or irregularities that may indicate fraudulent activity. AI can cross-reference data from multiple sources, such as invoices, shipment tracking, and customs documentation, to ensure that transactions are legitimate. When combined, blockchain's immutable nature and AI's anomaly detection capabilities create a powerful synergy that ensures both data integrity and transaction authenticity, offering a higher level of security in supply chain financial records (Kannengießer *et al*., 2020).

Traditionally, trade finance has been a paper-intensive process that involves multiple intermediaries, such as banks, customs authorities, and legal representatives. This often leads to inefficiencies, delays, and human error. Blockchain and AI, when integrated into trade finance processes, can significantly streamline these operations (Chang *et al*., 2019). Blockchain enables secure, automated transactions that eliminate the need for manual verification or third-party intermediaries. By using smart contracts, blockchain can automatically execute financial transactions when predefined conditions are met, reducing paperwork and manual interventions. AI further enhances this efficiency by automating decision-making processes and improving the accuracy of transaction approvals. AI can analyze historical data to predict the likelihood of successful transactions, assess creditworthiness, and determine the optimal financing terms (Faheem, 2021). This reduces the need for human involvement in routine decision-making tasks, allowing stakeholders to focus on more strategic activities. Together, blockchain and AI can create AI-driven blockchain platforms that not only enhance operational efficiency but also ensure a seamless and secure trade finance process, minimizing errors, delays, and costs.

One of the key advantages of integrating AI with blockchain in supply chains is the ability to monitor and report on financial transactions and supply chain activities in real-time. Blockchain provides a transparent and immutable record of all transactions, allowing stakeholders to track the movement of goods and payments at any given time (Brandín and Abrishami, 2021). However, blockchain alone does not provide the analytical capabilities required to process and interpret the vast amounts of data generated throughout the supply chain. This is where AI comes into play. AI-enabled dashboards can aggregate real-time data from blockchain records and other sources, providing stakeholders with up-to-date insights into supply chain operations. For example, AI can analyze data from inventory systems, shipment tracking, and sales figures to predict potential disruptions or inefficiencies in the supply chain. Similarly, AI can use predictive analytics to anticipate financial bottlenecks, enabling proactive decision-making and risk mitigation (Selvarajan, 2021). By combining blockchain's transparent, real-time transaction recording with AI's advanced analytics capabilities, supply chain participants can gain a comprehensive understanding of their operations. This enables them to make data-driven decisions quickly, minimizing downtime and improving overall supply chain performance (Gade, 2021).

The integration of blockchain and AI can also enhance trust and accountability among supply chain stakeholders. Blockchain's transparency and immutability ensure that all transactions are recorded in a way that is visible and auditable by all participants (Liu *et al*., 2019). This increases trust, as each party can verify the integrity of the data without relying on a centralized authority. For example, a supplier can be confident that payment will only be made once the goods have been delivered, and buyers can track the authenticity of the product throughout its journey. AI complements this transparency by providing predictive analytics and real-time insights that enable stakeholders to monitor performance and ensure that contractual terms are being met. AI algorithms can identify potential issues, such as delayed shipments or discrepancies in payment terms, and alert relevant parties to take corrective action before these issues escalate. By combining blockchain's inherent transparency with AI's predictive capabilities, supply chain participants are empowered with the tools they need to uphold their commitments and maintain accountability. This fosters a more trustworthy environment, which is essential for building long-term, collaborative relationships between suppliers, buyers, and financial institutions. The synergy between blockchain and AI offers transformative potential for modern supply chains, especially in the context of trade finance (Kouhizadeh *et al*., 2020). By creating tamper-proof financial records, blockchain ensures data integrity, while AI monitors and validates the authenticity of transactions in real-time. The integration of AI with blockchain streamlines trade finance processes, reducing paperwork, manual interventions, and human error, while enhancing efficiency. Furthermore, AI-enabled dashboards provide real-time insights, enabling proactive decision-making and continuous monitoring. Finally, the combination of blockchain's transparency and AI's predictive analytics builds trust and accountability among stakeholders, fostering more secure, efficient, and transparent supply chain operations. As these technologies continue to evolve, their integration will play a pivotal role in shaping the future of supply chain management, making it more resilient, efficient, and secure (Ivanov, 2021).

2.4 Case Studies and Real-World Applications

The integration of blockchain and Artificial Intelligence (AI) is revolutionizing supply chain management, particularly in the area of trade finance. Companies are increasingly adopting these technologies to improve the security, efficiency, and transparency of financial transactions (Roszkowska, 2021). This review explores several real-world applications of blockchain and AI in preventing fraud, implementing smart contracts, and fostering collaboration across supply chains. Through these examples, the value of these technologies in reshaping trade finance and supply chain operations becomes clear.

