



Blockchain and AI Convergence for Intelligent Supply Chains: A Systematic Review of Adoption Drivers and Service Innovation in E-Commerce

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ABSTRACT:

E-commerce is currently undergoing a paradigm shift toward a smarter, highly personalized, and socially responsible ecosystem. Central to this transformation is the synergistic interplay between two foundational technologies: Blockchain and Artificial Intelligence (AI). This review article provides an integrated analysis of blockchain adoption within supply chains—acting as a critical infrastructure for trust and transparency—and elucidates its role in fostering innovation in e-commerce services. By systematically reviewing 50 studies and synthesizing 14 core papers published between 2020 and 2024, this research demonstrates that blockchain adoption has transitioned from initial market hype to practical operational implementation and value creation. The findings identify key drivers—such as the demand for transparency, traceability, and efficiency—alongside structural barriers, including regulatory ambiguity, high implementation costs, and a lack of standardization. Utilizing a synthesis of methodologies including Delphi, DEMATEL, and the UTAUT framework, this study clarifies the causal relationships between these factors. Specifically, the paper argues that blockchain establishes a "foundation layer of trust" and immutable data, providing the necessary high-fidelity substrate for AI algorithms to optimize demand forecasting, service personalization, automated logistics, and risk management. This technological convergence is identified as the cornerstone of "Smart Service Provisioning" in the future e-commerce landscape. Finally, an integrated framework is proposed, outlining future research trajectories at the intersection of blockchain, AI, and service innovation.

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I. Introduction

The digital revolution has put the e-commerce industry at the edge of a change that has never happened before. Today's shoppers want more than fast delivery and ease - they want clear proof of where a product came from, proof that it is real and proof that it was made without harm to people or the planet [1]. At the same time, tougher rivals plus long, tangled supply chains force firms to work faster, bounce back from shocks and control risk. Two big technologies - Artificial Intelligence (AI) but also Blockchain - now sit at the center of board room talk. Many studies and trade papers praise AI for its power to spot patterns as well as guess what each buyer wants but they still play down blockchain, the tool that stores records in a way no single party owns or alters [2].

Actually, the entire worth of AI in online retail depends on how good, honest, and trustworthy the input data are. Blockchain is giving this essential data structure by establishing a safe and clear "single source of truth" that goes across the supply chain [3]. With this technology, the chain of the product from manufacturing to the end, user becomes very easy, as well as the automatic confirmation of the quality and the transparent performance of the contracts. Hence, using blockchain in the supply chain is not just a better way to run the operations but a strategic condition that is needed to realize the technological advances of AI for trusted e, commerce services.

While the amount of research is increasing, it is still quite surprising that a systematic review that specifically investigates the factors, obstacles, and changes related to the adoption of blockchain technology by combining it with AI for service innovation is missing. This article aims to fill this void by answering the following questions:

1. What is the evolutionary trajectory and current state of blockchain adoption in e-commerce-related supply chains?
2. What are the key drivers and barriers to this adoption, and how do they interact?
3. How does blockchain provide the necessary foundation for e-commerce service innovation, particularly in synergy with AI?
4. What are the future research directions at this critical intersection?

Answering these questions required a systematic review of 50 articles from Scopus and Web of Science databases by this study. In the end, 14 most influential papers that either empirically or analytically examine the use of blockchain technology in supply chains were chosen. The results are told as a critical synthesis within an integrated framework.

II. REVIEW METHODOLOGY

This paper employs a hybrid, critical review strategy. The first set of studies consisted of 50 primary research articles which were located by using combined keywords like "Blockchain adoption, " "Supply Chain, " and "E, commerce" in well, known scientific databases. Based on the selection criteria of thematic relevance, analytical depth, and methodological innovation, 14 significant articles were chosen for intensive study. This choice thus guaranteed the study cover the world (studies from India, Europe, East Asia, and the Middle East were included), various industries (general, agriculture/fisheries, oil and gas, finance), and different methodologies (surveys, Delphi studies, multi, case analysis, structural equation modeling, multi, criteria decision making). The data were analyzed thematically to identify the core themes, causal relationships, and contextual nuances.

III. EVOLUTIONARY MAPPING: FORM HYPE TO RELATIVE MATURITY

There is firm proof that the use of blockchain in supply chains has followed a typical S, curve pattern over time. The authors N. Vadgama and P. Tasca [4] in their paper analyzed 271 projects from 2010 to 2020 and concluded that the peak of the activity was in 2017 and 2018 which is the time when the prices of cryptocurrencies and the crypto media hype also peaked. The significant thing to note is that the kind of actors has changed from startup, led pilot projects (mostly on the Ethereum platform) to enterprise and consortium solutions focused on Hyperledger. The shift has resulted in higher success rates for Hyperledger projects with only 2% inactivity compared to 15% for Ethereum [4]. At present, the market is stabilizing with 23% of projects being "market, ready" and 67% "under development. " The first sectors to be targeted were agriculture, food, and logistics where product tracking was the main application (66% of projects).

IV. KEY APPLICATIONS AND VALUE CREATION DOMAINS

Despite the publicity surrounding complex smart contracts, practical adoption remains focused on foundational applications. Reference [2] identified seven Blockchain Application Areas (BAAs) that carry varying priorities for industry managers.

