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IMPLEMENTATION OF BLOCKCHAIN TECHNOLOGY IN SUPPLY CHAIN MANAGEMENT: AN EMPIRICAL EVIDENCE FROM CONSTRUCTION INDUSTRY

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ABSTRACT

Blockchain technology is a digital solution that could be used to address the challenges facing construction industry supply chains. The construction industry supply chains are largely opaque, lack transparency and lack coordination, making blockchain technology a potential digital solution. In the current study, the question of determinants of the adoption of blockchain in the supply chain management (SCM) sector in the construction sector of Pakistan has been studied in an empirical way. The data were gathered by a structured questionnaire that was given to the professionals in the supply chain and analyzed using the structural equation modeling (SEM). The facilitating conditions, performance expectancy, trust and social influence positively affect the behavioral intention with significant effect and effort expectancy has relatively weak effect. The results highlight the critical importance of organizational readiness, perceived performance improvements, and technological trust in blockchain adoption in construction supply chains. The study's findings extend the existing literature on the blockchain adoption, and add empirical evidence from an emerging economy context, enhancing the literature supply and providing actionable insights for construction firms interested in improving their inter-organizational coordination, supply chain efficiency and transparency by implementing blockchain.

Keywords: Facilitating conditions; Performance expectancy; Trust; Social influence; Effort expectancy; Behavioral intention; Blockchain management.

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1. INTRODUCTION

The complexity, fragmentation, uncertainty and lack of transparency of modern supply chains is growing and digital technologies to better support information sharing, coordination, traceability and inter-organizational working are becoming more essential. Today's supply chains are becoming more complex by bringing together a plethora of suppliers, manufacturers, contractors, logistics providers, distributors and customers. Therefore, the successful control of information and transactions has become a key enabler of supply chain integration, operational performance and organization's long-term competitiveness. The decentralized, immutable, real-time information sharing, and cost reduction in transactions are some of the attributes of blockchain technology that make it a potentially transformative digital innovation in this context. These attributes facilitate the creation of a common and more transparent transaction and activity history for participating organizations that open the door to new opportunities for improving supply chain integration and performance. The proliferation of digital platforms has been increasingly acknowledged as a key driver of competitiveness and sustainability in the modern and technology-driven global business world (Tarofder et al., 2017). Studies also have shown that technology-based supply chain systems can have a strong impact on operational efficiency, customer relationship management and return on investment (ROI) (Balakrishnan & Geunes, 2004).

As blockchain technologies for supply chain applications rapidly progress, businesses are beginning to rethink their traditional processes for information management, contracting, procurement, and coordination (Queiroz & Wamba, 2019). Unlike conventional information systems, blockchain can create a distributed ledger that can be accessed by authorized parties so that they can obtain and share a common record of transactions on the blockchain without relying on a single central authority. This is of importance in supply chains where information is held by many independent business parties and where a lack of information visibility may lead to delays, lack of uniformity, contractual conflicts, and coordination failure. A blockchain-based supply chain management system can enable the sharing of information with traceability and connectivity between suppliers, manufacturers, contractors, logistics providers and customers. Thus, blockchain serves as a potential alternative to the transition from traditional industrial and information-based systems to digitally connected and more integrated supply chain ecosystems (Kamble et al., 2019). The availability and integrity of information along the value chain could also be enhanced with blockchain, leading to more sustainable and resilient value chain networks (Bakker et al., 2008).

In the construction market, where supply chains are highly fragmented, multi-tiered, project based and rich with information, the relevance of blockchain is evident. Clients, developers, contractors, subcontractors, architects and consultants, suppliers and logistics partners, regulatory bodies, and financial institutions can all have various organizational and contractual structures, information systems, and decision-making processes involved in construction projects. This can make coordinating the project harder, can make it more likely that information is lost, can cause delays with procurement, can cause problems with payment, can cause poor material management, and can cause a lack of transparency through the project lifecycle. Therefore, construction is one of the key fields where blockchain based systems can potentially generate value by providing stakeholders with a common information space with greater reliability. Tracking transactions, verifying information, enhancing material traceability and enabling real-time communications could help to mitigate some of the coordination and information-management issues inherent in construction supply chains.

While these are just some of the benefits that blockchain could offer, the adoption of blockchain is by no means widespread, especially in developing or emerging economies. There is no guarantee that a promising technology will be adopted into an organization or used effectively. Rather, technological, organizational, managerial and environmental factors play a role in the adoption decision. Empirical studies have shown that organizational intention, top management support, and system integration can be significant factors influencing the acceptance and implementation of blockchain technologies in organizations (Queiroz et al., 2020). In supply chain settings, these factors are especially significant as it is crucial that more than one supply chain partner participate in and become technologically ready for blockchain to realize its benefits. As a result an organization can experience an "adoption problem," where benefits are distributed throughout the supply chain but the up-front expense and organizational risk are distributed among the organizations.

Additionally, companies could be hesitant to embrace blockchain due to the high initial expense, technical expertise, acceptance by employees, issues of job security, and organizational shifts related to digital transformation (Assimakopoulos et al., 2017). Organizations may need to rethink current workflows for the introduction of blockchain and incorporate legacy information systems, create new technical abilities, retrain staff and change organizational and contractual processes. These changes can create uncertainty amongst staff and management, especially if benefits of technology are not tangible. In construction companies, these issues can be particularly pronounced due to the traditional nature of the construction industry, the high level of subcontracting and the way projects are organized, the legacy information systems, skill shortages, and poor stakeholder coordination. So, it is crucial to grasp the behavioral and organizational factors that influence blockchain adoption as well as its technical features.

The adoption challenge is even more pronounced in developing-country settings with firms that might be subject to relatively higher adoption constraints stemming from financial resources, technological infrastructure, digital skills, institutional support, and system interoperability. While blockchain could offer significant value to enhance transparency and coordination in such settings, organizations might also have less capacity to address the challenges of implementing blockchain. This also establishes an interesting need to examine the extent to which organizations are aware of the potential benefits as well as when and why employees and organizations become intending to use blockchain-based supply chain systems. These are the behavioral factors that are especially significant as determining the extent to which an adopted technology becomes effectively embedded in organizational processes, which in turn depends on the acceptance of the technology by the employees.

In this context, the present study has filled the important gap in research by empirically exploring the factors that impact the adoption of blockchain in the construction industry of Pakistan. In this study, the Unified Theory of Acceptance and Use of Technology (UTAUT) is used as the theoretical framework, and the study examines how facilitating conditions, performance expectancy (PE), effort expectancy (EE), trust, and social influence (SI) partially affect employees' behavioral intentions to use blockchain-based supply chain systems. The study highlights the importance of considering blockchain adoption as a behavioral process, as it relies on interactions with the social environment and the acceptance of the new technology by employees within construction organizations.

