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IMPROVING SUPPLY CHAIN COLLABORATION AND PERFORMANCE BY USING BLOCKCHAIN TECHNOLOGY

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ABSTRACT

In the current digital-driven supply chain environment, blockchain technology application (BTA) has been introduced as an influential instrument to strengthen inter-firm cooperation and operational efficiency. This paper reviews how blockchain applications, such as transparency (TRNS), immutability (IMM) and smart contracts (SMRT), can improve supply chain performance (SCP) both directly and via supply chain collaboration (SCC). Data were gathered with a quantitative cross-sectional design involving 241 U.S. supply chain professionals and analysed using AMOS-SEM. Findings indicated high positive impacts of TRNS (β= 0.52) and IMM (β = 0.62) on collaboration, while SMRT show a moderating impact (β= 0.45). Furthermore, the results showed that SCC substantially enhances SCP (β= 0.46), and mediation analyses verified the existence of partial mediation in all three relationships (indirect effects = 0.16, 0.17, and 0.13). The findings show that BTA not only improves performance by increasing operational efficiency but also by reinforcing relationships and collaboration. Future research should enhance this research by investigating patterns of long-term adoption, incorporating dimensions of AI/IoT, and analysing and comparing supply chains backed by blockchain across industries or regions.

KEYWORDS: Blockchain Application Technology (BTA), Supply Chain Collaboration (SCC), Supply Chain Performance (SCP), Information Immutability, Smart Contract, Transparency.

1. INTRODUCTION

In a globalized world today, manufacturing companies have found themselves in a highly competitive and unstable environment where customers are demanding quality products at reduced prices and at shorter delivery times. These pressures push companies to enhance operational effectiveness and implement new approaches that facilitate a long-term competitive strength (Xu et al., 2023). Supply chain collaboration (SCC) is one of these strategies, as it allows companies to combine their resources, information exchange, and organize activities across organizational boundaries (Akhavan & Philsoophian, 2023).

According to previous research, SCC is a dynamic capability that increases responsiveness, customer service efficiency, and overall competitiveness of the supply chain. Nevertheless, regardless of its acknowledged significance, the process of building up and maintaining a collaboration is complicated due to the trust, risks of information sharing, and technological constraints (Nikookar et al., 2025; Olajide et al., 2023; Thakur, 2024). This is because most organizations are reluctant to share data due to fears of destructive practices and misuse, and conventional information systems lack the transparency (TRNS), trust, and information integrity to facilitate productive teamwork(Rejeb et al., 2021).

Blockchain Technology Applications (BTA) has come as a revolutionary facilitator that can enhance the level of TRNS, traceability, and trust among supply chain partners to these enduring challenges (Liu et al., 2025). The decentralized structure of BTA offers a safe system of reliable and non-manipulable data exchange (Korepin et al., 2021). These applications minimize asymmetry of information, instill confidence in partners and promote more stable collaborative decision-making in the supply chains (Vazquez Melendez et al., 2024).

Although despite its increasing potential for improving supply chain operation, there is no empirical evidence that shows how BTA enhances collaboration and optimises supply chain performance (SCP), and it has therefore become vital to know the BTA impact in optimising supply chain functioning. Available literature emphasises the advantages of blockchain-based TRNS and the significance of collaboration within a supply chain (Agrawal et al., 2023; Rejeb et al., 2021; Wu, 2025), but how BTA facilitates collaboration and performance enhancement has not yet been discussed. Specifically, the connection between BTA adoption and the performance outcomes through the mediating role of SCC has not been addressed in empirical research.

Moreover, the available studies have been conducted on Asian and European markets to explore the BTA role in supply chain (Jum'a, 2023; Kim & Shin, 2019; Yousefi & Tosarkani, 2023; Zhao et al., 2023), which creates a gap in comprehending the effects of BTA on the United States OF America (USA) manufacturing and logistics industry. This research, therefore, aimed to examine the relationship between the BTA, SCC, and SCP in the USA market to fill out the above-mentioned gaps. It is vital to fill this gap as the USA is strategically significant, and technological and performing research in this market can offer practical lessons to companies that operate over complicated and competitive networks.

The research has a theoretical contribution as it incorporates the BTA capabilities, collaborative mechanisms, and performance outcomes into one complete framework and tests the mediating role of SCC in the USA market, which has been a poorly explored area. In practice, it suggests recommendations to USA manufacturing and logistics companies to use blockchain to overcome trust and data-sharing barriers, create more resilient and efficient supply chains, and focus on investing in digital solutions that directly contribute to improving operational performance. The research utilised the quantitative approach to determine the BTA, SCC, and SCP relationship by targeting white collars USA supply chain personnel. The research determined the following research questions:

RQ1: What is the effect of blockchain technology application (BTA) on supply chain collaboration (SCC) in USA firms?

RQ2: What is the impact of applications of blockchain technology (BTA) on supply chain performance (SCP)?

RQ3: How does supply chain collaboration (SCP) mediate the relationship between blockchain technology applications (BTA) and supply chain performance (SCP)?

1.1. Theoretical Framework

The theoretical basis of the current research is based on the Resource-Based View (RBV) and the Dynamic Capabilities Theory (DCT), which jointly describe how companies can use technological resources to gain competitive advantage. RBV was initially defined by Edith Penrose in 1959 and expanded by Barney (1991), who highlights that superior performance can be due to the internal resources of a firm that are valuable, rare, inimitable, and non-substitutable (VRIN) in nature (Kumar et al., 2024; Lubis, 2022). BTA in this instance is conceptualised as a strategic digital tool that improves TRNS, data integrity and trust among supply chain partners. Through the effective use of BTA, companies will be able to minimise information asymmetry, reduce risk, and enhance collaboration throughout the supply chain, which will help them achieve a competitive advantage in operational performance, responsiveness, and overall performance (Sarfraz et al., 2023).

The Unified Theory of Acceptance and Use of Technology (UTAUT) can be incorporated into the theoretical framework of this study to elucidate the behavioural and adoption factors of blockchain technology in supply chains as indicated by Wamba et al. in their study on the dynamics between blockchain adoption determinants and supply chain performance (Wamba et al., 2020). Although the Resource-Based View (RBV) and the Dynamic Capabilities Theory (DCT) explain the ways the use of blockchain is a strategic resource that improves collaboration and performance, UTAUT is complementary to this as it explains why organisations and professionals are ready to adopt and use blockchain-based applications. In this regard, Performance Expectancy can be associated with the fact that blockchain transparency, immutability, and smart contracts enhance supply chain cooperation and performance results (Casati et al., 2024). Effort Expectancy is connected to the perceived simplicity of incorporating blockchain with the performance of upset chain systems. Social Influence implies the pressure at the industry, partners expectations, and competitive demand that promotes the adoption of blockchain by the supply chain networks. Facilitating Conditions relate to organisational preparation, digital infrastructure and IT that facilitate the successful implementation of blockchain.