Fraud is a major concern in trade finance, with risks ranging from document falsification to misrepresentation of goods and other fraudulent activities. Blockchain and artificial intelligence (AI) have proven to be effective risk mitigation tools. The use of blockchain in this case ensured that all transaction records were transparent and immutable, resulting in an accurate and tamper-resistant audit trail. Furthermore, AI-powered analytics helped to monitor and detect any irregularities in financial data, lowering the risk of fraud (Soviany, 2019). This integration of blockchain and AI ensured that the financial transaction was secure and that any potential fraudulent activity was detected in real time, thereby improving the integrity of trade finance processes. Another example can be seen in the automotive industry, where blockchain and AI are being used to secure payments and track the movement of goods. Companies like Daimler and

BMW have started using blockchain to verify the authenticity of transactions related to automotive parts and financing. By adopting AI-based fraud detection systems, these companies can better analyze patterns in transaction data and detect potential fraudulent activities before they occur (Bekee and Osuagwu, 2019). This proactive approach is essential for protecting sensitive financial data in trade finance.

Smart contracts are self-executing agreements that automatically execute actions when predefined conditions are met. These contracts, embedded within a blockchain, provide a secure and transparent way to ensure compliance with agreed-upon terms without relying on intermediaries. The integration of AI with smart contracts further enhances decision-making capabilities by enabling real-time data analysis and predictive insights (Engin and Treleaven, 2019).

A noteworthy case study is the partnership between IBM and Maersk, the world's largest container shipping company, to create TradeLens, a blockchain-based supply chain platform. TradeLens incorporates AI-driven smart contracts to automate and secure various processes, including the approval of shipments and financial transactions. By integrating AI, the system can assess a variety of factors such as weather conditions, customs clearance, and shipment status to make decisions about the execution of contracts. The success of this implementation is reflected in the increased efficiency and reduced fraud within the supply chain. By using smart contracts, TradeLens eliminates the need for manual intervention and minimizes the chances of human error or fraudulent activity (Aránguiz *et al*., 2021). The platform provides a transparent and immutable record of every transaction, making it nearly impossible for fraudsters to alter data without detection. This case study demonstrates how blockchain-backed smart contracts, powered by AI, have significantly reduced fraud and enhanced security in global trade finance.

One of the primary benefits of incorporating blockchain and AI into supply chains is the ability to promote collaboration among various stakeholders. Blockchain and artificial intelligence can help build trust and streamline operations by allowing for real-time data sharing and secure access to financial and logistical information (Nassar *et al*., 2020). The Food Trust Network, led by IBM and Walmart, is one example of a blockchain-based system that tracks food from farm to table. The network enables suppliers, retailers, and consumers to obtain real-time information about food products, such as their origin, quality, and safety. Artificial intelligence is used to analyze data trends and predict potential disruptions or quality issues. By integrating blockchain and AI, the platform enhances transparency, increases operational efficiency, and reduces fraud risks, particularly in the food industry where traceability and safety are of utmost importance. Another collaborative platform that highlights the potential of blockchain and AI is the Global Shipping Business Network (GSBN). GSBN is a blockchain-based platform that connects shipping companies, logistics providers, and financial institutions. By integrating AI into the platform, GSBN can predict potential delays, identify inefficiencies in the supply chain, and automatically execute financial transactions using smart contracts. This collaborative ecosystem ensures that all parties have access to secure, real-time data, reducing the likelihood of fraudulent activities and improving supply chain optimization.

The adoption of blockchain and AI technologies in trade finance and supply chain management is leading to transformative improvements in security, efficiency, and collaboration. Case studies from industries such as banking, automotive, food, and logistics demonstrate the value of these technologies in preventing fraud, automating financial transactions, and building trust among stakeholders. By leveraging blockchain-backed smart contracts and AI-driven analytics, companies can ensure that financial records remain tamper-proof and that supply chain operations run smoothly. As these technologies continue to evolve, they hold the potential to further enhance the security and efficiency of global trade, creating a more resilient and transparent supply chain ecosystem (Nandi *et al*., 2021).

2.5 Challenges and Limitations

While the integration of blockchain and Artificial Intelligence (AI) offers substantial benefits for enhancing security, efficiency, and transparency in supply chains, there are significant challenges and limitations that organizations must address before fully adopting these technologies (Singh *et al*., 2020). These challenges span across technical complexities, scalability issues, regulatory concerns, and cost implications.