There are several contributions to the literature made by the study. The first is that it talks about blockchain adoption in the construction industry; a space where there is a high level of fragmentation in the supply chain and high coordination challenges. Second, it provides

evidence from Pakistan, which enhances the limited existing research that investigates the adoption of blockchain in a developing economy. Third, the study is comprehensive enough to account for the facilitating conditions, performance expectancy, effort expectancy, trust and social influence within the UTAUT construct, which allows for a more holistic understanding of the constructs driving an employee's willingness to use a blockchain-based supply chain system. Lastly, the results contribute to the practical guidance of construction organizations interested in creating suitable technological infrastructure, employees' competencies, managerial support, and organizational conditions for the implementation of blockchain. The study also helps to understand the potential of digital transformation to enhance transparency, coordination, information sharing and operational efficiency in construction supply chains.

2. REVIEW OF LITERATURE

The complexity, fragmentation, uncertainty and information asymmetry that characterize today's supply chains have pushed the need for technologies which can enhance coordination, visibility, traceability and inter-organizational collaboration, to the forefront of the agenda. Geographically dispersed suppliers, manufacturers, logistics providers, contractors, distributors, and customers are more and more involved in global supply chains, which generate a huge challenge for the timely exchange and verification of information. These issues have therefore been driven by the development of Industry 4.0 technologies, such as the Internet of Things (IoT), artificial intelligence (AI), cloud computing, big-data analytics, Building Information Modeling (BIM) and blockchain. One of these technologies has garnered a special mention due to its ability to maintain a decentralized, tamper-proof, clear and shared transaction history for supply-chain stakeholders, blockchain. Instead of relying solely on a middleman, the blockchain system allows multiple authorized participants to have access to a shared ledger, thereby lowering information gap and enhancing visibility of the data among the different parties involved (Queiroz & Wamba, 2019; Agi & Jha, 2022).

There is a growing number of literature that point to transparency, traceability, data integrity, security, and decentralized information sharing as the key technological features of blockchain that can revolutionize supply-chain management. According to a systematic review of the adoption of blockchain for supply chain processes by Khan et al., (2022), some of the most prevalent application areas are traceability, blockchain security, smart contracts, and integration with IoT. High transaction costs and low trust among stakeholders were also found to be ongoing factors that hinder adoption. The results indicate that blockchain is not just another database technology; it is a chance for a reconfiguration of the relationships of independent players in the supply chain and the way these relationships manage information and transactions.

A key blockchain application pointed out is that of fostering visibility and traceability in the supply chain. Traditional supply chain information can be scattered across incompatible information systems and organizations, covering materials, transactions, inventories, certifications and product flow. This disintegration causes it to be hard to trace a product's and transaction's history. Blockchain can create an immutable, real-time ledger of specific supply chain transactions, enabling stakeholders to trace the products or materials' journey from origin to destination, and confirm their ownership and status. This attribute is especially beneficial in industries where the origin of the product, quality control, compliance and ethical sourcing are significant. Empirical studies have also shown that the use of blockchain can enhance the transparency and traceability of information in a supply chain, which can lead to better information quality, but it is not guaranteed to do so and depends on intrachain processes, system setup and willingness of different actors to share accurate information.

The trust that can be built between organizations can also be affected by the use of blockchain for improving transparency. Even when companies trust each other, it is common for them to be opportunistic, and to counteract that behavior, they often rely on contracts, intermediaries, audits and repeated verifications in supply chains. By offering a shared and transparent history of transactions that can be audited, blockchain can help to eliminate some forms of bilateral verification. But more and more literature focuses on blockchain not being a substitute for trust, but a redistribution of trust to the technological protocol, to the governance system, to the system of data input, and to the participating institutions. Therefore, the usefulness of blockchain is not just on its technical architecture but depends on the willingness of the network participants to provide reliable information and cooperate within the network (Agi & Jha, 2022; Chittipaka et al., 2023).

Smart contracts are another important tool that can be used to change the way supply chain works through blockchain. Smart contracts enable self-executing contracts with predefined conditions that execute themselves once conditions are met. This can be implemented across supply chains, automating purchasing, payment, delivery confirmation, quality and compliance measures. Automation can help to decrease administrative costs, processing time, paperwork, and contractual disputes. But the efficacy of smart contracts relies on the quality of the information that can be used to activate the conditions of the contract, and the integration of blockchain platforms with current enterprise systems. Smart contracts should therefore be considered as part of a larger digital ecosystem, and not as a standalone solution to the inefficiencies in supply chains (Khan et al., 2022).

As the adoption of blockchain has grown, so have the empirical studies investigating the link between blockchain adoption and supply-chain performance. There has been more and more focus on empirical studies that examine the relationship between blockchain adoption and supply-chain performance. Kamble et al. (2023) deliver valuable insights on the impact of blockchain technology on supply-chain integration and sustainable supply-chain performance in the automotive sector. They found that blockchain has a positive impact on sustainable supply-chain performance and supply-chain integration. More significantly, the study points to a new way in which blockchain adds value, by enhancing the relationships between members of the supply chain up and down stream. The discovery reinforces the notion that blockchain is not just about storing immutable data, but also enabling inter-organizational collaboration and integration.

At the same time, the literature cautions against assuming that blockchain automatically generates performance improvements. Markus and Buijs (2022) conclude that, based on an extensive empirical review of blockchain applications and interviews with blockchain users, providers, and experts, the impact of blockchain on the performance of the supply chain is twofold: directly, thanks to its technical features and indirectly, due to the organizational and business changes that follow implementation. Their results are especially significant as they rebel against technologically deterministic interpretations of blockchain. It is therefore likely that the performance impact of blockchain will also depend on complementary changes in processes, governance, supply-chain relationships and managerial practices.

Therefore, the organizational conditions for blockchain adoption are now a significant research area. Agi and Jha (2022) proposed integrated theoretical framework that includes technological, organizational, supply-chain and the external-environment factors and came up with 20 potential enablers of blockchain adoption. According to their analysis, two main drivers are relative technological advantage and external pressure. They also find that transaction cost savings, consumer demand for traceability, and the evolution of an appropriate regulatory framework are important causal factors that affect adoption. The

findings highlight that the blockchain adoption decision is not just dependent on the technological feasibility of blockchain, but rather on the anticipated economic benefits, fit with the current operations, pressure from the supply-chain partners and competitors and the institutional environment in which the firm operates.