Therefore, UTAUT also enhances theoretical reasoning by offering an approach to behavioural perspective to technological capability view of RBV and DCT (Wamba et al., 2020). It describes the factors that affect the adoption of blockchain with regard to user perceptions and organisational environment and subsequently lead to an increase in collaboration among the supply chain and ultimate performance of the supply chain. The incorporation of UTAUT hence establishes a holistic model to connect the ability of technology, acceptance of technology by users and performance.

DCT, based on RBV and developed by Teece, Pisano, and Shuen in 1997, describes how firms can convert their resources into adaptive capabilities in response to fast-changing environments (Herold et al., 2023; Montreuil et al., 2021). The blockchain-enabled capabilities become dynamic when companies employ them in coordination, exchange real-time information and make collaborative decisions to solve supply chain uncertainties. In this framework, SCC serves as a significant mediating factor, being used to convert blockchain-enforced TRNS and trust into better performance outcomes (Semenova, 2024). The research presents both theoretical and practical implications to the USA manufacturing and logistical companies by empirically investigating the mediating impact of SCC and enabling the use of BTA to improve the performance of the supply chain and collaborative networks.

2. LITERATURE REVIEW

2.1 Block-Chain Technology Application (BTA)

BTA has become a revolutionary technology in various industries because it ensures TRNS, decentralisation, and data, and information immutability (IMM). Recent research points out that BTA has been immensely improving the supply chain process through the provision of tracking goods in real time and access to verified records, which mitigate the effects of fraud, increase product quality, and tighten cooperation between partners (Kholis et al., 2024). As an example, food traceability, like the IBM Food Trust, has demonstrated that BTA can trace the sources of food contamination in a short amount of time, minimising delays and enhancing the safety of consumers (Raja et al., 2025).

The use of BTA in the financial industry has been increasing at a very high rate, particularly in remittance systems and cross-border payments. According to a report by the Pakistan Crypto Council published in 2025, the government has been considering blockchain-based financial infrastructures to facilitate remittances, cut down the cost of money, and enhance the security of transactions among workers abroad (Coindesk, 2025; Pal et al., 2021). Similarly, tokenisation, in which blockchain transforms real-life assets, including real estate, commodities, and securities, into digital tokens, has been embraced by global financial institutions to ensure even more efficient and accessible investment (Martins, 2024).

In addition to the field of finance and supply chains, BTA is also contributing significantly to the sphere of healthcare and the management of digital identities. It allows patients to have secure and tamper-proof patient records, improves data-sharing among hospitals, and makes the tracking of pharmaceutical products possible to prevent counterfeit drugs (Philsoophian et al., 2022). Digital identity systems powered by BTA are used to validate academic qualifications, licenses, and personal records, thus decreasing fraud and making the authentication process easier (Bagraff et al., 2024). Despite the limitation factors like regulatory uncertainties and integration issues, recent projects and governmental attention show that blockchain is increasingly becoming a key catalyst of TRNS, efficiency and trust in the contemporary digital ecosystems (Kassen, 2022; Nahi et al., 2025; Zutshi et al., 2021).

2.2. Information Transparency (TRNS)

TRNS in blockchain-based supply chains is the ability to see through all parties involved in a supply chain in real-time, immutably, through a decentralised registry so that the involved parties can access validated transaction history, product origin, and flow without the need for intermediaries (Baranidharan & Anagha, 2025). This functionality can overcome the conventional information silos by giving one source of truth, minimising discrepancies, fraud risks, and errors and creating accountability within industries, such as manufacturing and logistics (Ali et al., 2022). Ramkumar et al (2025) indicate that TRNS can help improve traceability; an example is that a blockchain logs all supply chain actions, including sourcing, delivery, and provides an audit trail that can be used to aid compliance, quality management, and consumer confidence (Ramkumar et al., 2025).

TRNS also contributes to efficiency through the reduction of information asymmetry to support a faster decision-making process, automated compliance through smart co, and enhanced coordination between partners, which, respectively, have increased operational resilience and sustainability outcomes, i.e., less waste and ethical sourcing verification (Nwariaku et al., 2024). TRNS boosts cooperation through real-time data sharing, which creates trust among partners, minimises the withholding of information because of confirmed visibility, and promotes joint decision-making between levels of the supply chain. The analysis of 2024-2025 empirical evidence demonstrates that TRNS moderates the effects of blockchain on performance because shared data is expected to enhance responsiveness and reduce transaction costs, but such issues as integration with legacy systems remain (Liu et al., 2025). Based on the above discussion, this research analysed the following hypothesis:

H1: TRNS positively and significantly influences SCC in USA companies.

2.3. Data, and Information Immutability (IMM)

IMM refers to the attribute of BTA that cannot alter the records and subsequently cannot erase or alter them once they have been added to the ledger. The cryptographic hash and distributed consensus mechanisms, which ensure this IMM, are structured in a way that all the transactions are stored permanently and can be checked by all the actors of the network (Yadav et al., 2023). It has been highlighted in literature that IMM has the power to enhance the safety of data, reduce the risk of fraud, and provide dependable audit trails to all supply chain operations. Due to the connection between each block to the previous one and thus, the inability to change the past mathematically, in practice, unless the entire chain is altered, blockchain is a highly secure technology applicable in the sectors where correct recordkeeping and verification are essential (Ahmed, 2025; Nero & Sarin, 2025; Ojadi et al., 2025).

IMM maintenance is also a key contributor to intensifying supply chain cooperation and coordination. As per Raja Santhi & Muthuswamy (2022), when everyone has access to one and unchangeable source of truth, information asymmetry is reduced and allows partners to make more confident decisions. Studies have shown that information that cannot be changed builds confidence among the members of the supply chain because all the members will be founded on verifiable records, unlike the subjective reports or centralised databases that can be easily compromised (Raja Santhi & Muthuswamy, 2022). This TRNS minimises conflict, enhances the level of accountability and compliance in the supply chain. As a result, IMM guarantees a high degree of operational reliability, yet it will also facilitate more constructive relations as all stakeholders will be working with the proven, reliable, and consistent information (Raja Santhi & Muthuswamy, 2022). Based on the above discussion, this research analysed the following hypothesis:

H2: IMM positively and significantly influences SCC in USA companies.

