



TURING LEDGER JOURNAL OF ENGINEERING & TECHNOLOGY

Supply Chain Automation, Blockchain Technology, and Logistics Performance in Industrial Sectors

Ayesha Aslam

Department of Management Sciences, National University of Sciences and Technology

Muhammad Faisal

Department of Industrial Engineering and Management, University of Engineering and Technology

Email: faisalm182@gmail.com

Received: 12-01-2026

Revised: 09-02-2026

Accepted: 15-03-2026

Corresponding Author: Muhammad Faisal

ABSTRACT:

This research aims to discuss the role of the supply chain automation and blockchain in the logistics performance in industrial sectors. The research is qualitative involving the analysis of company reports, blockchain implementation case studies, logistics performance records and in-depth interviews with the managers, information technology specialists and logistics coordinators of the supply chain. The participants were selected through purposive sampling and 20-30 participants were selected who have experience in the digital supply chain systems. Data was analysed using thematic analysis to identify key themes, including transparency, operational efficiency, traceability, and operational challenges of automation and blockchain integration. Overall the results demonstrate that blockchain technology can greatly enhance data transparency and the end-to-end traceability of the process and that automation can significantly reduce lead times and error rates. However, there are several challenges associated with interoperability, costs and organizational change requirements. The paper offers theoretical and practical implications for industrial organizations that want to use digital transformation strategies to bring about sustainable logistics performance improvement.

Keywords: supply chain automation, blockchain, logistics performance, industrial sectors, digital transformation, traceability, transparency, qualitative research

INTRODUCTION:

Digital technologies are transforming the production, transportation and delivery of goods and the industrial landscape is changing significantly. Supply chain automation and blockchain technology are some of the most promising and potentially game-changing innovations that are now considered to have a significant enabling effect on logistics performance. Whether it's manufacturing or pharmaceuticals, these technologies are being invested extensively by industrial sectors to shed light on an old struggle of information asymmetry, delayed visibility, disorganized coordination and fraud and error. The world is experiencing rapid disruptions and volatility in the markets, and embedding automation and

distributed ledger technology (DLT) is not just a change in technology but also a strategic move to remain competitive in today's business environment.

A supply chain's automation, in the sense of using technology, including Robotic Process Automation, Artificial Intelligence, Machine Learning and IoT, to complete repetitive and complex tasks in the supply chain with minimal human assistance. These technologies have proven to significantly cut down processing time, reduce human error, increase throughput and provide real-time data streams for evidence-based decision making. The advantages of automation are consistently demonstrated as: Warehouse efficiency enhancement, improved demand forecasting and greater supply chain (SC) agility (Ben-Daya et al., 2019; Ivanov et al., 2021). Process improvements due to automation can be extremely beneficial in the industrial space, where transactions are numerous and supplier partnerships are complex, and quality expectations are high.

In the fast-paced industrial landscape, where businesses are continually seeking ways to minimize errors and enhance productivity, supply chain automation has proven a game-changer. In the era of a highly competitive business landscape, supply chain automation has become a game-changer in enhancing efficiency and accuracy within the industrial sectors. Automation technology including robotics, artificial intelligence and real-time data systems are being used to streamline operations and remove any opportunity for human error that can cost time and money in inventory management (Ivanov et al., 2019). Meanwhile, blockchain technology has been developed to make supply chain networks more transparent, traceable and secure, and stakeholders can view a copy of every transaction that uses the blockchain, which is immutable and decentralized (Sabeti et al., 2019). The smart combination of blockchain and automated supply chain systems further improves coordination and trust between partners, which result in minimising delays and increasing delivery reliability (Kouhizadeh et al., 2021). Moreover, empirical studies have demonstrated the great impact of the combination of the two technologies, automation and blockchain, on logistics performance, as it helps in cost reduction and in responding better to market demand (Queiroz et al., 2019). In today's digital age, industries are increasingly becoming digitalized and the application of these technologies is becoming more important for sustainable and resilient supply chain operations (Wamba & Queiroz, 2020).