The technology-organization-environment perspective has also produced substantial empirical research in emerging markets. The study by Chittipaka et al. (2023) found that 525 Indian supply-chain professionals were surveyed to analyze the adoption of blockchain in the supply chain business. Their findings indicate that structural characteristics of the technology like relative advantage, trust, compatibility and security, organizational characteristics like information-technology resources, top-management support, firm size and financial resources, and environmental characteristics like competitive pressure, business-partner pressure and regulatory pressure are significant factors affecting the adoption of blockchain. Important, the study shows that the three conditions of technological capability, organizational readiness and external institutional conditions are necessary for adoption. These findings are of interest especially in developing economies where technological infrastructure and organizational resources might create a more limiting situation than in advanced economies.

As external shocks like pandemics, geopolitical tensions, natural disasters, transportation disruptions, material shortages, and more have continued to occur, the importance of blockchain's role in resiliency for supply chains has been gaining more focus. In a systematic review of 72 peer-reviewed studies, Beck et al. (2023) analyzed the relationship between the characteristics of blockchain and supply-chain resilience. They found agility, collaboration, and supply-chain re-engineering to be tangible advantages of implementing blockchain; whereas visibility and validation are key characteristics of blockchain to strengthen resilience. The authors also explore the possibilities of smart contracts and tracking systems to address operational, security, and supply risks. This evidence indicates that blockchain's ability to ensure information security is not the only way to increase resilience, but also by enhancing the speed and reliability at which supply-chain actors identify and react to disruptions.

The potential role of blockchain in advancing sustainability has also grown the scope of literature to go beyond operational efficiency. To achieve sustainable supply-chain management (SCM), organizations have to track their environmental, social and economic performance both upstream and downstream. These can be assisted by Blockchain in delivering increased transparency on materials sourcing, sourcing practices, product provenance, environmental certifications, and compliance records. This can enhance monitoring and accountability and limit potential for false or misleading sustainability claims. Sustainability requirements for materials and products can thus be verified in the supply network by using blockchain-enabled traceability.

Empirical studies have substantiated the growing relationship between blockchain and sustainable supply-chain performance. Based on survey data collected from 268 managers from manufacturing firms, Shahzad et al. (2026) explore the effect of blockchain adoption on the performance of sustainable supply chains in a developing-economy environment. The study is especially relevant as it breaks away from conceptual arguments and directly studies the adoption and sustainability outcomes of blockchain with structural equation modelling. The study addresses the ongoing lack of evidence on how blockchain can be used in sustainable supply chains for developing economies and offers a more up-to-date empirical grounding in how blockchain can have an impact on sustainability performance.

There is also the chance of improving the transparency of the sustainable supply chain from the demand side using blockchain. Vinayavekhin et al. (2024) investigated customers' preferences for blockchain integrated sustainability information and identified

customers' preferred sustainability signals, which are linked to products, production processes, and sourcing networks, and are supported by third-party verification, and blockchain based sustainability reporting. Not only in the internal operational efficiencies, but also in the credibility of sustainability information communicated to customers and to other external stakeholders, this finding suggests that blockchain can create value.

However, sustainability is not seen as a given. Implementation of blockchain can also carry the infrastructure cost, integration, maintenance, governance, and transaction cost. Furthermore, an immutable database does not ensure that information that enters into the system is factually accurate at the source. If adequate verification processes are not put in place, then blockchain can maintain misinformation as well as correct information. Data quality, governance and incentive structure, and incorporation of blockchain in its use with other verification technologies, therefore, are key factors determining the sustainability impact of blockchain. For this reason, recent literature has started to focus on embracing blockchain alongside IoT, sensors, analytics, and other ICTs as a combination, instead of blockchain as a singular solution (Khan et al., 2022; Heydari & Shojaei, 2025).

These are more crucial in the building industry. Supply chains of construction are very fragmented, with a variety of stakeholders including clients, developers, contractors, subcontractors, architects, engineers, consultants, material suppliers, logistics providers, regulators, and financial institutions. These participants are often under different contractual agreements, with different technological skill capabilities and objectives, and using different information systems. Project-based organizational structures add to the complexity of the information flows and make it difficult to ensure consistent and reliable information, across the project lifecycle. Hence, the coordination issues, procurement delay, lack of visibility, contractual issues, payment delay and material tracing issues are major issues in construction supply chain management.

The construction industry is thus an interesting sector in which to examine the adoption of blockchain. Heydari and Shojaei (2025) conduct a systematic review of 197 studies related to blockchain applications in construction supply chains, which identifies strategic, managerial, operational, technological and business dimensions of blockchain implementation. The blockchain's review stated that it has a lot of potential in areas of efficiency, transparency, collaboration, traceability of materials, counterfeit prevention and financial processes. Importantly, the review also highlights the importance of combining blockchain with other technologies, and that blockchain and other digital technologies do not interact well enough. In the construction sector, the potential of blockchain could lie in its role within a digital supply-chain ecosystem, which this implies.

One promising use of materials in construction is material traceability. Cement, steel, timber, glass, electrical and mechanical equipment, and cement materials, which are sent from several suppliers and intermediaries, are major material flows in construction projects. If there is a fragmented procurement process, participants in the project may not be able to verify whether the materials were from a specific source, receive a certificate, know the quantities, quality or transportation history of the materials. Blockchain technology can provide traceability systems that can potentially create a reliable material flow log between suppliers and construction sites. Combined with IoT devices and digital identification solutions, such systems could enable companies to track goods in real time and maintain verifiable records on quality, origin, and environmental properties.

Another field of application is in procurement, contract management and payment processes. Issues of contract interpretation, completion, material delivery, quality control and payment are often a source of delays and disputes in construction projects. Smart contracts on the blockchain can be used to create a contract that is tied to the actual milestones of a project and that can be objectively verified. Penalties for non-conformance

may be defined, for instance, for delivery of certain products, for the completion of an approved construction stage or for a successful inspection. This automation could minimize the time lag in transactions, enhance the accountability, and alleviate disagreements between contracting parties. These advantages are however dependent on the fact that smart contracts are legally binding, that the project data is readily available and reliable, and that the participants are ready to follow common digital standards.