2.4. Smart Contract (SMRT)

SMRT are termed a computerised contracts that operate on BTA, digital contracts, a self-executable type of contract that implements the terms and conditions upon fulfilment of specified conditions (Yadav et al., 2024). These contracts eliminate the intermediaries, reduce manual handling and provide a clear and untouched system in the management of the transactions. SMRT enable activities in the supply chains such as order placement, settlement of payment, quality assurance, and compliance assurance. Sharma et al (2024) indicate that SMRT significantly reduce the time and human error in administration because automated routine operational tasks are performed, which leads to faster and more predictable activities within the supply chain (Sharma et al., 2024). They are also decentralised, and this creates an additional advantage that all stakeholders, such as suppliers, manufacturers, logistics providers and customers, will be able to access synchronised and confirmed data and build the level of trust into the supply chain network (Yigit & Dag, 2024).

SMRT can also be critical in strengthening SCC. They facilitate real-time information exchange and automated business processes and therefore make the decision-making process more coherent and open. Using the example of fulfilling the terms of delivery, SMRT can automatically release payments, revise inventory, or inform about shipment without having to verify the deliveries with various parties (Raj et al., 2022). This automation reduces competition, speeds up business transactions and promotes a culture of teamwork where the parties involved depend on shared digital evidence rather than on personal meaning. The research also states that collaboration is made easier with SMRT, which encourages incentives and curbs opportunistic behaviour and creates an integrated digital platform in which all partners are aligned to the common good (Hunhevicz et al., 2022). Due to this, organisations that implement SMRT achieve a high rate of communication, improved quality of partnership, and execution of supply chains (Teng, 2024). Based on the above discussion, this research analysed the following hypothesis:

H3: SMRT positively and significantly influences SCC in USA companies

2.5. Supply Chain Collaboration (SCC)

Supply Chain Collaboration (SCC) is defined as the process of supply chain partners, that is, suppliers, manufacturers, distributors, and customers, working together and making joint decisions to achieve a common objective through cooperation and exchange of information and through harmonised processes. According to recent research, SCC has emerged as a fundamental competence of the contemporary supply chains because of the growing uncertainty of the world, the variability of demand, and the pressure of digitalisation (Tiwari et al., 2024). Salamah et al. (2023) found that highly collaborative supply chains are less affected by disruptions, recover more quickly, and are more responsive because collaboration makes partners work based on real-time and accurate information. SCC is thus deemed as a strategic process that promotes alignment, visibility and harmony of processes among networked partners (Salamah et al., 2023).

BTA has provided a significant contribution to the principles of SCC because it has brought the elements of trust, TRNS, and verification of data into the collaborative processes. TRNS in information allows partners to share one version of the truth, minimise conflicts, and facilitate more realistic joint planning (Omar et al., 2021). Shamsuzzoha et al. (2025) established that collaboration tools that include BTA can be used to achieve synchronised forecasting, coordinated inventory, and shared visibility of logistics processes (Shamsuzzoha et al., 2025). Similarly, Kamble et al. (2023) note that the unalterable data records of a BTA decrease relational risks that are typically inherent in inter-firm collaboration, including opportunism and information distortion. Consequently, BTA is not only beneficial in facilitating operational collaboration but also in strengthening strategic partnerships because of the increased credibility and efficiency in communication (Kamble et al., 2023).

Blockchain-based SMRT and IMM are the other important consideration that makes SCC critical. SMRT are automated contracts that minimise inter-organisational workflows, reduce manual approvals, and uncertainty through the reduction of delays. According to Pu and Qiao (2025), SMRT helps to improve collaborative governance by making sure that all the partners follow the previously determined rules without involving intermediaries to enhance the efficiency of coordination (Pu & Qiao, 2025). SCC also relies on data IMM as one of its components because it ensures the integrity of common data, which is a requirement of trust and commitment in long-term collaborative interactions (Aslam et al., 2025). Such BTA functionalities reduce the cost of transacting with one another, increase trust in collective operations, and allow partners to cooperate more efficiently and successfully.

Regarding the wider performance outcomes, SCC has been associated with the enhancement of supply chain sustainability, flexibility, speed and competitive advantage, in general. Collaboration boosts the performance of the supply chain by streamlining resource utilisation, minimising waste, increasing the quality of services, and improving customer responsiveness (Ahmed et al., 2022). By having BTA as a digital foundation of collaborative efforts, organisations create more robust and flexible networks that could respond to disruptions and perform at a high level. Charczuk et al (2025) indicate that a company with a high SCC has much better supply chain performance since it can better coordinate the decisions, risk sharing, and end-to-end operations optimisation (Charczuk et al., 2025). Thus, based on the above discussion, this research aimed to determine the following hypotheses:

H4: SCC mediate the relationship between TRNS and SCP

H5: SCC mediates the relationship between IMM and SCP

H6: SCC mediates the relationship between SMRT and SCP

H7: SCC positively and significantly influences SCP.

2.6. Supply Chain Performance (SCP)

Supply chain Performance (SCP) refers to the effectiveness and efficiency of a supply chain to manage information, finances, and the movement of products between suppliers and the end customers. Characteristics of efficient supply chains are reliability, rapidity, cost efficiency, and provision of products with minimal or no delays and disturbances (Thekkoote, 2022). The most important dimensions that are considered to assess SCP are delivery speed, accuracy of orders, inventory turnover, flexibility of production, and customer satisfaction. Such actions can assist organisations to determine the degree of alignment of their strategic goals in their supply chain without jeopardising operational excellence (Monostori, 2021).

SCP has emerged as a significant source of competitive advantage in the contemporary and competitive global environment. The consolidated systems, real-time exchange of information and shared planning are now being used by firms to enhance the performance of procurement, production, warehousing and logistics operations (Muhammad & Saad, 2023). Effective SCP assists businesses in minimising wastage, optimising inventory, cutting lead times and also delivering at a steady performance. As the complexity of supply chains increases, occurring due to globalisation, heightened customer expectations, and technological advancement, organisations that invest in enhancing their performance are better placed to acquire resilience and long-term viability (Birhanu et al., 2022).

New technologies such as BTA, Internet of Things (IoT), Artificial Intelligence (AI), and data analytics complement each other and are transforming the concept of SCP. These technologies will result in better performance outcomes because of their real-time visibility, predictive planning, risk management, and enhanced decision-making (Alii et al., 2025). To provide some examples, Saidu et a (2025) highlight that BTA can ensure TRNS and traceability, AI may be employed to enhance demand forecasting, and IoT could be applied to enhance the tracking and control of assets and operations (Saidu et al., 2025). These technologies, together with collaborative practices and agile processes, can enable organisations to have a significant advantage in improving the supply chain performance, increasing customer value and competitive advantage in the turbulent market environments.

2.7. Conceptual Framework

The conceptual framework shown in Figure 1 demonstrates that SCC is affected using BTA, such as TRNS, data and IMM, and SMRT. In its turn, SCC is a mediator which interprets these capabilities associated with BTA into a better SCP. Basically, the model has shown the indirect impact of BTA on performance by promoting collaboration between supply chain partners.