Integrating blockchain and AI systems into existing supply chain frameworks is a technically challenging task. Both blockchain and AI technologies are complex and necessitate specialized knowledge for successful implementation. Blockchain, while providing decentralization, immutability, and transparency, must be integrated with existing legacy systems that are frequently not designed to interact with decentralized networks. Similarly, AI algorithms require extensive data preparation, cleaning, and structuring before they can effectively analyse and provide predictive insights. Supply chains consist of numerous stakeholders, each with its own data management systems, making it difficult to harmonize data across platforms (Kush *et al*., 2020). The integration of blockchain requires significant changes to how transactions and records are stored and managed, while AI systems need constant updates and training to remain effective in detecting new patterns or anomalies. This integration often involves redesigning key processes and systems, which can be a lengthy and complex undertaking. Moreover, the technical expertise required to merge these two technologies into a seamless solution is scarce, making it a considerable hurdle for companies seeking to adopt them.

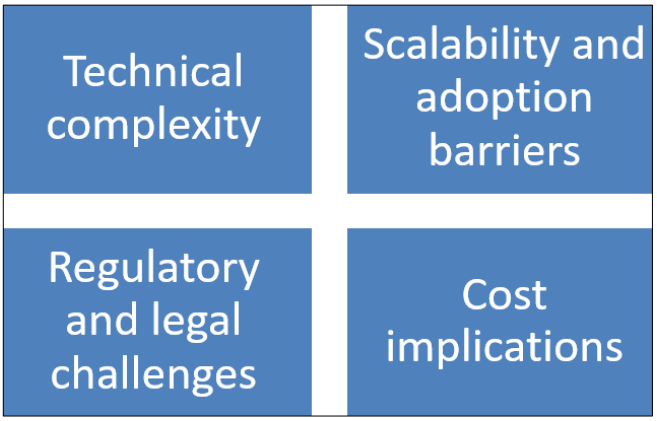

Fig 3: Challenges and limitations of blockchain and AI synergies for effective supply chain management

Scalability is a critical issue for both blockchain and AI

technologies when applied to supply chain networks. Blockchain networks, particularly public blockchains, face limitations in terms of transaction throughput. As the number of transactions increases, the time taken to process and validate transactions on blockchain platforms can become a bottleneck, leading to inefficiencies in large-scale supply chain operations (Yang *et al*., 2020). This limitation is particularly prominent in blockchain-based trade finance systems, where the speed of financial transactions is crucial for timely payments and processing. Similarly, AI systems face scalability challenges, especially when it comes to training models using large volumes of data. Effective AI models require high-quality, diverse, and voluminous data sets to deliver accurate predictions. However, obtaining sufficient data across multiple supply chain partners is often difficult, as businesses may not be willing to share sensitive information, and data may be inconsistent or incomplete. This lack of comprehensive training data can hinder the effectiveness of AI in detecting fraud or predicting financial discrepancies (Craja *et al*., 2020). As a result, scaling AI-driven solutions in large, global supply chains presents both technical and operational challenges.

Regulatory and legal challenges are significant impediments to the widespread use of blockchain and AI in trade finance. Blockchain technology is decentralized, making it difficult to apply traditional legal frameworks that rely on centralized control and authority. In many jurisdictions, the legal status of blockchain transactions, smart contracts, and digital assets is unknown. Businesses are hesitant to fully embrace blockchain in their trade finance operations in the absence of clear regulations, citing potential legal risks and uncertainty. Additionally, AI technologies used in supply chain management must comply with data privacy laws, such as the General Data Protection Regulation (GDPR) in Europe or the California Consumer Privacy Act (CCPA) in the United States. These regulations place constraints on how businesses can collect, process, and share data, which may conflict with AI's data-intensive requirements (Spanaki *et al*., 2021). The lack of standardization in blockchain-based trade finance also poses challenges, as businesses may face difficulties in ensuring compliance with international and national regulations. Inconsistent legal frameworks across borders further complicate the adoption of blockchain and AI for cross-border trade finance.

The initial investment required to implement blockchain and AI technologies is another significant barrier. Both technologies demand high upfront costs for development, integration, and training. Blockchain platforms require significant resources to build secure, scalable networks, while AI systems necessitate extensive data collection, model training, and algorithm refinement. Organizations must also invest in hardware infrastructure to support these systems, such as high-performance computing resources for AI analytics and nodes for blockchain networks. For many businesses, particularly small and medium-sized enterprises (SMEs), these high initial costs are a deterrent. In addition to development costs, businesses must also consider ongoing operational expenses, such as system maintenance, software updates, and hiring specialized personnel to manage and optimize AI and blockchain systems. The financial burden can be overwhelming for smaller companies, making it difficult for them to compete with larger enterprises that have the resources to invest in these technologies (Bagale *et al*., 2021).

2.6 Recommendations for Effective Blockchain-AI Integration

The integration of blockchain and Artificial Intelligence (AI) in supply chains promises transformative benefits, including enhanced security, transparency, and efficiency. However, realizing the full potential of these technologies requires careful planning, collaboration, and a structured approach to overcome inherent challenges.