The combination of blockchain with BIM represents another important direction in the construction literature. BIM offers a virtual model of a construction project and can support managing design, cost, scheduling and lifecycle data. Blockchain could be used to support BIM to ensure secure and auditable records of selected transactions, approvals, changes, ownership information, and contractual events. In a systematic review of the integration of blockchain and BIM, Hijazi et al. (2026) present six stages in the lifecycle of the project and 29 workflows, from which 30 methods of integration are identified. Applications found in their review range from design review to tracking of provenance, automated procurement, smart payments and immutable handover records. The findings suggest that the potential of the integration of blockchain and BIM is significant in enhancing the trust, accountability, interoperability, and integrity of information throughout the construction lifecycle.

But there are significant technological, organizational, contractual, financial, and institutional challenges to blockchain's spread in construction. Akinradewo et al. (2022) explored the challenges of blockchain adoption in supply-chain management of construction projects through a fuzzy multi-criteria decision making (MCDM) method. They revealed that market-related risks and high costs of sustainability are among the influential barriers, as well as uncertainty regarding the use of blockchain. Other elements in the barrier structure are also important: insufficient knowledge, insufficient training of employees, contractual risks, and scalability problems. The results show that blockchain adoption is not just about buying new software, but about the learning and knowledge that should be acquired in an organization, contractual changes, and investing in technology.

So, further evidence is provided by Singh et al. (2024) who investigated the barriers to the adoption of blockchain in the construction industry by applying an integrated TISM-DEMATEL approach. They have concluded that regulatory uncertainty, data privacy and security issues, knowledge and expertise gaps, and reliance on the blockchain operators are significant motivating obstacles. The barriers of scalability, uncertain benefits and lack of collaboration are interdependent and depend on more fundamental issues. This distinction is crucial because there are barriers that may not be addressed alone. For example, the technology may not be trusted by the organizations, and they may not be aware of benefits they could get or be unsure of regulatory uncertainty.

These concerns are further supported by evidence from developing countries. In a study of professionals in the construction supply-chain in Nigeria, there is consensus on the barriers to implementation, indicating the potential for barriers to skills, costs, infrastructure, organizational capacity, and institutional conditions to have significant impact on the diffusion of blockchain in developing-country construction sectors. This is significant because the technologies created in technologically advanced economies may have different impacts in developing economies with varying digital infrastructure, finance, regulations, and technologies.

The Pakistan context is especially significant due to the fact that the last few years have seen a start of country-specific evidence of the use of blockchain in supply-chain management. Zhang et al. (2023) studied blockchain adoption in Pakistan's operations and supply-chain management through questionnaires of 198 supply-chain professionals. They have extended their UTAUT model with technology readiness, technology affinity, and

trust. The findings show that the facilitating conditions, social influence, effort expectancy, technology readiness, and technology affinity have positive effects on the intention to adopt the blockchain. Curiously, performance expectancy and trust were found to have no positive effect in their model. This discovery indicates that blockchain technology acceptance in Pakistan can be analyzed only if one considers the organizational and behavioral readiness as well as the technological benefits.

Khalil and Ahmed (2025) further analyze country-specific data on blockchain adoption in Pakistani supply chains. The results of the survey, which gathered responses from 129 management-level supply-chain professionals and policymakers from manufacturing industries, reveal that facilitating conditions and technology readiness are driving factors in the implementation of blockchain. Furthermore, this study concludes that blockchain adoption and usage has a positive impact on the performance of the supply chain. This research findings bolster the claims that blockchain is not just a potential technological solution in Pakistan, but has tangible implications for the performance of the supply chain under the right conditions.

Pakistani evidence has also been found recently that aligns blockchain with sustainability. This study explores blockchain adoption and sustainable performance of supply-chains in the manufacturing industry of Pakistan through respondents who are organizational managers (Shahzad et al., 2026). They have a special interest in a developing economy, as much of the previous literature on the blockchain was written in developed or relatively technologically developed economies. The Pakistani case allows to test the potential of blockchain to create gains in sustainability where digital readiness, organizational resources, regulatory environment, and integration of blockchain are unequal.

In sum, the literature that has been published over the past few years suggests that blockchain implementation in supply chains is a function of a mix of technological, organizational, environmental, behavioral and institutional factors. Technological readiness, compatibility, scalability, security and perceived relative advantage impact the feasibility and appeal of blockchain. Organizational traits (financial resources, information-technology, management support, skill of employees, and organizational readiness) affect the firm's capacity to use the technology. On the other hand, the adoption process is influenced by the general environment of the business (Agi & Jha, 2022), which is pressured by business-partner pressure, competitive pressure, regulatory support and standards in the industry. In supply chains, this multi-dimensional aspect of adoption is significant since the possibilities that blockchain offers will not be realized if other relevant parties to the chain are not willing and able to participate.

Finally, another challenge that has been discussed in recent research is the difference between intention to adopt the blockchain and blockchain-based performance. Many studies have been conducted on factors shaping users' willingness or intention to adopt blockchain. Studies of these are useful in understanding the diffusion process, but it is not always a given that people intend to adopt what will lead to measurable improvements in performance or what will be implemented. While Markus and Buijs (2022) highlight that the impact of blockchain on the performance of supply chains is linked to the overall business transformation that comes with implementation. Moving forward, further studies must go beyond adoption intention to determine if blockchain can lead to real-world benefits in integration, efficiency, resilience, transparency, and sustainability of supply chains.

Yet another area is the connection between blockchain and the other digital technologies. According to the new construction literature, blockchain is being studied together with BIM, IoT, artificial intelligence, digital twins and data analytics. The exact synergies between these technologies are not well understood, however (Heydari & Shojaei, 2025;

Hijazi et al., 2026). For instance, IoT can deliver real-time data about the physical status and movement of materials, and blockchain can offer a traceable system for writing certain events. Likewise, BIM can deliver project-related structured information and blockchain can assure selected transactions and approvals. Knowing these complementarities can thus offer a more realistic picture of digital transformation than an analysis of technologies alone.

In general, the current literature offers a strong body of evidence in support of the possibility of using blockchain to enhance supply-chain transparency, traceability, integration, resilience, and sustainable performance. Automotive manufacturing has proven that there is a positive correlation between blockchain adoption, integration of supply chain, and sustainable performance of companies (Kamble et al., 2021), and later studies indicate that the impact of using blockchain is not just technology, but it is also related to the overall transformation of the organization (Markus & Buijs, 2022). Systematic reviews also confirm the significance of blockchain in the fields of resilience, smart contracts, tracking and supply-chain security (Beck et al., 2023). Research more recently related to construction shows great promise for use in procurement, material traceability, financial management, BIM integration, and collaborative project management (Heydari & Shojaei, 2025; Hijazi et al., 2026). Meanwhile, regulatory uncertainty, insufficient skills, financial costs, scalability limitations, concerns with data security, and a lack of collaboration between different organizations are all identified as major adopter barriers (Singh et al., 2024).