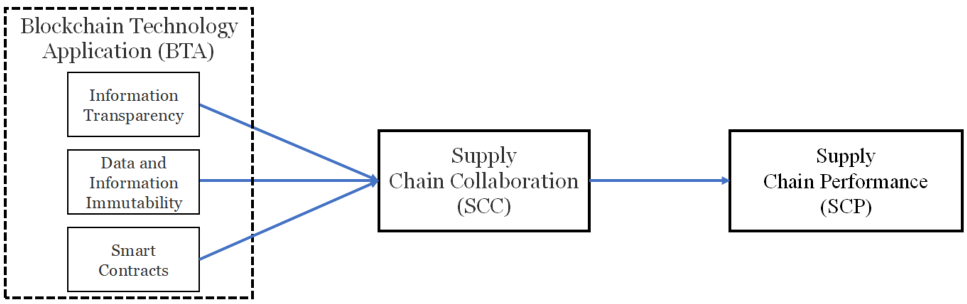

Figure 1: Conceptual Framework.

3. METHODOLOGY

3.1. Research Approach and Design

The presented research was a quantitative and cross-sectional survey to investigate the correlations between the BTA, SCC, and SCP. The quantitative approach was chosen as it provides an opportunity to test a theoretical relationship objectively and obtain statistically robust information that can be extrapolated to a large and heterogeneous sample.

Furthermore, the cross-sectional design also enabled the gathering of data at a single point in time of supply chain professionals in the USA who have an appropriate experience in the use and implementation of blockchain in supply chain operations (Ghanad, 2023).

3.2. Research Population

Supply chain practitioners in the USA were targeted in this research, which comprised managers, directors, vice presidents, and CEOs, to ensure that the information was based on real-world operational practices. The participants were recruited through a purposive sampling method based on their first-hand experience with blockchain implementation and integration in supply chains. This approach made sure that the researcher obtained the view of respondents who could offer knowledgeable opinions regarding the effect of blockchain on supply chain practices (Ahmad & Wilkins, 2025).

3.3. Sample Size and Data Collection Procedure

Data collection was carried out with the Pollfish platform, where the recruitment and quality filtering of responses could be done. Through the Pollfish 225 questionnaire was recieved. Following completeness and validity screening, 241 questionnaires were considered valid in the analysis, which constituted a 94.5% valid response rate. This sample is of adequate size to provide adequate statistical power to the analysis and diversity in the industries and organisational levels. This sample also increases the reliability and generalisation of the research results.

3.4. Instrument

The research employed a structured questionnaire as the primary tool of data collection. The tool was created based on the 5-point Likert scale, with the point scale of 1 (strongly disagree) to 5 (strongly agree), to assess the perception of respondents regarding blockchain applications, supply chain collaboration, and supply chain performance. The independent variable (BTA) was assessed through three constructs modified after Kim and Shin (2019) that are TRNS (3 items), Data (4 items), and SMRT (3 items) (Kim & Shin, 2019). The 10-item scale, which was adapted based on Afshan et al. (2018) and Fawcett et al. (2011) (Afshan et al., 2018; Cao & Zhang, 2011), was used to measure the mediating variable (SCC), whereas the measurable dependent variable (SCP) relied on a 4-item scale adapted by Zhao et al. (2023) and Beamon (1999) (Beamon, 1999; Zhao et al., 2023). Before the actual data collection, Pilot testing was run on 10% of the population, which helped in streamlining the questionnaire and making it more straightforward for the respondents.

3.5. Data Analysis Technique

The Analysis of Moment Structures (AMOS) software was used to conduct data analysis. This software helped test the measurement reliability, construct validity, and estimate path coefficients in the conceptual model. It also assessed the mediating impact of SCC between BTA and SCP, providing an influential approach to confirming the research framework (Al-Fadhali, 2024).

3.6. Ethical Considerations

The research followed the set of ethical standards. A web-based informed consent statement was given to participants that included the purpose of the study, its voluntary nature, and their right to withdraw without being penalised. No personal identifiers were taken, and data were obtained anonymously to guarantee confidentiality. All data were placed in a safe place in coded form and utilised only in academic research. The participants were reassured that their answers would not be disclosed to third parties, and thus they were guaranteed complete privacy in the research.

4. RESULTS

4.1 Demographic Analysis

Table 1: Demographic Table

DV	F (*N* = 200)	(%)
Gender		
Male	98	49.00
Female	102	51.00
Age		
20 - 29 years	19	9.50
30 - 39 years	41	20.50
40 - 49 years	42	21.00
50 - 59 years	40	20.00
60 and above	58	29.00
Educational level		
High school	48	24.00
Diploma	27	14.50
Bachelor's degree	86	43.00
Master's degree	33	16.50
Doctorate /PhD	6	3.00
Years of experience		
Below 1 year	3	1.50
1-5 years	23	11.50
6-10 years	35	17.50
11-20 years	53	26.50
Above 20 years	86	43.00
The age of your firm		
Below 5 years	17	8.50
5-10 years	23	11.50
11-15 years	28	14.00
16-20 years	29	14.50
Above 20 years	103	51.50
Firm sales		
Less than 1 million	63	31.50
1-10 million	55	27.50
10-50 million	38	19.00
50-100 million	12	6.00
Above 100 million	32	16.00

The demographic population of Table 1 show that the gender distribution is almost equal, 51% of the respondents are women, and 49% are men. The age distribution is biased towards the older age group, as 29% were 60 years and above, and 21% were aged 40-49 years, indicating that there is a large proportion of experienced professionals in the sample. Regarding education, most of the participants have a bachelor's degree (43%), and then a master's degree (16.5%), which means that the respondents are relatively well-educated. This observation can also be backed by the experience levels of the participants, where 43 per cent had over 20 years of experience, 26.5 per cent had between 11 and 20 years of experience, showing that the study involved a highly experienced workforce.

Concerning firm-related attributes, the majority of the firms (51.5%) have an operating history of above 20 years, which demonstrates the presence of a mature organisational foundation amongst the respondents. There is a diversification of firm sales, with the highest sales (31.5) producing below 1 million in sales, and the next most significant segment (27.5) is producing 1-10 million sales. This dispersion indicates that the sample has a combination of small, medium, and large businesses, and this distribution offers a representative view of the performance of organisations in terms of their sizes. On the whole, the demographic and organisational data represent a well-balanced sample in terms of age, education, experience, and firm characteristics, which can give credible information about the variables of the study.

