The Role of Artificial Intelligence in Automating and Managing Blockchain-Based Supply Chain Transactions in MENA Countries

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Abstract. This paper explores the role of Artificial Intelligence (AI) in automating and managing blockchain-based supply chain transactions in MENA countries (Middle East and North Africa), a region undergoing rapid digital transformation in trade and logistics. It examines how AI enhances blockchain systems by improving transparency, operational efficiency, and transaction reliability.

The study adopts a qualitative analytical approach based on recent literature and selected regional examples. The analysis focuses on current adoption trends, existing challenges, and AI-driven automation mechanisms. Findings show that AI strengthens predictive decision-making, automates smart contracts, and improves fraud detection and real-time tracking. Despite these benefits, regulatory gaps, technological integration issues, and skills shortages remain significant barriers. Overall, AI–blockchain integration presents strong potential for building efficient and resilient smart supply chains in MENA.

Keywords: Artificial Intelligence, Blockchain, Supply Chain, MENA Region

1 Introduction

Supply chains in the MENA region (Middle East and North Africa) are undergoing a rapid digital transformation, driven by the growth of international trade, the expansion of e-commerce, and the modernization of logistics and transport infrastructure [1]. Traditional supply chains in the region have faced challenges such as fragmented operations, limited transparency, and high operational costs, which have often hindered efficiency and trust among stakeholders [2]

In recent years, blockchain technology has emerged as a promising solution for supply chain management, providing secure, immutable, and transparent transaction records that enhance trust between suppliers, distributors, and end customers [3]. Blockchain enables real-time tracking of goods, verification of product authenticity, and automation of transactions through smart contracts, making it particularly relevant for sectors such as food, energy, and logistics in MENA countries [2].

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Alongside blockchain, Artificial Intelligence (AI) has been increasingly applied to optimize supply chain processes. AI technologies, including predictive analytics, machine learning, and intelligent automation, offer opportunities to improve decision-making, forecast demand, manage inventory, and detect problems or fraud within blockchain-enabled supply chains [4]. By combining AI with blockchain, supply chains can become more resilient, responsive, and efficient, addressing many of the operational and strategic challenges faced in the MENA region [3].

Despite the potential of these technologies, the integration of AI and blockchain in MENA supply chains is still limited. Key barriers include technological integration issues, regulatory gaps, high implementation costs, and a shortage of specialized digital skills [1] [4].

This study aims to fill this gap by exploring how AI can support the automation and management of blockchain-based supply chain transactions in MENA countries, providing both a conceptual framework and insights from selected regional examples.

Research Objectives

The main objectives of this paper are:

- To examine the current state of blockchain-based supply chain transaction management in MENA countries, including adoption trends and challenges.
- To investigate the role of AI in automating and enhancing the management of these blockchain-enabled transactions, focusing on operational efficiency, transparency, and risk management.

1.1 Research Questions

To achieve these objectives, the study addresses the following research questions:

-What is the current adoption status of blockchain for supply chain transactions in MENA countries, and what are the main challenges?

-How can AI contribute to the automation, efficiency, and reliability of blockchain-enabled supply chain transactions in the region?

2 Methods

2.1 Research Design:

This study adopts a qualitative analytical approach to explore the integration of Artificial Intelligence (AI) in automating and managing blockchain-based supply chain transactions in MENA countries. A qualitative approach is appropriate because it enables in-depth understanding of emerging technologies, their adoption patterns, and operational impacts within regional supply chains [5]. Research Methods for Business Students (8th ed.). Harlow, United Kingdom: Pearson Education Limited. This approach also allows the identification of challenges and opportunities that are specific to the MENA context.