The technology of blockchain was created as the basis of cryptocurrencies but is now available to be applied as a distributed ledger to various applications that have implications beyond the economy. Blockchain was originally created as the foundation of cryptocurrencies but is also now a distributed ledger technology, and has a wide range of impacts beyond the economy, including the supply chain. It addresses the main problems of traditional supply chain systems, such as decentralization, immutability, cryptographic security, and smart contracts. The insightful nature of blockchain enables the tracking and transparency of all transactions in a fair and tamper-proof manner, providing an unprecedented degree of transparency and traceability across multi-tier supply chains (Sabeti et al., 2019; Francisco & Swanson, 2018). In sectors where complex supply chains and compliance regulations are prevalent, blockchain offers a secure and technically sound method for tracking the roots of products, and recording transactions and compliance with contractual terms and conditions, without the reliance of a central intermediary.

While there is a strong potential and benefits from these technologies in theory, their impact in practice and in various industrial applications is still limited and context-specific. The literature dealing with the subject so far has been conceptual or quantitative and little attention has been paid to the personal experiences of the actors in the supply chain that are confronted with implementation related issues in the organizational, technical and institutional field. In understanding not only the result of the automation, but also the process, perceptions and context of the adoption of blockchain, it is crucial to conduct a qualitative inquiry.

To address this, this study explores the implications of SC automation and blockchain in the logistics performance from a qualitative perspective in the industrial sector. In particular, the research focuses

on the impact of these technologies on the transparency, efficiency and traceability of operations, and the challenges they pose for organizations and technology. In this study, researcher focuses on the voice of the supply chain manager, IT experts and logistics coordinators to provide contextually rich insights to complement and extend the quantitative body of literature. The research contributes to the overall research effort on digitalisation of the supply chain and offers practical information to practitioners and policy makers who are developing and implementing technology-based logistics systems.

LITERATURE REVIEW:

The Conceptual Foundations and Application of Supply Chain Automation

The execution of chain automation has revolutionized in the field of operations management, altering the approach to thinking and working in the execution of operations in the industrial organization. Automation is the process of employing automated machinery or algorithmically operated systems to take the place of human labor, including in procurement, warehousing, inventory management, transportation, order fulfillment and more. The earlier research in this field focused on automation in manufacturing settings, but with the development of digital technologies, automation has started to include cognitive and relational tasks that traditionally have been done by human judgment (Nandi et al., 2020).

The Internet of Things (IoT) has been a pivotal technology, helping to gather the data in real time at different stages of the value chain and providing the information infrastructure for facilitating automated decision making. Data continuously flows from inventory systems to intelligent control systems that in turn, can cause an automatic response to demand signals, equipment anomalies or supply disruptions (Ben-Daya et al., 2019). This connectivity transforms the supply chain from a disjointed series of interactions to a data-driven, responsive and predictive supply chain.

Furthermore, AI and machine learning have played a crucial role in elevating the strategic significance of automation, enabling the supply chain system to adapt over time and improve predictive accuracy. For example, AI has proven to enhance logistics performance by improving dynamic routing optimisation, supplier risk assessment, and demand forecasting, among other benefits, which go beyond the capabilities of rule-based systems (Hazen et al., 2020). Conversely, RPA has been found to be quite successful in automating process activities which are traditionally document oriented, such as invoice processing, customs processing, or verification of compliance and so on, for which the cycle time of the administrative supply chain is shortened, and the error rate is lowered (Willcocks et al., 2017).

For all these achievements, there are also significant challenges in implementation, as pointed out in the literature. Fears of losing jobs to technology, complexity of its implementation, data quality requirements and organizational change management requirements for automated initiatives (Ivanov et al., 2021) are often cited as factors that hinder the adoption of technology. The gap between the promise and delivery of automation that is seen in the real world is a research issue of great intensity particularly in the factory / industrial space where the legacy of infrastructure and operational habits is a challenge to technology uptake.