A phased implementation strategy is critical for successfully integrating blockchain and AI technologies in supply chains. Supply chains are frequently complex, with multiple stakeholders and disparate systems. Thus, a gradual adoption process enables businesses to mitigate risks, test the technology's functionality, and fine-tune the system prior to a full-scale rollout. The first phase of integration could include pilot projects that target specific aspects of the supply chain, such as trade finance or product traceability. These pilot programs can help organizations assess the effectiveness of blockchain and AI in real-world scenarios, providing valuable insights that inform subsequent phases. In the initial phase, companies should prioritize smaller, less complex use cases where blockchain's tamper-proof records and AI's predictive capabilities can quickly demonstrate value. For instance, implementing blockchain to track goods' movement through a supply chain can show immediate improvements in transparency and security. As these systems prove their reliability and scalability, they can be expanded across broader supply chain operations. By taking a phased approach, businesses can reduce the uncertainty and operational risks associated with full-scale adoption while ensuring smoother integration of blockchain and AI technologies.

Collaboration is essential for the successful implementation of blockchain and AI in supply chains. Engaging with technology providers, financial institutions, and regulators ensures that all stakeholders align their efforts and interests to facilitate smooth integration. Technology providers, including blockchain and AI experts, offer the necessary tools, platforms, and technical support for businesses looking to adopt these solutions. Financial institutions can provide valuable insights into the regulatory and compliance aspects of trade finance, ensuring that blockchain and AI systems adhere to legal frameworks. Moreover, regulatory bodies play a critical role in standardizing blockchain technologies and ensuring compliance with data protection and privacy laws. Given the decentralized nature of blockchain and the data-intensive requirements of AI, regulatory clarity is crucial for businesses to avoid legal pitfalls. Collaborating with regulators to develop clear and consistent guidelines for blockchain-based transactions and AI use in supply chains will foster a more predictable and secure environment for implementation. Additionally, industry partnerships can promote information-sharing and best practices, further accelerating the adoption of these technologies.

For blockchain and AI to be effective in supply chains, systems must be designed with interoperability in mind. Supply chains involve multiple organizations with different technological infrastructures, platforms, and data standards. Therefore, developing blockchain and AI systems that can integrate with existing supply chain platforms is essential for seamless operation. Interoperability ensures that data flows smoothly between various parties, without the need for complete overhauls of existing systems. Blockchain solutions should be compatible with a variety of enterprise resource

planning (ERP) and supply chain management software, allowing businesses to capitalize on their existing investments while embracing new technologies. AI systems, too, must be adaptable enough to integrate with existing data sources, ensuring that algorithms can access high-quality data from a variety of supply chain partners. A focus on interoperability will help organizations avoid costly disruptions during integration and ensure that blockchain and AI technologies can collaborate effectively across diverse supply chain environments.

2.7 Future Trends in Blockchain and AI for Supply Chain Management

The integration of blockchain and artificial intelligence (AI) in supply chain management is rapidly transforming the way businesses approach transparency, security, and efficiency (Tamm *et al*., 2020). As these technologies evolve, several emerging trends suggest they will reshape the future of global supply chains.

One of the most significant trends on the horizon is the emergence of blockchain-AI hybrid platforms. These integrated platforms will offer businesses end-to-end visibility across their supply chains, combining blockchain's decentralized, immutable ledger with AI's ability to process large volumes of data and detect patterns. The convergence of these technologies will allow organizations to track the movement of goods, monitor financial transactions, and ensure compliance with regulations in real-time. Blockchain's transparency and security features will provide a solid foundation for the AI systems to operate, while AI's predictive analytics will optimize decision-making, identify risks, and automate responses. For example, in a supply chain network, these platforms could help predict supply disruptions or demand fluctuations based on historical data and real-time inputs, allowing businesses to act proactively and minimize downtime. As blockchain and AI continue to mature, the integration of these technologies will foster greater collaboration, innovation, and efficiency in supply chain management.

Another emerging trend is the development of autonomous supply chains, which combine blockchain and AI to create self-managed networks. Autonomous supply chains use AI algorithms to forecast supply and demand, automate inventory management, and optimize transportation routes (Helo, 2022). Blockchain, in turn, will secure data exchanges and validate transactions, ensuring that the information passing through the system is correct, immutable, and tamper-resistant. The autonomous nature of such supply chains will significantly reduce human intervention, lower the risk of errors, and increase efficiency. This synergy will lead to smarter, more responsive supply chains that can adapt to changing circumstances without the need for manual oversight.