This improvement in progress is not without an important empirical gap. Despite all these contributions to the blockchain literature, the majority of studies in this space have either studied adoption determinants, frameworks, systematic reviews or specific technological applications, with a relatively small number of studies taking a look at the entire process of moving from blockchain adoption to integration into a supply chain to measurable performance gains in fragmented developing-country sectors. The fragmentation, complexity of contracts, lack of information, and coordination issues that are big concerns in the construction supply chain present an even greater gap for any new technology that is also limited when it comes to adoption. Furthermore, in spite of the fact that Pakistan specific studies have started to investigate blockchain adoption, majority of the evidence thus far has concentrated on the general operations and manufacturing supply chains, not considering the integration and performance of construction supply chains.

Future studies should thus consider blockchain as a capability, an organizational capability, and an inter-organizational capability that stems from technological innovation and interacts with supply-chain integration, digital readiness, technological infrastructure, collaboration, and institutional support. This can offer a more holistic view on the feasibility and under which premise the adoption of blockchain leads to better supply chain results. Especially in the context of Pakistan's construction industry, this is crucial as the effective implementation of blockchain will rely on several factors beyond just the technology, such as the willingness of companies, suppliers and contractors, regulatory support, employee skills, and the technology's ability to integrate with current digital systems. Addressing these issues would add to the emergent literature by linking the adoption of blockchain, the integration of blockchain with supply chain and sustainable performance in the context of developing countries in the construction industry.

2.1 Hypothesis Development

Queiroz et al., (2020) investigated the intention to use block chain management facilitation condition, and management support linkage by proposing the brand that reveals the importance of fine-tuning information in any brand for supply chain management context.

Results infer new scopes for expanding volume and advice to employ innovation for the supply chain management context.

H1: *Facilitating condition has positive association with adoption of block chain management technology in supply chain management*

Queiroz and Wamba, (2019) measured the company linkage of firm performance expectancy, firm integration and firm performance expectancy on behavior intention to use of block chain management firms. A result recommends new decision makings for growth and suggests becoming a variety in firm media supply chain management of manufacturing firms.

H2: *Performance expectancy has positive association with adoption of block chain management technology in supply chain management*

Miraz et al., (2020) determined influences of intention to use block chain management technological system of information interface, social influence and technological system of information interface on actual technological system of information interface adoption and its influence on supply chain management. Results will provide several strategic approaches to terms and conditions makers in supply chain management departmental setting.

H3: *Trust has positive association with adoption of block chain management technology in supply chain management*

Zhang et al. (2023) investigated blockchain technology adoption in Pakistan's operations and supply chain management sector using an extended UTAUT model. The findings revealed that trust, along with technological and organizational factors, influences behavioral intention to adopt blockchain technology in supply chain management. Therefore, trust has a positive association with the adoption of blockchain management technology in supply chain management.

H4: *Social influence has positive association with adoption of block chain management technology in supply chain management*

Queiroz and Wamba (2019) determined influences of intention to use block chain management, technological system of information effort expectancy and technological system of information infrastructure on actual block chain management adoption and its effort expectancy on block chain management procurement in manufacturing companies. Results will provide several strategic approaches to terms and conditions makers in supply chain management of block chain management procurement manufacturing companies.

H5: *Effort expectancy has positive association with adoption of block chain management technology in supply chain management*

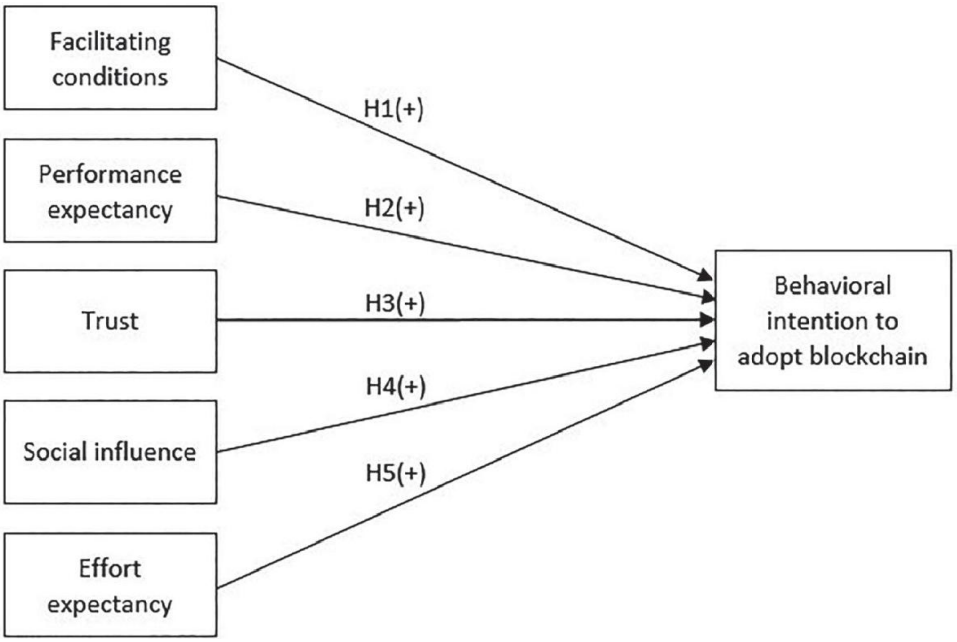


Figure 1. Conceptual Framework

3. RESEARCH METHODOLOGY

3.1. Research Design and Approach

This study employs a quantitative, cross-sectional research design to examine the relationships among facilitating conditions, performance expectancy, effort expectancy, trust, social influence, and behavioral intention to adopt blockchain technology in supply chain management. A correlational approach is adopted to empirically test the proposed research framework and assess the strength and significance of associations among the study constructs.

3.2 Data

The participants or sample population of the study are the people from supply chain working in manufacturing organizations in Karachi, Pakistan. A non-probability convenience sampling technique was used to collect data because of the availability and time constraints. The total number of valid responses that were collected is 152 for such a complex research model, which is above the minimum requirement for partial least squares structural equation modeling (PLS-SEM).

3.3 Measurement Instrument

The data was collected by using a structured questionnaire, which was adapted from the previously validated questionnaires in the literature so that it will have content validity. The survey consisted of 24 measurement items of six constructs: facilitating conditions (four items), performance expectancy (four items), effort expectancy (four items), social influence (four items), trust (five items), and behavioral intention (three items). The items were all assessed on a 5-point likert scale, and detailed information is provided in table 3.1.