4.2. Measurement Model

Researchers often employ post-hoc statistical methods to assess the existence of common method bias (CMB). Harman's one-factor test is a widely utilized instrument for identifying CMB issues (Podsakoff & Organ, 1986). This method has been extensively applied by scholars to input all variables into an exploratory factor analysis and then analyze the unrotated factor solution to determine the count of initial factors that account for the variance among the variables. If a single factor accounts for the majority of the covariance among the measurements (for instance, >50%), it suggests a considerable presence of CMB. The principal component analysis with varimax rotation applied to the questionnaire indicates the existence of eight distinct factors. The results from this study show that loading all values onto one factor accounts for 41.924% of the overall variance,which remains substantially under 50% (the baseline criterion for assessing CMB using Harman's single factor analysis as highlighted by Podsakoff et al., 2012). Given that several factors have emerged without any taking precedence over the overall variance, CMB is of minimal concern and is unlikely to skew the findings of this research (Podsakoff et al., 2003). Similarly, primary correlations were assessed among variables to determine if they were exaggerated (Spector, 2006). The correlations between the observable variables were kept within acceptable boundaries. This empirical data, combined with the reliability of the results, theoretical reasoning, and prior studies, indicates that any issues related to CMB can be ignored. Furthermore, the researcher considered CMV, or common method variance, which indicates the systematic variance stemming from the method of data collection (for example, a personality evaluation survey). CMV is often linked to worries that the connections between variables may be artificially intensified (Spector & Brannick, 2010). In this study, the blue color variable served as a marker variable to assess the CMV; Table 3 displays the correlation coefficients among variables both before and after the incorporation of the attitude blue. No instances of CMV were found, as there were no significant differences in the correlation coefficients pre- and post-adjustment for attitude blue, as evidenced by the figures above and below the diagonal.

4.2.1 Convergent Validity

Table No. 2: Construct Reliability and Validity

	Mean	SD	α	C.R.	A.V.E.
TRNS	3.48	0.67	0.92165	0.524618271	0.597754171
IMM	3.41	0.63	0.6748	0.848542069	0.5383764
SMRT	3.41	0.81	0.756	0.85533186	0.5441342
SCC	3.51	0.70	0.900	0.861907206	0.510844667
SCP	3.53	0.62	0.703	0.887835933	0.591215503

Note: α; alpha chronbach, C.R.; composite reliability, AVE; average variance extracted, TRNS; Information Transparency, IMM; Data and Information Immutability, SC; Smart Contracts, SCC; Supply Chain Collabration, SCP; Supply chain performance.

Table 2 shows construct reliability and convergent validity of study variables. All constructs demonstrate good internal consistency with composite reliability (C.R.) values ranging between 0.6748 (IMM) and 0.9216 (TRNS), which is above the suggested level of 0.70 (Hair et al., 2019). On the same note, the average value of extracted variance (AVE) is between 0.5108 (SCC) and 0.5978 (TRNS), exceeding the minimum threshold of 0.50, which indicates sufficient convergent validity (Fornell & Larcker, 1981). These findings indicate that both constructs are reliable to measure the underlying theoretical dimension and that they have more variance with their indicators than with error. The standard deviations of the constructs are of a relatively moderate range (3.41 to 3.53), with a standard deviation value of 0.62 to 0.81, which implies that responses are evenly distributed among the respondents. In general, the reliability and validity scores confirm that the measurement model is strong and can be further expanded with structural equation modelling.

4.2.2 Discriminatory Validity

Table 3: Discriminatory Validity

	TRNS	IMM	SMRT	SCC	SCP
TRNS	0.724305	0.698***	0.573***	0.475***	0.449***
IMM	.713***	0.73	0.595***	0.552***	0.501***
SMRT	.586***	.607***	0.74	0.535***	0.496***
SCC	.515***	.574***	.551***	0.710	0.509***
SCP	.496***	.527***	.514***	.539***	0.768905

Note: TRNS; Information Transparency, IMM; Data and Information Immutability, SC; Smart Contracts, SCC; Supply Chain Collabration, SCP; Supply chain performance. ***p < .001. **p < .01. *p < .05

The discriminant validity of the study constructs is presented in Table 3 using the Fornell-Larcker criterion. The diagonal values, the square root of the AVE of each construct, are greater than their off-diagonal correlations, suggesting that each construct has more variance with its indicators than with the other constructs. To illustrate, the square root of the AVE of TRNS (0.724) is greater than the correlation of TRNS with IMM (0.698), SMRT (0.573), SCC (0.475), and SCP (0.449). This is the same pattern as all the other constructs, which proves that the constructs are not equal. These findings reveal sufficiently strong discriminant validity and indicate that the problem of multicollinearity is not present in the measurement model (Cheung et al., 2024).

4.3. Confirmatory Factor Analysis

Table 4: Confirmatory Factor Analysis

Fit indices	Estimates	Acceptable Level
Chi-square	1438.68	
Degree of freedom (d.f)	998	
P	0.000	>0.05
Normed Chi-square (CMIN/DF)	1.44	<3.00
Goodness -of -Fit Index (GFI)	0.957	>0.90
Adjusted Goodness of Fit Index (AGFI)	0.932	>0.90
Norm Fit Index (NFI)	0.963	>0.90
Comparative Fit Index (CFI)	0.973	>0.90
Root Mean Square Error Approximate (RMSEA)	0.051	<0.08
Standardized Root Mean Square Residual (SRMR)	0.0409	<0.08

Table 4 shows the fit indices of the measurement model, which shows that the model fits well. The normed chi-square (CMIN/DF) stands at 1.44, which is significantly lower than the recommended figure of 3.0. GFI (0.957) and AGFI (0.932), NFI (0.963) and CFI (0.973) are above the widely used value of 0.90, and thus, they indicate a great fit (Legate et al., 2024). Moreover, the RMSEA (0.051) and SRMR (0.0409) satisfy the 0.08 threshold, which indicates an acceptable error in approximation (Putra & Fariz, 2022). On the whole, these indices show that the measurement model is suitable and adequate to analyse these data further.

4.4. Structural Model and Hypothesis Development

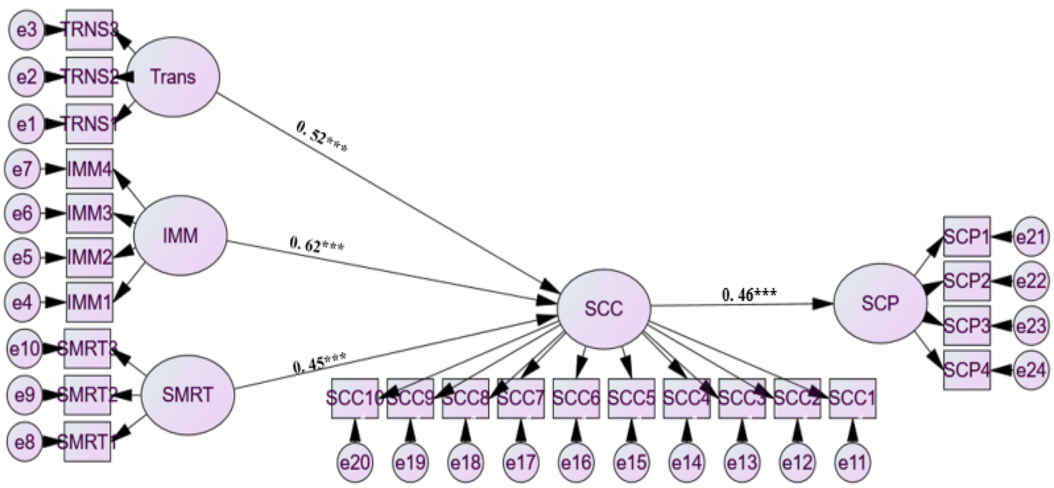

Figure 2: Structural Equation Model.