2.2 Data Sources

Three main types of data sources were used:

- **Academic Literature**: Peer-reviewed journal articles focusing on blockchain, AI, and supply chain management, including studies on their integration in global and regional contexts
- **Industry and Regional Reports**: Reports from logistics authorities, smart port initiatives, and digital trade agencies in MENA countries, providing up-to-date information on blockchain and AI adoption trends
- **Case Examples**: Practical implementations of blockchain-enabled supply chain systems in MENA, focusing on sectors such as logistics, food, and energy supply chains

2.3 Analytical Framework

The collected data were analyzed using a thematic analysis approach, structured around three main dimensions:

- **Blockchain Adoption and Current Practices**: Examines the degree of blockchain implementation in supply chain transactions, types of smart contracts used, and real-world applications in MENA.
- **Challenges in Supply Chain Management**: Identifies technical, regulatory, organizational, and economic barriers to blockchain adoption and AI integration.
- **AI-Driven Automation Mechanisms**: Evaluates how AI contributes to blockchain systems, including predictive analytics, smart contract automation, anomaly detection, and operational decision-making.

3 Results

3.1 Current State and Challenges of Blockchain-Based Supply Chain Transactions in MENA

Blockchain Adoption and Applications in MENA Supply Chains:
Numerous previous and recent studies have highlighted the key applications of blockchain technology in MENA countries, which can be summarized in the following table:

Table 1. A review of applications of blockchain technology in the Middle East [6]

Study Title	Research Questions	Findings
Blockchain Adoption in the Middle East: A Systematic Literature Review (Al Qasimi, 2021)	1. What are the current trends in blockchain adoption in the Middle East? 2. What are the primary challenges and opportunities?	1. Adoption is growing across sectors such as finance and healthcare. 2. Challenges: Regulatory uncertainty, lack of infrastructure, and limited awareness. 3. Opportunities: Cost reduction, improved efficiency, and greater transparency.
Blockchain Adoption in the UAE: A Comparative Study of Dubai and Abu Dhabi (Alblooshi, 2020)	1. How does blockchain adoption differ between Dubai and Abu Dhabi? 2. What factors have driven adoption in each city?	1. Dubai has been more proactive, with more government-led initiatives and private-sector partnerships. 2. Key drivers include government support, regulatory clarity, and private-sector engagement.
The Impact of Blockchain Technology on the Financial Industry in the Middle East (Al-Fakhri, 2020)	1. How is blockchain being applied in the Middle Eastern financial sector? 2. What are its benefits and challenges?	1. Primary uses: cross-border payments, trade finance, and digital identity verification. 2. Benefits: Enhanced efficiency, lower costs, and improved security. 3. Challenges: Regulatory ambiguity and a lack of industry-wide standards.
Blockchain Adoption in the Saudi Arabian Government Sector (Almehmadi, 2020)	1. How is blockchain being utilized within Saudi Arabia's government? 2. What are the perceived benefits and obstacles?	1. Current implementations focus on land registry management and digital identity systems. 2. Benefits: Increased transparency, operational efficiency. 3. Challenges: Unclear regulations and insufficient technological infrastructure.

The studies documented in the table demonstrate a growing trend in the adoption of blockchain technology in the Middle East and North Africa region, with a clear focus on the financial, governmental, and healthcare sectors in leading countries such as the UAE and Saudi Arabia. The findings consistently highlight substantial benefits, including improved efficiency, increased transparency, and enhanced security, particularly in the management of records and digital identities. Conversely, common chal-

lenges emerge, such as regulatory ambiguity, insufficient technological infrastructure, and limited awareness of the technology.

The studies also emphasize the role of government support and private-sector partnerships as key drivers for successful technology adoption. Despite notable progress, there remains a critical need to develop clear regulatory frameworks and robust digital infrastructure to fully realize the transformative potential of this technology.

It can be argued that the adoption of blockchain technology in supply chains across the Middle East and North Africa (MENA) region is emerging, yet it remains uneven across countries and sectors. Key applications include logistics tracking, food safety verification, and energy distribution monitoring [7].