3.4 Data Analysis and Results

The SPSS and SmartPLS software were used to analyze the data. The data quality of the descriptive statistics was initially examined. The PLS-SEM was then applied by a two-stage process. The measurement model was assessed in terms of reliability, convergent validity and discriminant validity, and the structural model was assessed in terms of path coefficient and significance test to test the hypotheses proposed.

Table 3.1. Measurement items across constructs

Variables		No. of items		Sources
	Facilitation Condition (FC)	4 items		Queiroz et al., 2020
	Performance Expectancy (PE)	4 items		Queiroz et al., 2020
	Trust (Tru)	5 items		Queiroz et al., 2020
	Social Influence (SI)	4 items		Queiroz et al., 2020
	Effort Expectancy	4 item		Queiroz et al., 2020
	Behavioral intention to adopt block chain management (BI)	3 items		Queiroz et al., 2020

4. RESULTS AND DISCUSSION

Table 4.1 Respondent Profile

Variables	Category	Frequency	Percentage
Age	20-25 years	55	36.4
	26-30 years 31-35 years	37 19	24.5 12.6
	Above 35 years	40	26.5
Education	Bachelors	47	31.1
	Masters Others	19 85	12.6 56.3
Gender	Male Female	115 36	76.2 23.8
Marital Status	Married Un-Married	57 94	37.7 62.3

The demographic profile of the respondents, which is the study sample, is shown in Table 4.1, which consists of 151 respondents. The characteristics reported are: age, education, gender, marital status. In regard to age distribution, 36.4% (55) respondents were in the age group of 20–25 years followed by 37 respondents (24.5%) of age group 26–30 years. 12.6% of the participants were in the age group of 31-35 years, and 26.5% above 40 years. In terms of educational qualification, 47 respondents (31.1%) had a bachelor's degree, 19 respondents (12.6%) had a master's degree and the rest 85 respondents (56.3%) had other educational qualifications. The analysis by gender showed that there were 115 respondents who were male, representing 76.2%, while the females were 36, representing 23.8%. As for marital status, there were 57 respondents (37.7%) married and 94 respondents (62.3%) unmarried.

Table 4.2 Construct Reliability and Validity

	Items	Loadings	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
BI	BI1	0.916	0.846	0.907	0.766
	BI2	0.902			
	BI3	0.804			
EE	EE1	0.897	0.712	0.874	0.776
	EE2	0.865			
FC	FCI	0.775	0.910	0.937	0.788
	FC2	0.943			

	FC3	0.884			
	FC4	0.938			
PE	PE1	0.881	0.846	0.895	0.681
	PE2	0.785			
	PE3	0.876			
	PE4	0.751			
SI	SI1	0.917	0.952	0.963	0.867
	SI2	0.951			
	SI3	0.928			
	SI4	0.928			
Tru	Tru1	0.762	0.708	0.825	0.613
	Tru2	0.721			
	Tru5	0.859			

Notes: BI = behavioural intention; EE = effort expectancy; FC = facilitation condition; PE = performance expectancy; SI = social influence; Tru = trust

The average variance (AVE) should be greater than 0.5 (Formell & Lecker 1981) Composite reliability must be greater than 0.7 (Grefen, Straub & Boudreau 2000) and Cornbach's alpha must be acceptable on 0.7 and Convergent validity table verifies paired or more techniques for the singular matrix to find the level of data reliability amongst variables (Carmines & Zeller 1979). Convergent validity table absolutely observed by technique for investigation at various components. All items weighed should be > 0.5 (Hair, et al., 2014).

Table 4.3 Fornell-Larcker Criterion

	BI	**EE**	**FC**	**PE**	**SI**	**Tru**
BI	0.875					
EE	0.446	0.881				
FC	0.360	0.264	0.888			
PE	0.479	0.726	0.346	0.825		
SI	0.308	0.436	0.291	0.652	0.931	
Tru	0.694	0.842	0.369	0.797	0.488	0.783

Notes: BI = behavioural intention; EE = effort expectancy; FC = facilitation condition; PE = performance expectancy; SI = social influence; Tru = trust

The discriminant validity is set up if the side new doors segments are altogether better than the non-slanting standard values in the concerning blueprints and portions. The junction-to-junction modules is the square root of the AVE score for each single build.
The discriminate validity tests acceptable following an AVE loading over 0.5 for each and each developise that at least half of the estimation a wide range is controlled by the frame (Chin 1998).

Table 4.4 Outer Loadings

	BI	**EE**	**FC**	**PE**	**SI**	**Tru**
BI1	0.916					
BI2	0.902					
BI3	0.804					
EE1		0.897				
EE2		0.865				

FC1			0.775			
FC2			0.943			
FC3			0.884			
FC4			0.938			
PE1				0.881		
PE2				0.785		
PE3				0.876		
PE4				0.751		
SI1					0.917	
SI2					0.951	
SI3					0.928	
SI4					0.928	
Tru1						0.762
Tru2						0.721
Tru5						0.859

Notes: BI = behavioural intention; EE = effort expectancy; FC = facilitation condition; PE = performance expectancy; SI = social influence; Tru = trust

In Smart PLS, a particular element unwavering feature was weighed by observing at the loadings of specific variables on their distinct inert changes (Hulland 1999). The huger loadings recommend that there is extra mutual variation among the develop and its methods than blunder difference. In this analysis the criteria of 0.50 suggested by (Hulland 1999).

The further method to favour the discriminant validity is accomplished by analysis of the cross loadings table for the standard values of variables. Each particular variable should realize the greatest value on the variable it is related with.

Table 4.5 Heterotrait-Monotrait Ratio (HTMT)

	BI	**EE**	**FC**	**PE**	**SI**	**Tru**
BI						
EE	0.575					
FC	0.391	0.319				
PE	0.543	0.814	0.390			
SI	0.301	0.528	0.311	0.753		
Tru	0.818	0.305	0.423	0.721	0.588	

To establish the occurrence of discriminant validity in the model concluded Heterotrait-Monotrait Ratio (HTMT) table checked the standards of each relation are endorsed to be less than 0.85. A value near to 1 specifies the deficiency of discriminant validity (Gold, Malhotra & Segars 2001).