The figure illustrates a structural equation model in which three BTA-related variables include TRNS, data and IMM, and SMRT as exogenous latent variables with observed indicators. The combination of these three constructs predicts SCC, which is measured as a latent mediator and assessed with several SCC items. SCC, in turn, predicts SCP, which is a matrix of several SCP indicators. Altogether, the model demonstrates the impact of various applications of BTA on collaboration in the supply chain and, as a result, improves the performance of the entire supply chain.

4.4.1 Direct Effects of BTA on SCP and SCP

Table 5: Direct Effects of Blockchain Technology Attributes on Supply Chain Collaboration and Performance

	Coefficient (β)	p-value	Strength of Impact
TRNS → SCC	0.52***	0.000	Strong
IMM → SCC	0.62***	0.000	Strong
SMRT → SCC	0.45***	0.000	Moderate
SCC → SCP	0.46***	0.000	Moderate

Note: TRNS; Information Transparency, IMM; Data and Information Immutability, SC; Smart Contracts, SCC; Supply Chain Collabration, SCP; Supply chain performance.

Table 5 indicates the direct correlation between BTA, SCC and SCP. TRNS and IMM of BTA significantly influence SCC with β=0.52 and β=0.62, respectively, with statistically significant (0.000) p-values. SMRT also has a positive influence on SCC, yet its effect is moderate (β= 0.45, p = 0.000). Moreover, the impact of SCC on SCP is moderate and significant (β= 0.46, p = 0.000), which means that improved collaboration leads to improved performance of the supply chain.

Table 6: Mediating Impact

Relationship	Total effect	Direct effect	Indirect effect	Confidence interval		T statistics	Conclusion
				Lower bound	Upper bound		
TRNS → SCC → SCP	0.45***	0.29***	0.16***	0.07	0.28	4.54	Partial Mediation
IMM → SCC → SCP	0.50***	0.33***	0.17***	0.08	0.30	4.59	Partial Mediation
SMRT → SCC → SCP	0.38***	0.25***	0.13***	0.06	0.21	4.66	Partial Mediation

Note: TRNS; Information Transparency, IMM; Data and Information Immutability, SC; Smart Contracts, SCC; Supply Chain Collabration, SCP; Supply chain performance.

The mediating analysis in Table 6 tests the connection of SCC between BTA dimensions that are TRNS, IMM, and SMRT and SCP. The overall impact of TRNS, IMM, and SMRT on SCP is 0.45, 0.50 and 0.38, with all of them being highly significant ($p < 0.001$), showing that these applications of BTA have a positive impact on the performance of the supply chain. The indirect ones using SCC are also relevant (0.16 in TRNS, 0.17 in IMM, and 0.13 in SMRT), and the confidence intervals do not contain zero, which proves the importance of SCC as a mediator. This indicates that some of the beneficial effects of BTA on performance work by strengthening partner collaboration within the supply chain.

The direct effects are statistically significant (0.29 TRNS, 0.33 IMM, 0.25 SMRT), indicating that SCC does not entirely mediate the relationships, but instead partially. The indirect effects T-statistics are all greater than 4.5, which also supports the strength of the mediation. In general, the results demonstrate that, although BTA directly benefits the performance of the supply chain, it also leads to an increase in collaboration, which subsequently increases the performance results. This highlights the duality of SCC as an amplifier and mechanism of positive influence of BTA on supply chain efficiency and effectiveness. Thus, based on the above analysis, the following hypotheses have been accepted in this research:

Table 7: Hypotheses Result

Hypothesis Code	Hypothesised Relationship	β (Path Coefficient)	p-value	Indirect Effect (if applicable)	Mediation Type	Decision
H1	TRNS → SCC	0.52	0.000	–	–	Accepted
H2	IMM → SCC	0.62	0.000	–	–	Accepted
H3	SMRT → SCC	0.45	0.000	–	–	Accepted
H4	TRNS → SCC → SCP	Direct = 0.29	0.000	0.16 (CI: 0.07–0.28)	Partial mediation	Accepted
H5	IMM → SCC → SCP	Direct = 0.33	0.000	0.17 (CI: 0.08–0.30)	Partial mediation	Accepted
H6	SMRT → SCC → SCP	Direct = 0.25	0.000	0.13 (CI: 0.06–0.21)	Partial mediation	Accepted
H7	SCC → SCP	0.46	0.000	–	–	Accepted

Note: TRNS; Information Transparency, IMM; Data and Information Immutability, SC; Smart Contracts, SCC; Supply Chain Collabration, SCP; Supply chain performance.

5. DISCUSSION

This research results show good empirical evidence that BTA can significantly improve collaboration and performance in supply chain networks. The three dimensions of BTA that are TRNS, IMM, and SMRT were positively identified to have an impact on SCC. The high impact of TRNS on SCC proves that the real-time visibility and common, verified data enhance confidence and decrease information asymmetry among members of the partnership. The finding aligns with recent studies, which point to the fact that TRNS promotes data sharing openness, minimises the risk of transactions, and eases the collaborative process in the supply chains (Liu et al., 2025). The discovery supports the notion that transparent ecosystems generated via blockchain can help firms to plan and implement more effectively.

IMM has also shown a substantial effect on SCC, which proves that data integrity and records that are tamper-proof are the core concerns of enhancing collaboration. Unchangeable records minimise conflicts, boost confidence in mutual data, and dispel doubt on the validity of operational data (Luo et al., 2024). Raja et al (2025) indicate that IMM increases accountability and is an essential process of establishing long-term, trust-based relationships (Raja et al., 2025). This relationship strength implies that organisations are placing great trust in the IMM of blockchain when working in partnership on sensitive operational activities, including forecasting, order reconciliation, and quality assurance.

It was also revealed that SMRT had a positive impact on collaboration, but with a moderate effect relative to TRNS and IMM. This indicates that automation using SMRT, including automated verification, payment release and compliance checks, does provide coordination, though organisations might still be in their initial stages of adopting or complete implementation of these systems into inter-organisational processes (Amato et al., 2021). It is in line with earlier studies that state that although SMRT minimise human error, shorten the time of process, and enhance trust in transactions, this technology might be limited by technical integration risks and the regulatory barrier (El Mane et al., 2024; Raj et al., 2022; Sharma et al., 2024) to leverage the potential of automated contracting further.