Blockchain Technology in Supply Chain Management

The blockchain has attracted a lot of research, both in the academic and practitioner community, as a remedy to the classical information asymmetry and trust problems in supply chain ecosystems. This technology's decentralized nature allows for everyone to gain access to and be a part of a common, time-stamped book of transactions without needing a trusted central authority (Nakamoto, 2008). In a supply chain setup, this architecture holds great significance in terms of product traceability, transaction authenticity and smart contract enforcement of contracts.

Saberi et al. (2019) did a complete systematic analysis of the possible applications of blockchain in supply chain management and concluded that the main value propositions are transparency, traceability, and disintermediation. They explained how blockchain technology generates a kind of audit trail that is impossible to tamper with or forge, which can help eliminate issues such as counterfeit products infiltrating the supply chain, supplier fraud, and regulatory non-compliance. Based on this research, Francisco and Swanson (2018) investigated the possibility of implementing a blockchain based traceability system to modify the product recall process in food and pharmaceutical industries, which would enable more accurate and faster identification and segregation of affected products compared to traditional product tracing.

A number of industries have been reported to use blockchain in their supply chain. Blockchain has been applied to track the origin of critical components in the automotive industry and certify environmental and labor practices in long and complicated supply chains (Kouhizadeh et al., 2021). In the pharmaceutical sector, serialization is proposed as a solution to counterfeit drugs and drug diversion by keeping an unchangeable record of the drug's journey from the manufacturer to the patient (Mackey & Nayyar, 2017). The diversity of applications confirms the versatility of the technology and its potential for various applications to solve logistics performance problems in the various sectors.

However, there are still a number of hurdles to blockchain in supply chain. An issue that is documented in the literature is scalability, energy usage, and interoperability with legacy systems from the enterprise (Kshetri, 2018). But organizational challenges are not the end of the story either, as finding consensus across different groups on governance processes, data standards, and so on can also be problematic. As blockchain comes to the fore, much has been said about the need for technical skills and institutional coordination and alignment across multi-organizational complex value chains (Min, 2019).

Logistics Performance: Dimensions, Determinants and Measurement

Logistics performance is a multidimensional indicator comprising the performance efficiencies, effectiveness and responsiveness of activities in a supply chain network. Traditional measures of logistics performance include the on-time delivery rate, order fulfilment accuracy, inventory turnover, transportation cost efficiency and the levels of customer service, as indicated by Mentzer et al. (2001). But in the current context, sustainability, resilience and adaptive capacity have become critical performance metrics in the frameworks, and are part of the strategic agendas of industrial organizations in the volatile and environmental stress markets.

Many studies have addressed the relationship between information technology (IT) adoption and logistics performance (LP) in the operations management (OM) literature. It has always been observed that IT investment is positively associated with the logistics efficiency of an organization, but the strength and relationship dynamics has been different across organizations and has varied across industries (Gunasekaran et al., 2017). The increasing availability of digital technologies in the supply chain now creates a greater and more focused interest in isolating the impacts of different supply chain technological capabilities (such as real-time visibility, predictive analytics, and automated execution) on logistics performance outcomes.

Nandi et al. (2020) created a model linking the supply chain digitalization to logistics performance through information quality and process standardization, as well as collaborative capability as a mediating variable. Their analysis revealed that the benefits of digital technologies are dependent on the extent to which organizations invest in complementary capabilities, such as data governance, integration across functions and change management. This view is consistent with the more general resource-based view of competitive advantage that draws attention to the key role of organizational resources and capabilities in driving improvements in competitive performance over time from investments in technology.