As blockchain continues to gain traction in supply chain management, the push for global standardization of blockchain protocols is becoming increasingly important. Unified blockchain systems will enable seamless trade finance operations across borders, reducing barriers to international trade and improving the efficiency of cross-border transactions (Wagener *et al*., 2020). Standardized protocols will ensure that blockchain solutions are interoperable, making it easier for businesses, financial institutions, and regulators to collaborate and share data securely. Global standardization will help streamline customs procedures, reduce the complexity of compliance requirements, and lower the costs associated with cross-border trade. Moreover, a standardized blockchain system could support more efficient execution of smart contracts, as parties across different jurisdictions can rely on a consistent framework for contract execution and dispute resolution. As countries and industries work toward the development of universal blockchain standards, the global supply chain ecosystem will become more integrated and efficient (Jovanovic *et al*., 2022).

AI-powered blockchain analytics is another critical trend that will influence the future of supply chain management. As blockchain collects more transaction data, AI systems can be used to extract advanced insights from it, allowing businesses to make better decisions. AI's machine learning algorithms can analyze massive amounts of blockchain transaction data to spot trends, detect anomalies, and forecast future outcomes. Businesses that integrate AI and blockchain analytics will gain real-time insights into their operations, allowing for better risk management, forecasting, and decision-making (Araz *et al*., 2020). Additionally, AI-powered analytics will enable companies to derive more value from the vast amount of data stored on blockchain networks, creating new opportunities for innovation and competitive advantage.

Conclusion

The integration of blockchain and artificial intelligence (AI) presents a groundbreaking synergy that is poised to reshape the landscape of trade finance and supply chain management. Key insights from this review highlight how blockchain's decentralization, immutability, and transparency, when combined with AI's advanced data processing and predictive analytics, provide an effective framework for securing financial transactions and reducing fraud within supply chains. By ensuring tamper-proof records and enabling real-time monitoring, this combination significantly enhances trust and accountability among stakeholders, creating a more resilient supply chain ecosystem.

The integration of blockchain and AI is significant because it has the potential to revolutionize how businesses manage financial data, streamline operations, and mitigate risks. Blockchain's role in maintaining secure, transparent transaction records, combined with AI's capacity for detecting fraud patterns and automating decision-making processes, creates a robust defense against financial discrepancies, fraud, and operational inefficiencies.

As the global supply chain ecosystem becomes increasingly complex, it is crucial for businesses to adopt blockchain and AI technologies to stay competitive and safeguard against emerging threats. Organizations should prioritize the integration of these solutions to enhance transparency, ensure secure financial transactions, and streamline operational workflows. By doing so, businesses will not only secure their supply chains but also position themselves as leaders in the ongoing digital transformation of trade finance. The future of global supply chain management lies in the effective adoption and utilization of blockchain and AI, ensuring robust and transparent operations in an ever-evolving marketplace.