The mediation findings also show that SCC moderates the relationship between all three BTA dimensions and SCP to some degree. This observation suggests that BTA not only has a direct impact on performance by increasing data quality and process efficiency but also has an indirect impact on performance by reinforcing collaborative practices. The indirect effects prove that collaboration is one of the instrumental means via which BTA abilities can be converted to better operational results like responsiveness, reliability, and cost-efficiency. This correlates with the recent findings that more collaborative supply chains, supported by digital technologies, can manage disruption, optimise logistics flows, and increase the level of customer service (Charczuk et al., 2025; Hall et al., 2022; Salamah et al., 2023). SCC thus has an important role in transforming capabilities made blockchain-enabled into real performance benefits.

Lastly, the direct positive impact that SCC has on SCP indicates the strategic significance of teamwork as a performance driver. Companies that successfully plan together, integrate information systems, and coordinate decision-making with partners show a much more effective supply chain performance. Previous research also proves that collaboration brings about operational efficiencies, more precise inventories, faster operations, and greater resiliency in the entire supply chain (Ahmed et al., 2022; Birhanu et al., 2022). In partnership with BTA, collaboration becomes even more effective since partners can organise operations based on common, reliable information. All findings thus show that BTA is not only a technological breakthrough but a ground-level enabler of high-performance supply chain systems of collaboration.

6. CONCLUSION

This research shows that BTA (TRNS, IMM, and SMRT) can significantly enhance supply chain collaboration, which further boosts supply chain performance. TRNS (0.52) and IMM (0.62) significantly affect collaboration, whereas SMRT have a moderate effect (0.45), and collaboration has a positive effect (0.46). The mediation analysis supports the aspect of partial mediation, which states that blockchain has direct and collaborative effects on performance. Theoretically, the paper is a continuation of the Resource-Based View (RBV) and the Dynamic Capabilities Theory, as it demonstrates that BTA is a valuable and dynamic strategic resource that is transformed into collaborative capabilities within U.S. supply chains. In practice, the results will inform managers to invest in blockchain functionality to improve visibility, information integrity, and automated operations and align them with organisational practice, partner coordination, and workforce preparedness. Thus, the findings can support the view of blockchain as a technological and relational facilitator of resilient, efficient, and high-performing supply chain ecosystems.

7. LIMITATIONS

The research has a limitation due to its use of cross-sectional data, which hinders the possibility of drawing long-term causal relationships. The sample was restricted to U.S. supply chain professionals, and this could restrict generalisation to other regions or industries. Moreover, the research considered three BTA dimensions, and ignoring other technological or organisational aspects can also affect the collaboration and performance. Lastly, the research is only based on self-reported data, which could create bias in the results.

7.1. Future Implication

This research can be extended in longitudinal designs to future investigate the effects of BTA adoption on collaboration and performance over time. Other aspects that researchers can examine to enhance the knowledge on blockchain-enabled supply chains include digital readiness, organisational culture, and the integration of AI and IoT. The comparative research between various nations or industries might offer more comprehensive information about contextual differences. The findings may be further validated and expanded by including experimental or case-based approaches.

REFERENCES

Afshan, N., Chatterjee, S., & Chhetri, P. (2018). Impact of information technology and relational aspect on supply chain collaboration leading to financial performance: A study in Indian context. *Benchmarking: An International Journal*, *25*(7), 2496-2511.

Agrawal, T. K., Angelis, J., Khilji, W. A., Kalaiarasan, R., & Wiktorsson, M. (2023). Demonstration of a blockchain-based framework using smart contracts for supply chain collaboration. *International journal of production research*, *61*(5), 1497-1516.

Ahmad, M., & Wilkins, S. (2025). Purposive sampling in qualitative research: A framework for the entire journey. *Quality & Quantity*, *59*(2), 1461-1479.

Ahmed, I., Zhang, Y., Jeon, G., Lin, W., Khosravi, M. R., & Qi, L. (2022). A blockchain-and artificial intelligence-enabled smart IoT framework for sustainable city. *International Journal of Intelligent Systems*, *37*(9), 6493-6507.

Ahmed, S. (2025). Enhancing Data Security and Transparency: The Role of Blockchain in Decentralized Systems. *International Journal of Advanced Engineering, Management and Science*, *11*(1), 593258.

Akhavan, P., & Philsoophian, M. (2023). Improving of supply chain collaboration and performance by using block chain technology as a mediating role and resilience as a moderating variable. *Journal of the Knowledge Economy*, *14*(4), 4561-4582.

AL-Fadhali, N. (2024). An AMOS-SEM approach to evaluating stakeholders' influence on construction project delivery performance. *Engineering, Construction and Architectural Management*, *31*(2), 638-661.

Ali, S., Shin, W. S., & Song, H. (2022). Blockchain-enabled open quality system for smart manufacturing: applications and challenges. *Sustainability*, *14*(18), 11677.

Alii, H. M., Ugli, A. A. G., Mannonov, A., & Lalnunthari, L. (2025). Artificial Intelligence and IoT in Logistics management for the Intelligent Supply chain Management For The Future era. 2025 International Conference on Computational Innovations and Engineering Sustainability (ICCIES),

Amato, F., Cozzolino, G., Moscato, F., Moscato, V., & Xhafa, F. (2021). A model for verification and validation of law compliance of smart contracts in IoT environment. *IEEE Transactions on Industrial Informatics*, *17*(11), 7752-7759.

Aslam, A., Postolache, O., Oliveira, S., & Pereira, J. D. (2025). Securing IoT Sensors Using Sharding-Based Blockchain Network Technology Integration: A Systematic Review. *Sensors (Basel, Switzerland)*, *25*(3), 807.

Bagraff, H. A., Kholis, N., Mugiyati, M., & Nabila, F. G. (2024). Implementing Blockchain Technology for Optimized Supply Chain and Enhanced Sustainability. *International Journal of Innovative Science and Research Technology*, *9*(8), 1697-1702.

Baranidharan, K., & Anagha, S. (2025). Blockchain technology for enhancing supply chain transparency: opportunities and challenges. *IJARSCT*, 345-353.

Beamon, B. M. (1999). Measuring supply chain performance. *International journal of operations & production management*, *19*(3), 275-292.

Birhanu, Y., Gizaw, T., Teshome, D., Boche, B., & Gudeta, T. (2022). The mediating effect of information sharing on pharmaceutical supply chain integration and operational performance in Ethiopia: an analytical cross-sectional study. *Journal of Pharmaceutical Policy and Practice*, *15*(1), 44.