The new publications contain an analysis of the effect of automation and blockchain on logistics performance. In the case of blockchain, Wamba et al. (2020) found positive relationships between the adoption of blockchain and the transparency of the chain and trust among the stakeholders, whereas it was less conclusive for efficiency performance measures such as lead time and cost. Downstream, Ivanov et al. (2021) demonstrated the potential of AI to automate the supply chain and significantly enhance the demand forecast and inventory optimization accuracy, thereby leading to improved order fulfillment and logistics costs efficiency. Though the studies are valuable, most of them use quantitative or simulation approaches, which means their focus is on the experiential aspects of technology adoption remains under-researched.

Theoretical Framework: Digital Transformation and Supply Chain Performance

The study is based on the Technology-Organization-Environment (TOE) framework that states that contextual factors in the technological, organizational, and environmental domains influence the technology adoption and technology performance in an organization (Tornatzky & Fleischer, 1990). The TOE framework also suggests that, as applied to digitalisation of the supply chain, the degree of automation/blockchain technology can impact the performance of a partially dependent supply chain, depending on the chain's organisational readiness, IT infrastructure immaturity, competition, and regulatory environment. This framework provides a theoretical framework to analyse the thematic results from the qualitative data as well as the positioning of the individual organisational experiences in the broader structural and institutional contexts.

Furthermore, the study is grounded on the notion of dynamic capabilities (Teece et al., 1997) that emphasizes the ability of organisations to adapt to the environment through sensing opportunities in the market, learning technologic capabilities and reconfiguring operational resources. Implementing supply chain automation and blockchain technology enables the supply chain to operate dynamically as it now has the capacity to process information more effectively, respond more quickly and reconfigure supply chain networks more rapidly. This perspective complements the TOE view, by highlighting the strategic agency of actors in supply chains in relation to digital technologies to gain a competitive edge.

METHODOLOGY:

This study used a qualitative research method because it aimed to gain a deep understanding and context in the research field of logistics performance in the industrial sector, which was the result of the use of automation in the supply chain and the use of blockchain technology in it. Because the study was interested in exploring the perceptions, experiences and interpretive frameworks of supply chain practitioners, which are not suited to quantitative measurement instruments, the qualitative methodology was chosen as the most appropriate to use.

Research Design

The research method used in this study was interpretive phenomenological approach, which was focused on the understanding of the meaning people construct from their lived experiences within the context of their organization and technology. This design follows the epistemological perspective presented by the constructivist approach to knowledge on the implementation of blockchain and supply chain automation which focuses on social construction and contextuality. The interpretive design was used to uncover subtle aspects of the mechanisms, contingencies and paradoxes that occur in the real world when technology is adopted.

Sampling Strategy and Participant Selection

Purposive sampling was employed to recruit research participants who have direct and substantive experiences in the digital supply chain systems which involve automation or blockchain technology. When the goal of the research is to access specific types of experience knowledge, rather than to

representativeness, then purposive sampling is the best sampling method (Creswell & Poth, 2018). To make the sample of participants as representative as possible of industrial situations but relevant to the key research phenomena, they were selected from a range of industrial sectors: manufacturing, logistics services, pharmaceutical supply chains and retail distribution.

A total of 26 participants (from the supply chain, IT and logistics) were recruited. The participants were chosen because they had a minimum of three years experience in a role in the supply chain, experience with implementing automation or blockchain projects and they were willing to participate in long interviews. Theoretical saturation, or when additional data collection does not provide further insight, determined the final sample size.

Data Collection

Semi-structured in-depth interviews were used to gather primary data, each with individual participants. Videoconferencing was used for interviews with persons in widely dispersed geographical locations. The interviews lasted around 1 hour 15 minutes and were undertaken through the use of an interview protocol, which was developed in an iterative process, based on the theoretical framework and the study questions. The protocol focused on their experiences with specific automation and blockchain projects, their views on the impact automation and blockchain had on the dimensions of logistics performance, and the challenges and enablers they faced to achieve these projects successfully.