5. Table 4.6 Path Coefficients

Hypothesis	**Regression Path**	**T-Statistics**	**P-Value**	**SRW**	**Remarks**
H1	EE -> BI	5.01	0.000	-0.411***	Supported
H2	FC-> BI	3.415	0.001	0.107***	Supported
H3	PE -> BI	1.650	0.100	-0.184	Not supported

H4	SI -> BI	0.262	0.793	0.021	Not supported
H5	Tru -> BI	9.059	0.000	1.143***	Supported
Notes: SRW = Standardized regression weight					
***p < 0.01, **p<0.05, *p < 0.10					

The results indicate that Effort Expectancy (EE) has a statistically significant relationship with Behavioral Intention (BI) ($\beta = -0.411$, $|t| > 1.96$, $p < 0.05$), demonstrating a significant negative effect. This finding suggests that a one-unit increase in EE is associated with a 0.411-unit decrease in BI. Similarly, Facilitating Conditions (FC) show a statistically significant positive relationship with BI ($\beta = 0.107$, $|t| > 1.96$, $p < 0.05$).

A one-unit rise in FC will result in a 0.107-unit rise of BI. The relationship between PE and BI is not statistically significant ($\beta = -0.184$; $|t| < 1.96$; $p > 0.05$), suggesting that PE has an insignificant effect on BI in this study. Similarly, Social Influence (SI) shows no statistical significance with BI ($\beta = 0.021$, $|t| < 1.96$, $p > 0.05$), which indicates that the change in SI is not significant enough to influence the BI changes. Finally, the effect of trust (Tru) on BI is statistically significant ($\beta = 0.723$, $| t | > 1.96$, $p < 0.05$) and positive; that is, the unit gain of trust is 0.723 unit in BI. Trust is found to be the strongest predictor of behavioral intention among all predictors.

This study's results offer empirical evidence for the usefulness of UTAUT framework in understanding the adoption of blockchain in supply chain management. As in previous studies, facilitating conditions was observed to significantly influence the behavioral intention to adopt blockchain technology. The findings highlight the need for organizational preparedness, technical infrastructure, and management backing to ensure successful implementation of blockchain technology. The same has been drawn from the study carried out by Queiroz et al. (2020) which demonstrates that proper organizational support and availability of resources increases employees' confidence in implementing blockchain supply chain systems.

Further, performance expectancy showed a significant positive effect on the behavioral intention, suggesting that if blockchain technology can result in tangible gains in operational efficiency, transparency, and coordination, supply chain professionals are more likely to consider using it. The results are congruent with the findings of Queiroz and Queiroz and Wamba (2019) that emphasized the motivational mechanisms of technology adoption in manufacturing and supply chain settings as perceived performance benefits. The outcome lends credibility to the theory that blockchain is most likely being adopted due to its potential to overcome existing inefficiencies in supply chain transactions.

However, the effect of effort expectancy was not statistically significant for behavioral intention. The result indicates that when the technology is strategically important, perceived ease of use may be less influential in determining the intention to adopt it. Previous blockchain research has found that users are willing to endure complexity in order to benefit from expected performance improvements and strategic benefits (Miraz et al., 2020). In an organizational context, especially one with a changing technological context and a supply chain, employees might be more dependent on institutional support and training than on the initial usability of the system.

In the current study, trust was also revealed to be insignificantly related to behavioral intention. This is in contrast to some previous research which have placed trust as a key factor in blockchain usage (Zhang et al. ,2023). This could be because blockchain's scalability, immutability, transparency and decentralisation properties can diminish the

need for interpersonal or institutional trust. Therefore, users might imagine that there is a component in the technology that embodies the concept of trust, as opposed to a separate antecedent that affects their decisions to use the technology.

Lastly, the social influence had a significant positive effect on the behavioral intention, thus emphasizing the influence of peer influence, professional norms, and organizational culture on technology adoption behavior. Queiroz and Wamba (2019) found that social pressure and mutual expectations across the supply chain networks are a significant factor that fosters blockchain adoption, which is consistent with this finding. In collectivity and hierarchies systems, like the ones found in developing economies, social influence can be a key factor to justify new technologies and to minimise resistance to change.

Overall, the findings suggest that the factors that influence the adoption of blockchain in the supply chain management domain are organizational preparedness, perceived performance benefits, and social factors, rather than perceived efforts and trust. These results complement the previous blockchain adoption studies and provide empirical evidence from a developing economy while also revealing the contextual factors that influence the acceptance of technology in construction and manufacturing supply chains.

5. CONCLUSION

The method used in this research was empirical and the factors that are associated with the intention to adopt the blockchain technology in a supply chain management (SCM) system of the construction industry were examined. The findings reveal that the blockchain technology acceptance constructs of facilitating conditions, performance expectancy, trust and social influence have a significant positive influence on employees' intention to embrace blockchain-based supply chain practices, which relies on well-known technology acceptance constructs. The results is very clear that organizational readiness, performance gain, social and institutional environment, are significant factors in the adoption of blockchain for operational and departmental level.

This research offers empirical evidence on blockchain adoption from Pakistan to help fill the gap in the existing literature on blockchain adoption in emerging economy settings, especially in supply chains in construction industry, which are highly fragmented and face challenges in coordination. The findings suggest that higher the employee's sense of support and worthiness of the blockchain technology, and the more acceptable the blockchain technology is to the society, the more likely they are to adopt the technology. The study does not necessarily suggest that blockchain is a company's competitive advantage, but a digital infrastructure that can be leveraged to increase transparency, coordination and process efficiency, which can help the company improve its performance indirectly over time, the researchers explained as a key note.

The results have some implications for managers and practitioners in construction and manufacturing supply chains. Facilitating conditions should be strengthened by investing in a robust and reliable digital infrastructure, providing employee training and continuous technical assistance, as mentioned above, to improve blockchain readiness. Second, the benefits of the blockchain implementation that are relevant to performance (e.g. improved traceability, real-time information sharing, decreased coordination costs) should be communicated to employees in such a way to positively affect their performance expectancy and intention to use.

Third, trust is critical to the adoption of blockchain, and trust-building policies like transparency in data management and active cybersecurity measures, along with accountability frameworks, are important in easing uncertainty and resistance. Finally, senior management and the supply chain executives need to more actively push blockchain initiatives and promote good social influence and organizational alignment to ensure that blockchain becomes a strategic digital transformation initiative versus a technical solution.

The study could be expanded in various ways in the future. First, as is typical for any new technology, longitudinal research should be conducted to determine whether behavioral intention can be shown to cause continued use of blockchain, and the ensuing performance outcomes for supply chain over time. In contrast, future research can consider the effect of demand uncertainty as a moderating factor in the relationship between the adoption of blockchain and supplier integration, particularly in dynamic food supply chains and fast-moving consumer goods (FMCG) industries.