Reference

1. Adegoke SA, Oladimeji OI, Akinlosotu MA, Akinwumi AI, Matthew KA. Hemo TypeSC point-of-care testing

shows high sensitivity with alkaline cellulose acetate hemoglobin electrophoresis for screening hemoglobin SS and SC genotypes. Hematol Transfus Cell Ther. 2022;44(3):341-345.
2. Alessa H. The role of Artificial Intelligence in Online Dispute Resolution: A brief and critical overview. Inf Commun Technol Law. 2022;31(3):319-342.
3. Aparício D, Barata R, Bravo J, Ascensão JT, Bizarro P. Arms: Automated rules management system for fraud detection. arXiv preprint arXiv:2002.06075. 2020.
4. Aránguiz M, Margheri A, Xu D, Tran B. International trade revolution with smart contracts. In: The Digital Transformation of Logistics: Demystifying Impacts of the Fourth Industrial Revolution; c2021. p.169-184.
5. Araz OM, Choi TM, Olson DL, Salman FS. Role of analytics for operational risk management in the era of big data. Decis Sci. 2020;51(6):1320-1346.
6. Arslanian H, Fischer F. The future of finance: The impact of FinTech, AI, and crypto on financial services. Springer; c2019.
7. Asante M, Epiphaniou G, Maple C, Al-Khateeb H, Bottarelli M, Ghafoor KZ. Distributed ledger technologies in supply chain security management: A comprehensive survey. IEEE Trans Eng Manag. 2021;70(2):713-739.
8. Azcárraga AAP, San Juan R. Strengthening the Core Customs Processes through Integrated Risk Management. In: Strengthening Customs Administration in a Changing World; c2022. p.131.
9. Bagale GS, Vandadi VR, Singh D, Sharma DK, Garlapati DVK, Bommisetti RK. Small and medium-sized enterprises' contribution in digital technology. Ann Oper Res. 2021:1-24.
10. Bai C, Quayson M, Sarkis J. Analysis of Blockchain's enablers for improving sustainable supply chain transparency in Africa cocoa industry. J Clean Prod. 2022;358:131896.
11. Bekee SY, Osuagwu OE. Intelligent agent-based fraud detection and prevention model for financial institutions. West Afr J Ind Acad Res. 2019;20(2):4.
12. Brandín R, Abrishami S. Information traceability platforms for asset data lifecycle: blockchain-based technologies. Smart Sustain Built Environ. 2021;10(3):364-386.
13. Centobelli P, Cerchione R, Del Vecchio P, Oropallo E, Secundo G. Blockchain technology design in accounting: Game changer to tackle fraud or technological fairy tale? Account Audit Acc J. 2022;35(7):1566-1597.
14. Chang SE, Chen YC, Wu TC. Exploring blockchain technology in international trade: Business process re-engineering for letter of credit. Ind Manag Data Syst. 2019;119(8):1712-1733.
15. Chou CC, Hwang NCR, Schneider GP, Wang T, Li CW, Wei W. Using smart contracts to establish decentralized accounting contracts: An example of revenue recognition. J Inf Syst. 2021;35(3):17-52.
16. Cole R, Stevenson M, Aitken J. Blockchain technology: implications for operations and supply chain management. Supply Chain Manag. 2019;24(4):469-483.
17. Craja P, Kim A, Lessmann S. Deep learning for detecting financial statement fraud. Decis Support Syst. 2020;139:113421.
18. Dash R, McMurtrey M, Rebman C, Kar UK. Application of artificial intelligence in automation of supply chain management. J Strateg Innov Sustain. 2019, 14(3).
19. Dubey R, Gunasekaran A, Bryde DJ, Dwivedi YK, Papadopoulos T. Blockchain technology for enhancing swift-trust, collaboration and resilience within a humanitarian supply chain setting. Int J Prod Res. 2020;58(11):3381-3398.
20. Dutta SK. Smart contracts. In: The definitive guide to blockchain for accounting and business: Understanding the revolutionary technology. Emerald Publishing Limited; c2020. p.61-78.
21. Eggers J, Hein A, Weking J, Böhm M, Krcmar H. Process automation on the blockchain: an exploratory case study on smart contracts. 2021.
22. Engin Z, Treleaven P. Algorithmic government: Automating public services and supporting civil servants in using data science technologies. Comput J. 2019;62(3):448-460.
23. Faheem MA. AI-Driven Risk Assessment Models: Revolutionizing Credit Scoring and Default Prediction. Iconic Res Eng J. 2021;5(3):177-186.
24. Gade KR. Data-Driven Decision Making in a Complex World. J Comput Innov. 2021, 1(1).
25. Gardner TA, Benzie M, Börner J, Dawkins E, Fick S, Garrett R. Transparency and sustainability in global commodity supply chains. World Dev. 2019;121:163-177.
26. Golubev A, Ryabov O, Zolotarev A. Digital transformation of the banking system of Russia with the introduction of blockchain and artificial intelligence technologies. In: IOP Conference Series: Materials Science and Engineering. Vol. 940, No. 1, p. 012041. IOP Publishing; c2020.
27. Habib G, Sharma S, Ibrahim S, Ahmad I, Qureshi S, Ishfaq M. Blockchain technology: benefits, challenges, applications, and integration of blockchain technology with cloud computing. Future Internet. 2022;14(11):341.
28. Hamledari H, Fischer M. Role of blockchain-enabled smart contracts in automating construction progress payments. J Leg Aff Dispute Resolut Eng Constr. 2021;13(1):04520038.
29. Handfield R, Jeong S, Choi T. Emerging procurement technology: data analytics and cognitive analytics. Int J Phys Distrib Logist Manag. 2019;49(10):972-1002.
30. Hassija V, Chamola V, Gupta V, Jain S, Guizani N. A survey on supply chain security: Application areas, security threats, and solution architectures. IEEE Internet Things J. 2020;8(8):6222-6246.
31. Hastig GM, Sodhi MS. Blockchain for supply chain traceability: Business requirements and critical success factors. Prod Oper Manag. 2020;29(4):935-954.
32. Helo P, Hao Y. Artificial intelligence in operations management and supply chain management: An exploratory case study. Prod Plan Control. 2022;33(16):1573-1590.
33. Henninger A, Mashatan A. Distributed interoperable records: The key to better supply chain management. Computers. 2021;10(7):89.
34. Iftekhar A, Cui X, Hassan M, Afzal W. Application of blockchain and Internet of Things to ensure tamper-proof data availability for food safety. J Food Qual. 2020;2020(1):5385207.
35. Ivanov D. Digital supply chain management and