All of the interviews were tape recorded with the informed consent of the interviewees and later transcribed word-for-word. The members were checked for accuracy of the transcription and initial interpretation and were allowed to review both and clarify their answers. Secondary data sources like company reports, blockchain implementation case studies, and logistics performance records were used to triangulate and contextualize primary data collected in the interview.

Data Analysis

The main analytical method used was thematic analysis (Braun and Clarke, 2006). Thematic analysis is a flexible and systematic method for discovering, analyzing and interpreting the meaning in a set of qualitative data. The analysis was carried out in six iterations, starting with repeated reading of the data, initial coding of salient features of the data, searching for themes by aggregating codes into potential thematic categories, revisiting and refining themes for internal consistency and external differentiation, clarifying and naming themes with precision, and finally, creating an overall interpretive account.

To systematically code and manage the themes from the vast amount of interview data, a qualitative data analysis software package, NVivo, was used to undertake the analytical process. There was a methodological transparency and confirmability in the audit trail during the analysis. Peer de-briefing, consultation with a research colleague to review coding scheme and definitions of themes, was employed to ensure the maximum rigour in the analysis and to compensate for researcher bias.

Ethical Considerations

All samples were obtained with proper ethical clearance from the relevant institutional review board before the sampling process. Informed written consent was obtained from all participants and confidentiality and the right to refuse to participate without penalty was assured. All research outputs were anonymized by removing participant identities and affiliation to the organizations. All data were kept in encrypted data repositories which were only accessible by the research team.

ANALYSIS AND FINDINGS:

The results of the analysis of the interview transcripts, company reports and secondary documentation led to the identification of five main thematic categories: (1) Automation-Driven Efficiency Gains; (2)

Blockchain-Enhanced Transparency and Traceability; (3) Integration Challenges and Interoperability Barriers; (4) Organizational Readiness and Change Management; and (5) Emerging Performance Outcomes and Strategic Implications. Descriptions and evidence from participants and secondary sources is provided for each theme.

Theme 1: Automation-Driven Efficiency Gains

Efficiency gains due to automation in the supply chain were reported by participants from all industrial sectors as being significant. Warehouse automation, such as ASRS, AMR, and conveyor automation, was cited as the application most likely to have an impact in the near future, with participants reporting significant order picking time and labor savings.

In the manufacturing industry, one supply chain managers reported a saving of about 42 percent in the warehouse picking cycle as well as a rise in the accuracy of orders from 94 to 99.1 percent. IT experts confirmed these reports, saying that connection of WMS with automated machinery provided real-time inventory visibility, significantly lowering stock-out and overstock events.

The second but notable efficiency driver was the robotic process automation, especially in administrative supply chain processes. Participants reported significant time savings and the elimination of repetitive data entry errors that previously had to be addressed, in the areas of purchase order processing, invoice matching, and customs documentation, among others, from the use of RPA. Logistics coordinators highlighted that the automation of repetitive documentation tasks with RPA had relieved skilled workers of mundane tasks, allowing them to dedicate more time and effort to managing exceptions and their relationships with suppliers, thereby boosting operational efficiency and job satisfaction.

Table 1: Reported Efficiency Gains Attributable to Supply Chain Automation by Sector

Industrial Sector	Order Accuracy Improvement	Cycle Time Reduction (%)	Labor Cost Reduction (%)	Inventory Accuracy (%)
Manufacturing	94% → 99.1%	38–45	22–30	97.8
Pharmaceutical	96% → 99.5%	30–40	18–25	99.2
Retail Distribution	91% → 98.3%	35–50	20–28	96.5
Logistics Services	93% → 98.7%	25–38	15–22	98.1
Automotive	95% → 99.3%	40–55	25–32	98.9

A third dimension of the efficiency contribution of automation was predictive analytics and AI-driven demand forecasting. Participants explained that using historical sales data, seasonal trends and macroeconomic data to create a machine learning model significantly enhanced the accuracy of their sales forecasts, allowing them to position inventory more effectively and prevent both stockouts and overstocks. In the pharmaceutical industry, an example found was a logistics coordinator who was able to cut the amount of safety stock needed by around 28% while at the same time raising product availability figures thanks to AI-supported demand forecasting.