TABLE 1: PRIORITIZATION OF BLOCKCHAIN APPLICATION AREAS FROM INDUSTRY PERSPECTIVES

<i>Rank</i>	<i>Application Area</i>	<i>E-commerce Value Proposition</i>
<i>1</i>	<i>Product Tracking</i>	<i>Spatio-temporal transparency, error reduction, improved CX</i>
<i>2</i>	<i>Proof of Provenance</i>	<i>Anti-counterfeiting, quality assurance, ethical/environmental compliance</i>
<i>3</i>	<i>Asset Management</i>	<i>Optimization of containers/pallets, logistics cost reduction</i>
<i>4</i>	<i>IP Protection</i>	<i>Security for digital designs and data in high-tech supply chains</i>
<i>5</i>	<i>Contract Management</i>	<i>Automation of payments and delivery, dispute reduction</i>
<i>6</i>	<i>Identity Management</i>	<i>Reliable authentication of suppliers and partners</i>
<i>7</i>	<i>Supply Chain Finance</i>	<i>Facilitating liquidity access, especially for SMEs</i>

The divide between academic experts and executive managers is quite substantial: whereas experts highlight the revolutionary potential of Supply Chain Finance (SCF), industrial managers mainly consider operational applications for enhancing transparency and tracking as more straightforward and less risky [2]. This insight is crucial for an e, commerce environment where customer trust, which is established through transparency, serves as the basis for all other services.

Tonal and industrial differences are also evident:

- In the food and fisheries industries, tracking provenance to ensure safety and respond to consumer pressure is the primary driver [5].
- In the oil and gas sector, given the security sensitivities, cybersecurity and financial data integrity are prioritized [6].
- In Supply Chain Finance, blockchain resolves information asymmetry and the risk of double financing, improving credit access for SMEs [3], [7].

V. ANALYSIS OF BARRIERS AND DRIVERS: AN INTEGRATED FRAMEWORK

A. Structural Barriers

Studies indicate that barriers extend beyond technical issues, rooted in organizational and environmental dimensions. Using the TOE framework, barriers can be categorized as follows [7], [8]:

- Technological Barriers: Lack of standards, interoperability issues, and scalability concerns.
- Organizational Barriers: High initial costs, lack of internal expertise, and resistance to culture change.
- Environmental Barriers: Legal ambiguity, lack of government support, and absence of inter-organizational governance.

Fuzzy-DEMATEL analyses in Indian studies [7], [8] provide a key insight: regulatory barriers emerge as the "root cause" that exacerbates other organizational and technological obstacles.

A. B. Drivers and Enablers

Organizations are attracted to blockchain by a multitude of enablers. Reference [9] distinguishes these into two classes: Push Drivers (e. g. transparency for resolving inefficiencies) and Pull Drivers (e. g. business model innovation for value creation). Empirical studies grounded in the UTAUT model [1], [10], [11] unanimously indicate that "Performance Expectancy" is the major factor leading to the intention to adopt the technology. It is worth noting that the insignificant impact of "Perceived Ease of Use" in certain studies [10] implies that managers are ready to endure an initial technical complexity if they can reap strategic benefits.

VI. THE ROLE OF CONTEXTUAL VARIABLES

- Firm Size: Network pressure from bigger partners is usually a more powerful factor for SMEs to change than the direct advantages of the technology in their own company [10]. Nevertheless, the issue of costs and lack of skills still remains quite severe [7].
- Geography: Poor infrastructure and inadequate legal frameworks are major hurdles in the case of developing countries [8], whereas the problem of integration with the legacy system is more significant in the developed nations. Reference [11] highlights "Trust" as a mediator in the Vietnamese market.
- Organizational Readiness: Reference [12] reveals that supply chain capabilities (transparency, agility) can be seen as the basis for understanding the value of blockchain. Reference [13], [14] also supplements the company theoretical framework for organizational adoption.

VII. BLOCKCHAIN AND THE SUSTAINABILITY AGENDA

Blockchain has become a core factor in the evolution of sustainability strategies. Reference [1] shows how it influences positively the three pillars: Economic (cost reduction), Environmental (carbon tracking), and Social (labor rights). The technology, thus, offers a way to verify in an unalterable manner the sustainability claims and so it acts as a mediator between producers and consumers in terms of trust [14].

VIII. DISCUSSION AND SYNTHESIS: AN INTEGRATED FRAMEWORK

After combining the results, a comprehensive framework for the integration of Blockchain and AI in e-commerce has been presented (Fig. 1). The framework considers a successful implementation as a result of the interaction of the three layers: Environmental, Regulatory Layer, Organizational, Strategic Layer (which is affected by the firm size and readiness [12], [13]), and the Technical, Operational Layer. AI algorithms receive accurate and reliable data recorded on the blockchain as their high, quality input to carry out radical personalization and smart risk management [3], [7].



FIG. 1 INTEGRATED FRAMEWORK FOR BLOCKCHAIN-AI CONVERGENCE IN E-COMMERCE

IX. CONCLUSION AND FUTURE OUTLOOK

Through this systematic review, it becomes clear that the future of e-commerce is no longer about choosing between individual technologies, but rather about how effectively we can integrate Blockchain with Artificial Intelligence. Our analysis shows that this convergence is the key to moving beyond the current limitations of global supply chains. The real value of blockchain lies in its ability to act as a "foundation of trust"; by creating an unchangeable record of data, it solves the "garbage in, garbage out" problem that has long hindered AI performance.

We found that this synergy is what truly drives Service Innovation in today's market. It isn't just about tracking a package; it's about a new era of "Smart Service Provisioning." For instance, when AI can rely on the absolute integrity of blockchain data, we see the rise of autonomous systems—like smart contracts that handle disputes automatically or logistics networks that predict and fix

risks before they happen. These are not just technical upgrades; they are fundamental shifts in how businesses create value and build trust with the modern, socially-conscious consumer.

As we look forward, it is evident that the initial hype around these technologies has matured into a strategic necessity. However, for this to work at scale, future research must address the "human" and "regulatory" side of the equation. We need a better understanding of how different industries can standardize their data and how legal frameworks can keep up with such rapid digital change. Ultimately, the winners in the e-commerce space will be those who can best manage this digital ecosystem, turning transparent data into intelligent, personalized services.

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