technology to enhance resilience by building and using end-to-end visibility during the COVID-19 pandemic. IEEE Trans Eng Manag. 2021.
36. Jain N, Sedamkar RR. A blockchain technology approach for the security and trust in trade finance. In: 2020 14th International Conference on Innovations in Information Technology (IIT). IEEE; c2020. p. 192-197.
37. Javaid M, Haleem A, Singh RP, Khan S, Suman R. Blockchain technology applications for Industry 4.0: A literature-based review. Blockchain Res Appl. 2021;2(4):100027.
38. Jovanovic M, Kostić N, Sebastian IM, Sedej T. Managing a blockchain-based platform ecosystem for industry-wide adoption: The case of TradeLens. Technol Forecast Soc Chang. 2022;184:121981.
39. Kannengießer N, Lins S, Dehling T, Sunyaev A. Trade-offs between distributed ledger technology characteristics. ACM Comput Surv. 2020;53(2):1-37.
40. Khurana R. Fraud detection in ecommerce payment systems: The role of predictive AI in real-time transaction security and risk management. Int J Appl Mach Learn Comput Intell. 2020;10(6):1-32.
41. Koh L, Dolgui A, Sarkis J. Blockchain in transport and logistics–paradigms and transitions. Int J Prod Res. 2020;58(7):2054-2062.
42. Komalavalli C, Saxena D, Laroiya C. Overview of blockchain technology concepts. In: Handbook of Research on Blockchain Technology. Academic Press; c2020. p.349-371.
43. Kouhizadeh M, Zhu Q, Sarkis J. Blockchain and the circular economy: potential tensions and critical reflections from practice. Prod Plan Control. 2020;31(11-12):950-966.
44. Kush RD, Warzel D, Kush MA, Sherman A, Navarro EA, Fitzmartin R, Pétavy F, Galvez J, Becnel LB, Zhou FL, Harmon N. FAIR data sharing: the roles of common data elements and harmonization. J Biomed Inform. 2020;107:103421.
45. Laroiya C, Saxena D, Komalavalli C. Applications of blockchain technology. In: Handbook of Research on Blockchain Technology. Academic Press; c2020. p.213-243.
46. Lavanya M, Kavitha V. Secure tamper-resistant electronic health record transaction in cloud system via blockchain. Wirel Pers Commun. 2022;124(1):607-632.
47. Liu M, Wu K, Xu JJ. How will blockchain technology impact auditing and accounting: Permissionless versus permissioned blockchain. Curr Issues Audit. 2019;13(2):A19-A29.
48. Madhani PM. Supply chain transformation with blockchain deployment: enhancing efficiency and effectiveness. IUP J Supply Chain Manag. 2021;18(4):7-32.
49. Mahtani U. Fraudulent practices and blockchain accounting systems. J Account Ethics Public Policy. 2022;23(1):97-148.
50. Matsudaira T, Koh J. Customs administration and digitalization. In: Customs Matters. International Monetary Fund; c2022.
51. Moin S, Karim A, Safdar Z, Safdar K, Ahmed E, Imran M. Securing IoTs in distributed blockchain: Analysis, requirements and open issues. Future Gener Comput Syst. 2019;100:325-343.
52. Moore PV. OSH and the future of work: benefits and risks of artificial intelligence tools in workplaces. In: Digital Human Modeling and Applications in Health, Safety, Ergonomics and Risk Management. Human Body and Motion: 10th International Conference, DHM 2019, Held as Part of the 21st HCI International Conference, HCII 2019, Orlando, FL, USA, July 26–31, 2019, Proceedings, Part I 21. Springer International Publishing; c2019. p. 292-315.
53. Nandi S, Sarkis J, Hervani AA, Helms MM. Redesigning supply chains using blockchain-enabled circular economy and COVID-19 experiences. Sustain Prod Consum. 2021;27:10-22.
54. Nassar M, Salah K, ur Rehman MH, Svetinovic D. Blockchain for explainable and trustworthy artificial intelligence. Wiley Interdiscip Rev Data Min Knowl Discov. 2020;10(1):e1340.
55. Nicholls J, Kuppa A, Le-Khac NA. Financial cybercrime: A comprehensive survey of deep learning approaches to tackle the evolving financial crime landscape. IEEE Access. 2021;9:163965-163986.
56. Omar IA, Jayaraman R, Salah K, Debe M, Omar M. Enhancing vendor managed inventory supply chain operations using blockchain smart contracts. IEEE Access. 2020;8:182704-182719.
57. Peters E, Subar K, Martin H. Late payment and nonpayment within the construction industry: Causes, effects, and solutions. J Leg Aff Disput Resolut Eng Constr. 2019;11(3):04519013.
58. Politou E, Alepis E, Virvou M, Patsakis C. Privacy in blockchain. In: Privacy and Data Protection Challenges in the Distributed Era. Springer; c2022. p. 133-149.
59. Politou E, Casino F, Alepis E, Patsakis C. Blockchain mutability: Challenges and proposed solutions. IEEE Trans Emerg Top Comput. 2019;9(4):1972-1986.
60. Pramod D. Robotic process automation for industry: adoption status, benefits, challenges and research agenda. Benchmarking Int J. 2022;29(5):1562-1586.
61. Qian J, Ruiz-Garcia L, Fan B, Villalba JIR, McCarthy U, Zhang B, Yu Q, Wu W. Food traceability system from governmental, corporate, and consumer perspectives in the European Union and China: A comparative review. Trends Food Sci Technol. 2020;99:402-412.
62. Rejeb A, Keogh JG, Treiblmaier H. Leveraging the internet of things and blockchain technology in supply chain management. Future Internet. 2019;11(7):161.
63. Roszkowska P. Fintech in financial reporting and audit for fraud prevention and safeguarding equity investments. J Account Organ Change. 2021;17(2):164-196.
64. Saeed G, Kohler JC, Cuomo RE, Mackey TK. A systematic review of digital technology and innovation and its potential to address anti-corruption, transparency, and accountability in the pharmaceutical supply chain. Expert Opin Drug Saf. 2022;21(8):1061-1088.
65. Sambrow VDP, Iqbal K. Integrating Artificial Intelligence in Banking Fraud Prevention: A Focus on Deep Learning and Data Analytics. Eigenpub Rev Sci Technol. 2022;6(1):17-33.
66. Sapian SM, Abdulkadir N, Ibrahim N. Trade finance in digital era: Can FinTech harness the current risks and challenges?. J Muamalat Islam Financ Res. 2021;18(1):78-89.
67. Sarode RP, Poudel M, Shrestha S, Bhalla S. Blockchain for committing peer-to-peer transactions using