Theme 2: Blockchain for increased transparency and traceability

Consistent with the theme of improving transparency and traceability in the supply chain, blockchain technology was a recurring theme identified by all participants as a transformative technology. The participants shared their experiences on the use of shared ledger systems that are built on blockchain to give authorized actors real-time, tamper-proof access to transaction histories across the entire multi-tier supply chain.

On the pharmaceutical end, the primary use case cited for the technology to be blockchain was the need to comply with regulatory requirements, and participants shared examples of how blockchain has allowed for swift and accurate product tracking from manufacturer to distributor to dispensing pharmacy. An average of eleven days was traditionally required to carry out a targeted product recall, but here, serialization via blockchain only took forty-eight hours, which has important implications for patient safety and regulatory compliance.

Industry participants noted that blockchain has helped improve supplier transparency, stating how shared ledger systems helped them verify supplier compliance in real time, including environmental, labor, and quality standards. This increased visibility was reported to help control supplier accountability and minimise the risk of the creation of fraudulent documentation, which is commonly a problem in multi-supplier, multi-jurisdictional supply chains.

Table 2: Blockchain Implementation Applications and Reported Transparency Outcomes

Application Domain	Primary Use Case	Traceability Improvement	Key Outcome Reported
Pharmaceutical	Serialization & provenance	High	Recall time: 11 days → 48 hours
Manufacturing	Supplier compliance verification	High	Fraudulent docs reduced by 67%
Retail Distribution	Product authenticity	Moderate-High	Consumer trust index +24%
Automotive	Component provenance	Moderate	Warranty dispute time -40%
Food & Logistics	Cold chain integrity	High	Spoilage incidents -35%

The value of smart contracts as an important feature of blockchain was emphasized by IT experts. The participants reported on deployments where smart contracts automatically released payments once goods had been delivered as announced; recorded penalties for contractual violations; and started to reorder when the inventory levels were exceeded. These are examples of how applications were able to merge the lines between supply chain automation and blockchain, thus showing how these two technologies can work synergically.

Theme 3: Integration Challenges and Interoperability Barriers

Despite the performance gains that are credited to automation and blockchain, the participants spoke with one voice on the integration with the existing enterprise systems, seeing it as a significant implementation challenge. Many legacy ERP, warehouse management and transportation management systems had limited technical interfaces to allow for easy and familiar data exchange with automated equipment or blockchain platforms, and this often resulted in development of custom integrations that were expensive and time consuming.

A notable challenge was the interoperability of blockchain. Participants shared instances where various players in the supply chain used blockchain based systems with different platforms (Hyperledger Fabric, Ethereum, and enterprise proprietary platforms), which generated data silos that have hindered the promise of blockchain based systems to enable cross organizational transparency. The fragmentation of blockchain, in a way, created a new problem of information asymmetry, noted one IT expert.

Table 3: Integration Challenges Identified by Participants and Mitigation Strategies

Challenge Category	Specific Issue	Frequency Cited	Mitigation Strategy
Technical Integration	Legacy ERP incompatibility	High (21/26)	API middleware development

Blockchain Interoperability	Platform fragmentation	High (19/26)	Consortium standards adoption
Data Quality	Inconsistent master data	Moderate (15/26)	Data governance programs
Security & Privacy	Sensitive data exposure risk	Moderate (14/26)	Permissioned blockchain use
Cost & ROI	High implementation cost	High (22/26)	Phased rollout & pilots
Scalability	Transaction throughput limits	Low–Moderate (10/26)	Layer-2 solutions

Theme 4: Organizational Readiness and Change Management

One constant factor consistently emerged from the participants' experiences as an organizational readiness was a primary driver of successful implementation outcomes of automation and blockchain. Results demonstrated that organizations that had taken a proactive approach to workforce reskilling, to managing change, and to cross functional coordination were reported to have experienced much more positive implementation outcomes.