To identify the areas of blockchain implementation in each MENA country, this is illustrated in the following table :

Table 2. Applications of blockchain technology in each MENA country [6]

Country	Status & Key Application Areas
Algeria	Under exploration for potential use across various industries.
Bahrain	Used in banking and financial services.
Egypt	Implemented for property registration and trade facilitation.
Iran	Finance and supply chain management.
Iraq	In exploratory phases for potential industry applications.
Jordan	Trade and supply chain management.
Lebanon	Used for remittance services and supply chain applications.
Morocco	Pilot projects underway across various sectors.
Palestine	Banking and financial services.
Qatar	Digital identity and financial services.
Saudi Arabia	Digital identity and supply chain management.
Tunisia	Improving public service delivery.
Turkey	Finance and supply chain management.
UAE	Actively used for identity verification and financial services.

The table reveals significant variation in the adoption level of blockchain technology across the region. Gulf states such as the UAE, Saudi Arabia, and Qatar lead in implementing advanced applications in digital identity, finance, and supply chain management, while other nations remain in exploratory or pilot phases. The financial sector and supply chain management represent the most prevalent areas of deploy-

ment. There is evident commitment from both governments and the private sector to leverage this technology for enhancing transparency and efficiency in public services and economic activities, despite persistent challenges related to digital infrastructure and regulatory frameworks.

The use of smart contracts to automate transactions is increasing, particularly in port and customs operations in countries such as the UAE, Saudi Arabia, and Egypt [8].

A fundamental feature of these contracts is their one-way, immutable nature, meaning they cannot be modified or reversed once signed. This enhances transparency and security in transaction execution.

Technical/Regulatory Barriers and Practical Challenges

Despite these advancements, several factors limit broader blockchain adoption in the region. Technical constraints, including limited digital infrastructure, lack of data standardization, and interoperability issues, hinder smooth implementation. Additionally, organizational and regulatory limitations such as high implementation costs, shortages of skilled personnel, and unclear legal frameworks further slow the uptake of blockchain technologies [9].

In real-world supply chains, companies may face product shortages, delivery delays, or unexpected disruptions, making the strict execution of smart contracts impractical in some cases. This represents a significant operational challenge, as the rigidity of blockchain-based contracts may not always align with supply chain realities [10].

3.2 Role of AI in Automating and Managing Blockchain-Enabled Supply Chain Transactions

AI Integration for Enhanced Automation and Feasibility

Integrating Artificial Intelligence (AI) with blockchain can enhance the accuracy of information and link real-world conditions to blockchain records. AI allows for the assessment of resource readiness before contract execution, ensuring practical feasibility while maintaining transparency and security in transactions [11]. AI-driven analytics can also support predictive maintenance, demand forecasting, and anomaly detection, further improving supply chain efficiency and resilience.

AI for Risk Management and Supply Chain Transparency

Another critical role of AI in blockchain-enabled supply chains is enhancing risk management and transparency. AI algorithms can analyze blockchain data in real-time to detect problems, prevent fraudulent transactions, and identify potential operational risks before they escalate. This integration allows stakeholders to monitor supply chain activities continuously, optimize compliance with regulations, and improve trust among partners by providing intelligent alerts and actionable insights [12].

In order to address these operational challenges, integrating Artificial Intelligence (AI) with blockchain can provide adaptive solutions. AI can analyze real-time supply

chain data such as inventory levels, shipment status, and demand fluctuations and adjust the execution of smart contracts accordingly. For example, AI-driven predictive analytics can identify potential shortages or delays before contract execution, allowing the system to conditionally trigger or modify contract actions without compromising transparency or security. This integration ensures that blockchain transactions remain both practical and reliable, aligning smart contract enforcement with real-world supply chain conditions while maintaining traceability and operational resilience [13].

Overall, the results indicate that blockchain adoption in MENA is growing but sector-specific, with the strongest uptake in logistics, energy, and food supply chains. Real-world operational challenges and technical/regulatory barriers continue to limit broader implementation. AI plays a crucial role in addressing these challenges, enhancing automation, predictive capabilities, and risk management. The combined use of AI and blockchain presents significant potential to improve transparency, traceability, and operational resilience across MENA supply chains.