distributed ledger technologies. Int J Comput Sci Eng. 2021;24(3):215-227.
68. Selvarajan G. Leveraging AI-Enhanced Analytics for Industry-Specific Optimization: A Strategic Approach to Transforming Data-Driven Decision-Making. Int J Enhanced Res Sci Technol Eng. 2021;10:78-84.
69. Singh S, Sharma PK, Yoon B, Shojafar M, Cho GH, Ra IH. Convergence of blockchain and artificial intelligence in IoT network for the sustainable smart city. Sustain Cities Soc. 2020;63:102364.
70. Sobb T, Turnbull B, Moustafa N. Supply chain 4.0: A survey of cyber security challenges, solutions and future directions. Electronics. 2020;9(11):1864.
71. Soviany C. AI-powered surveillance for financial markets and transactions. J Digit Bank. 2019;3(4):319-329.
72. Spanaki K, Karafili E, Despoudi S. AI applications of data sharing in agriculture 4.0: A framework for role-based data access control. Int J Inf Manag. 2021;59:102350.
73. Tamm K, Leht R, Vaher M, Rebane K, Poder A, Batan A. Transformative Impacts of Artificial Intelligence on E-Commerce Supply Chain Management: Enhancing Transparency, Mitigating Risks, and Advancing Adaptive Logistics Strategies. 2020.
74. Tyagi AK, Aswathy SU, Abraham A. Integrating blockchain technology and artificial intelligence: Synergies perspectives challenges and research directions. J Inf Assur Secur. 2020;15(5):1554.
75. Unsworth R. Smart contract this! An assessment of the contractual landscape and the Herculean challenges it currently presents for "Self-executing" contracts. In: Legal Tech, Smart Contracts and Blockchain. 2020. p. 17-61.
76. Wagener N, Aritua B, Zhu T. The new silk road: Opportunities for global supply chains and challenges for further development. Logforum. 2020;16(2):193-207.
77. Wang Y, Jia F, Schoenherr T, Gong Y, Chen L. Cross-border e-commerce firms as supply chain integrators: The management of three flows. Ind Mark Manag. 2020;89:72-88.
78. Yang D, Long C, Xu H, Peng S. A review on scalability of blockchain. In: Proceedings of the 2020 2nd International Conference on Blockchain Technology. 2020. p. 1-6.
79. Zeleznikow J. Using artificial intelligence to provide intelligent dispute resolution support. Group Decis Negot. 2021;30(4):789-812.
80. Zhao L. Event prediction in the big data era: A systematic survey. ACM Comput Surv. 2021;54(5):1-37.
81. Zou Y, Meng T, Zhang P, Zhang W, Li H. Focus on blockchain: A comprehensive survey on academic and application. IEEE Access. 2020;8:187182-187201