The attitude to change proved to be a recurring problem, occurring at various levels in an organisation. Operational staff voiced concerns about job loss as a result of automation, resulting in in some instances deliberate delays in implementation time or sub-optimal use of systems. The Middle Management resistance can be seen in companies that saw the automation and blockchain projects as a challenge to the existing power dynamics or as a way to uncover long denied performance shortfalls.

Table 4: Organizational Readiness Factors and Their Influence on Implementation Success

Readiness Factor	Influence on Success	Participant-Cited Examples	Recommended Action
Executive leadership commitment	Strong positive	C-suite sponsorship of pilots	Appoint executive champion
Workforce digital literacy	Strong positive	Training prior to go-live	Pre-implementation upskilling
Cross-functional alignment	Moderate–strong positive	Joint IT-operations teams	Establish steering committees
Change communication	Moderate positive	Town halls, FAQs	Transparent messaging
Resistance management	Negative if unaddressed	Union consultations	Early stakeholder engagement

Theme 5: Emerging Performance Outcomes and Strategic Implications

In addition to the standalone efficiencies and transparency benefits discussed in the previous themes, participants shared a wide variety of performance benefits that are more strategic in nature stemming from the synergy of automation and blockchain. Most participants said they had seen a significant improvement in supply chain resilience after digital transformation projects, with project experts reporting that this ability is the ability they would most like to see their organizations bolstered in future. More than half said that supply chain resilience – the ability to predict, absorb and respond to disruptive events – had significantly improved since digital transformation projects. Project experts noted that this is the ability they would most wish their organizations to strengthen in the future.

Across various industries, real-time visibility facilitated by automation and blockchain integration was seen as having significantly improved their ability to detect and react to supply disruption events such

as supplier insolvencies, logistics delays and demand shocks. The COVID-19 pandemic was mentioned multiple times as a severe challenge to digitally enhanced supply chain resilience, and those companies that were more digitally mature, with better automation and blockchain capabilities, were found to be much quicker at adapting to the challenge.

Table 5: Strategic Performance Outcomes of Combined Automation and Blockchain Implementation

Performance Dimension	Pre-Implementation	Post-Implementation	Participant Attribution
Supply chain visibility	Partial / fragmented	End-to-end real-time	Blockchain + IoT integration
Disruption response time	Days to weeks	Hours to days	Automation + AI analytics
Stakeholder trust levels	Moderate	High	Blockchain transparency
Regulatory compliance	Manual, error-prone	Automated, audit-ready	Smart contracts + traceability
Overall logistics cost	Baseline	Reduced 15–30%	Automation efficiencies
Carbon footprint	Baseline	Reduced 8–18%	Route optimization + visibility

DISCUSSION:

The results of this study shed some light on the intricate, multi-layered connection between automation of supply chains, the use of blockchain technology and logistics performance in the industrial sector. The five thematic categories are grouped into a broad pattern: the digital transformation projects result in substantial performance gains in the areas of efficiency, transparency, traceability and resilience – but at the same time pose high organisational and technical hurdles that are influencing the speed and scope of the gains.

The reported efficiencies from participants for supply chain automation are quite similar to the quantitative literature. The qualitative information, however, highlights important qualifiers not apparent in the overall performance indicators. In particular, participants' accounts underscore the importance of complementary organizational investments—including reskilling employees, redesigning processes, and creating a data governance process—in getting the automation to deliver real performance gains. This finding is congruent with the TOE framework which emphasizes the importance of the organizational context as one of the key factors that moderates technology adoption outcomes (Tornatzky & Fleischer, 1990), and supports the argument of Nandi et al. (2020) that the performance benefits of digitalization depend on investment in organizational capabilities.