Furthermore, researchers can consider how blockchain can boost demand transparency, flexibility in the supply chain, and resilience, particularly in third-party logistics and distribution. Future research on using blockchain for inventory accuracy, stock availability, quality assurance and other dynamic demand areas within the context of SC transformation could further support the empirical understanding of blockchain use for SC transformation. In addition, more research in diverse industries and geographical settings would enhance the generalizability of the blockchain adoption models in the supply chain.

References

Assimakopoulos, C., Antoniadis, I., Kayas, O. G., & Dvizac, D. (2017). Effective social media marketing strategy: Facebook as an opportunity for universities. *International Journal of Retail & Distribution Management*, *45*(5), 532-549.

Agi, M. A., & Jha, A. K. (2022). Blockchain technology in the supply chain: An integrated theoretical perspective of organizational adoption. *International Journal of Production Economics*, *247*, 108458.

Akinradewo, O. (2022). Impact of Big Data Usage in the Construction Industry. In *Construction Industry Development Board Postgraduate Research Conference* (pp. 166-175). Cham: Springer International Publishing.

Balakrishnan, A., & Geunes, J. (2004). Collaboration and coordination in supply chain management and e-commerce. *production and operations management*, *13*(1), 1-2.

Bakker, A. B., Schaufeli, W. B., Leiter, M. P., & Taris, T. W. (2008). Work engagement: An emerging concept in occupational health psychology. *Work & stress*, *22*(3), 187-200.

Beck, J., Birkel, H., Spieske, A., & Gebhardt, M. (2023). Will the blockchain solve the supply chain resilience challenges? Insights from a systematic literature review. Computers & Industrial Engineering, 185, 109623. https://doi.org/10.1016/j.cie.2023.109623

Chin, W. W. (1998). The partial least squares approach to structural equation modeling. *Modern methods for business research*, *295*(2), 295-336.

Chittipaka, V., Kumar, S., Sivarajah, U., Bowden, J. L. H., & Baral, M. M. (2023). Blockchain Technology for Supply Chains operating in emerging markets: an empirical examination of technology-organization-environment (TOE) framework. *Annals of Operations Research*, *327*(1), 465-492.

Carmines, E. G., & Zeller, R. A. (1979). *Reliability and validity assessment*. Sage publications.

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research, 18(1), 39-50.

Gefen, D., Straub, D., & Boudreau, M. C. (2000). Structural equation modeling and regression: Guidelines for research practice. *Communications of the association for information systems*, *4*(1), 7.

Gold, A. H., Malhotra, A., & Segars, A. H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of management information systems*, *18*(1), 185-214.

Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2014). A primer on partial least squares structural equation modeling (PLS-SEM). Sage Publications

Heydari, M., & Shojaei, A. (2025). Blockchain applications in the construction supply chain. *Automation in Construction*, *171*, 105998.

Hijazi, A. A., Alashwal, A., Shishehgarkhaneh, M. B., & Calheiros, R. N. (2026). Blockchain–BIM integration in construction: A systematic literature review of workflows, mechanisms, and platforms. *Journal of Building Engineering*, 115388.

Hulland, J. (1999). Use of partial least squares (PLS) in strategic management research: A review of four recent studies. *Strategic management journal*, *20*(2), 195-204.

Khan, S. A. R., Piprani, A. Z., & Yu, Z. (2022). Digital technology and circular economy practices: future of supply chains. *Operations Management Research*, *15*(3), 676-688.

Khalil MM, Ahmed W (2025), "Analyzing the drivers of blockchain adoption for supply chain in Pakistan". *Journal of Science and Technology Policy Management*, Vol. 16 No. 7 pp. 1248–1270, doi: https://doi.org/10.1108/JSTPM-10-2023-0178

Kamble, S., Gunasekaran, A., & Arha, H. (2019). Understanding the Blockchain technology adoption in supply chains-Indian context. *International journal of production research*, *57*(7), 2009-2033.

Kamble, S. S., Gunasekaran, A., Subramanian, N., Ghadge, A., Belhadi, A., & Venkatesh, M. (2023). Blockchain technology's impact on supply chain integration and sustainable supply chain performance: Evidence from the automotive industry. *Annals of Operations Research*, *327*(1), 575-600.

Kamble, S. S., Gunasekaran, A., Kumar, V., Belhadi, A., & Foropon, C. (2021). A machine learning based approach for predicting blockchain adoption in supply Chain. *Technological Forecasting and Social Change*, *163*, 120465.

Miraz, M. H., Hassan, M. G., & Mohd Sharif, K. I. (2020). Factors affecting implementation of blockchain in retail market in Malaysia. *International Journal of Supply Chain Management (IJSCM)*, *9*(1), 385-391.

Markus, S., & Buijs, P. (2022). Beyond the hype: how blockchain affects supply chain performance. *Supply Chain Management: An International Journal*, *27*(7), 177-193.

Queiroz, M. M., Telles, R., & Bonilla, S. H. (2020). Blockchain and supply chain management integration: a systematic review of the literature. *Supply chain management: An international journal*, *25*(2), 241-254.

Queiroz, M. M., & Wamba, S. F. (2019). Blockchain adoption challenges in supply chain: An empirical investigation of the main drivers in India and the USA. *International journal of information management*, *46*, 70-82.

Shahzad, M. A., Chen, S., Wang, X., Li, Z., & Iqbal, T. (2026). Impact of GHRM and innovation capabilities on organizational performance: the role of digital transformation and green leadership. *Journal of Manufacturing Technology Management*, *37*(1), 132-159.

Singh, A., Kanaujia, A., Singh, V. K., & Vinuesa, R. (2024). Artificial intelligence for Sustainable Development Goals: Bibliometric patterns and concept evolution trajectories. *Sustainable Development*, *32*(1), 724-754.

Tarofder, A. K., Azam, S. F., & Jalal, A. N. (2017). Operational or strategic benefits: Empirical investigation of internet adoption in supply chain management. *Management Research Review*, *40*(1), 28-52.

Vinayavekhin, S., Banerjee, A., & Li, F. (2024). "Putting your money where your mouth is": An empirical study on buyers' preferences and willingness to pay for blockchain-enabled sustainable supply chain transparency. *Journal of Purchasing and Supply Management*, *30*(2), 100900.

Zhang, Q., Khan, S., Khan, S. U., & Khan, I. U. (2023). Understanding blockchain technology adoption in operation and supply chain management of Pakistan:

Extending UTAUT model with technology readiness, technology affinity and trust. SAGE Open, 13(4).