4 Discussion

4.1 Interpretation of Results

The results demonstrate that blockchain adoption in MENA supply chains is gradually increasing but remains sector-dependent, particularly in logistics, food, and energy industries. However, real-world operational constraints such as unpredictable disruptions, inconsistent data flows, and infrastructure limitations continue to affect implementation. Recent research emphasizes that blockchain enhances traceability, trust, and decentralized data governance, but its effectiveness depends on integrating intelligent data processing mechanisms capable of adapting to dynamic operational conditions [14].

The integration of Artificial Intelligence (AI) with blockchain provides a practical solution by enabling adaptive automation, predictive analytics, and real-time data interpretation. AI can transform static blockchain records into actionable insights, allowing organizations to anticipate disruptions and align smart contract execution with real-world conditions. This combined framework enhances operational resilience and bridges the gap between theoretical blockchain adoption and practical supply chain requirements in MENA contexts.

4.2 Practical and Policy Implications

From a practical perspective, organizations should adopt AI-driven monitoring and analytics systems capable of interpreting blockchain transaction data and detecting operational anomalies. Integrating AI with decentralized data governance models enables better management of digital supply chain records and improves transparency between stakeholders [12].

Supply chain managers are encouraged to:

- Implement AI-assisted data validation before executing smart contracts.
- Integrate predictive analytics for inventory and logistics optimization.
- Develop interoperable digital systems that facilitate blockchain adoption.

From a policy perspective, governments in MENA should establish regulatory frameworks supporting decentralized digital infrastructures, encourage open innovation ecosystems, and promote investment in digital logistics infrastructure. Policy support is essential to enhance trust, ensure compliance, and accelerate technology adoption across industries.

4.3 Limitations of the Study

Despite providing valuable insights, this study has several limitations. First, it is based primarily on qualitative analytical methods and secondary data sources, which may not fully capture operational diversity across all MENA countries. Second, blockchain and AI technologies are evolving rapidly, meaning that practical implementations may change as new frameworks and architectures emerge. Third, variations in digital infrastructure maturity across sectors and regions may limit the generalizability of findings.

4.4 Future Research Directions

Future studies should focus on empirical and quantitative evaluations of AI–blockchain integration in real supply chain environments, including performance measurement and cost-benefit analysis. Comparative studies between MENA countries could identify scalable adoption models and best practices.

Furthermore, future research should explore the integration of blockchain with decentralized identity systems, data governance architectures, and intelligent automation frameworks, which represent emerging research directions for resilient and transparent supply chains [15].

5 Conclusion

This study examined the integration of Artificial Intelligence (AI) with blockchain for automating and managing supply chain transactions in MENA countries. The findings indicate that blockchain adoption is growing but remains sector-specific, with logistics, energy, and food supply chains showing the strongest uptake. Operational challenges, such as product shortages, delivery delays, and dynamic market conditions, alongside technical and regulatory barriers, continue to limit broader implementation.

The study highlights that AI plays a crucial role in overcoming these challenges. AI enhances automation, predictive capabilities, risk management, and real-time monitoring, ensuring that smart contract execution is both practical and aligned with real-world supply chain dynamics. The combined AI–blockchain approach can significantly improve transparency, traceability, and operational resilience, providing tangible benefits for managers and policymakers in the region.

For practitioners, the study recommends:

- Integrating AI-driven analytics with blockchain enabled supply chain systems to optimize operations and anticipate disruptions.
- Developing human capacity through targeted training programs in AI and blockchain technologies.

For policymakers, the study emphasizes:

- Establishing clear regulatory frameworks to support digital transformation.
- Providing incentives and infrastructure support to facilitate the adoption of these emerging technologies.

Finally, the study identifies areas for future research, including quantitative evaluation of AI–blockchain systems, cross country and cross-sectoral comparisons, and the exploration of emerging technologies such as IoT and edge computing to further enhance supply chain performance and resilience.

In conclusion, the integration of AI with blockchain represents a promising pathway for MENA supply chains to achieve operational efficiency, adaptability, and competitive advantage in an increasingly dynamic global market.

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