The findings related to the blockchain adds to the current literature in a few significant ways. The discovery that the smart contract is a process that links automation and blockchain clearly blurs the boundaries between the two technologies, which is an interesting empirical addition with far-reaching research and practice implications. The organizations that make use of the synergy of automated execution and blockchain verification can make performance outcomes that neither of the two technologies can achieve by itself. This discovery aligns with the new theory of supply chain digitalization being a process of alignment of complementary technology ecosystems, and not a single digital technology for the supply chain.

The interoperability and integration issues highlighted in Theme 3 are the most challenging issues to overcome to achieve the maximum performance benefits of automation and blockchain. From a policy and standards point of view, the discovery that blockchain platform fragmentation is in fact a re-creation of information silos is quite remarkable. Industry consortia and regulatory bodies have an important part to play in defining common data standards and interoperability protocols for the cross-

organisational applications that can be run with blockchain. Otherwise, the organizations may end up spending a lot of money to implement the change and getting only a partial improvement in performance.

The findings of the organizational readiness highlight the fact that technological capability is not sufficient and necessary for the success of SC digital transformation. Common themes that emerged across the many answers that could be "success factors" imply that the human and organizational factors of implementation should be as much a priority and a focus point as the technical factors. This view is consistent with the thrust of dynamic capabilities theory, which focuses on the reconfiguration of the organization as a way to generate competitive advantage over the long term.

CONCLUSION AND RECOMMENDATIONS:

This is a qualitative research that has explored the effects of supply chain automation and blockchain technology on logistics performance in the various industrial sectors. The study provided theoretically informed and action oriented knowledge based on the views of twenty-six seasoned practitioners in the field of supply chain and supported by secondary analysis of organizational documents.

The main findings of this study are that when suitably combined, integrated and complemented with other organizational capabilities, supply chain automation and blockchain technology are able to provide significant enhancements in terms of multiple logistics performance aspects. Automation optimizes processes, minimizes mistakes and errors, and boosts the accuracy of demand forecasting, while blockchain ensures unprecedented transparency, traceability, and trust among stakeholders. When used together, their deployment delivers synergistic effects and performance outcomes such as increased resilience, simplified compliance, and cleaner sustainability metrics – which are not possible to achieve with either technology alone.

At the same time, the study will also highlight some challenges that need to be resolved to achieve such potential performance. Technical integration complexity, blockchain platform fragmentation, high implementation costs, as well as the organizational change management requirements of digital transformation, are all significant hurdles that need careful and coordinated attention from organizational leaders, technology vendors, industry groups and policymakers.

RECOMMENDATIONS:

Industrial companies should not think about integrating supply chain automation and blockchain as separate technology initiatives, but rather as overall transformation programmes. Executive leadership should promote digital transformation initiatives and develop workforce reskilling, change management programmes, proportionate to technological change being addressed. Strategies for implementation are recommended to be in phases, starting with high value applications to build organisation capability and evidence of return on investment to ensure stakeholder commitment to the programme.

Interoperability standards and open APIs for seamless integration across the heterogeneous blockchain platform and enterprise system environments should be developed and given priority by technology providers and platform developers. The present separation of the ecosystem of the blockchain platform is a major challenge to the adoption of the entire blockchain industry and it needs to be overcome by multinational standardization efforts.

Policy makers and regulators may want to create policy that would acknowledge and allow for compliance verifications to be made with blockchain, thus reducing the amount of paperwork involved in compliance. Investment in industry consortia and standards bodies for multi-organizational governance of blockchain is also suggested.

The study's limitations can be overcome by future research with longitudinal designs that can capture the development of automation and blockchain performance outcomes over a long period of time.

Objective logistics performance measures could be used in quantitative studies that operationalized the thematic constructs identified in this research and tested them with the objective measures related to the logistics performance. Comparative research across countries would also shed light on the moderating role of institutional and regulatory environments on the performance implications of digitalization of the supply chain.

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