Cao, M., & Zhang, Q. (2011). Supply chain collaboration: Impact on collaborative advantage and firm performance. *Journal of operations management*, *29*(3), 163-180.

Casati, M., Soregaroli, C., Frizzi, G. L., & Stranieri, S. (2024). Impacts of blockchain technology in agrifood:

exploring the interplay between transactions and firms' strategic resources. *Supply Chain Management: An International Journal*, *29*(7), 51-70.

Charczuk, J. B., Silva, K., & da Silva Lima, M. T. (2025). The Potential of Blockchain Technology for Collaboration among Countries. Conference on Digital Government Research,

Cheung, G. W., Cooper-Thomas, H. D., Lau, R. S., & Wang, L. C. (2024). Reporting reliability, convergent and discriminant validity with structural equation modeling: A review and best-practice recommendations. *Asia pacific journal of management*, *41*(2), 745-783.

CoinDesk. (2025). *Pakistan to Explore Blockchain for Multibillion Dollar Remittances From Abroad: Adviser*. https://www.coindesk.com/tech/2025/03/10/pakistan-to-explore-blockchain-for-multibillion-dollar-remittances-from-abroad

El Mane, A., Tatane, K., & Chihab, Y. (2024). Transforming agricultural supply chains: Leveraging blockchain-enabled java smart contracts and IoT integration. *ICT Express*, *10*(3), 650-672.

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

Ghanad, A. (2023). An overview of quantitative research methods. *International journal of multidisciplinary research and analysis*, *6*(08), 3 .3803-794

Hall, K. K. L., Richey Jr, R. G., & Patil, R. K. (2022). Collaboration, feedback, and performance: Supply chain insights from service-dominant logic. *Journal of Business Research*, *146*, 385-397.

Herold, S., Heller, J., Rozemeijer, F., & Mahr, D .(2023) .Dynamic capabilities for digital procurement transformation: a systematic literature review. *International Journal of Physical Distribution & Logistics Management*, *53*(4), 424-447.

Hunhevicz, J. J., Motie, M., & Hall, D. M. (2022). Digital building twins and blockchain for performance-based (smart) contracts. *Automation in construction*, *133*, 103981.

Jum'a, L. (2023). The role of blockchain-enabled supply chain applications in improving supply chain performance: the case of Jordanian manufacturing sector. *Management Research Review*, *46*(10), 1315-1333.

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.

Kassen, M. (2022). Blockchain and e-government innovation: Automation of public information processes. *Information systems*, *103*, 101862.

Kholis, N., Bagraff, H. A. & ,Mugiyati, M. (2024). Implementing Blockchain Technology for Optimized Supply Chain and Enhanced Sustainability. *International Journal of Innovative Science and Research Technology (IJISRT), 0 [10.38124/ijisrt/IJISRT24AUG1218]*.

Kim, J.-S., & Shin, N. .(2019)The impact of blockchain technology application on supply chain partnership and performance. *Sustainability*, *11*(21), 6181.

Korepin, V., Dzenzeliuk, N., Seryshev, R., & Rogulin, R. (2021). Improving supply chain reliability with blockchain technology. *Maritime Economics and Logistics*, *4*, 1-16.

Kumar, M., Raut, R. D., Mangla, S. K., Moizer, J., & Lean, J. (2024). Big data driven supply chain innovative capability for sustainable competitive advantage in the food supply chain: Resource-based view perspective. *Business Strategy and the Environment*, *33*(6), 5127-5150.

Legate, A. E., Ringle, C. M., & Hair Jr, J. F. (2024). PLS-SEM: a method demonstration in the R statistical environment. *Human Resource Development Quarterly*, *35*(4), 501-529.

Liu, W., Zhang, X., & Chen, H. (2025). Improving Supply Chain Transparency through Blockchain Technology. *OPTIMIZATIONS IN APPLIED MACHINE LEARNING*, *5*(1).

Lubis, N. W. (2022). Resource based view (RBV) in improving company strategic capacity. *Research Horizon*, *2*(.596-587 ,(6

Luo, Y., Shen, J., Liang, H., Sun, L., & Dong, L. (2024). Supporting building life cycle carbon monitoring, reporting and verification: A traceable and immutable blockchain-empowered information management system and application in Hong Kong .*Resources, Conservation and Recycling*, *208*, 107736.

Martins, R. (2024). *Web3 in Financial Services: How Blockchain, Digital Assets and Crypto are Disrupting Traditional Finance*. Kogan Page Publishers.

Monostori, J. (2021). Mitigation of the ripple effect in supply chains: Balancing the aspects of robustness, complexity and efficiency. *CIRP Journal of Manufacturing Science and Technology*, *32*, 370-381.

Montreuil, V.-L., Lauzier, M., & Gagnon, S. (2021). A closer look at determinants of organizational capability to innovate (OCI) A dynamic capabilities perspective. *European Journal of Innovation Management*, *24*(3), 820-847.

Muhammad, R., & Saad, S. (2023). Achieving a competitive advantage supply chain management practices and responsiveness. *Information Management and Business Review*, *15*(3), 451-461.

Nahi, H. A., Ali, A. K., Alaraji, M. A., Mohi, Z. J., Mahmood, N. T., Mousa, A. M., Saeed, M. M., & Almansoori, R. A. (2025). Blockchain Network for Regulation Decentralized E-Government Systems.

Nero, A & ,.Sarin, G. (2025). A Study on Analysing the Role of Blockchain in Supply Chain Data Security and Developing a Conceptual Diagram. *J. Manag. Res. Anal*, *11*, 202-208.

Nikookar, E., Ali, I., Stevenson, M., & Shokouhyar, S. (2025). Necessary Antecedents of Supply Chain Resilience: The Nonnegotiable Influence of Supply Chain Responsiveness and Collaboration. *Journal of Supply Chain Management*.

Nwariaku, H., Fadojutimi, B., Lawson, L. G. L., Agbelusi, J., Adigun, O. A., Udom, J. A., & Olajide, T. D. (2024) . Blockchain technology as an enabler of transparency and efficiency in sustainable supply chains. *International Journal of Science and Research Archive*, *12*(2), 1779-1789.

Ojadi, J. O., Owulade, O. A., Odionu, C. S., & Onukwulu, E. C. (2025). Blockchain and IoT for transparent carbon tracking and emission reduction in global supply chains. *International Journal of Scientific Research in Science, Engineering and Technology*, *12*(2), 78-118.

Olajide, J. O., Otokiti, B. O., Nwani, S., Samuel, A., Ogunmokun, B. I. A., & Fiemotongha, J. E. (2023). Cross-Functional Finance Partnership Models for Strategic P&L and Forecast Ownership in Multinational Supply Chains.

Omar, I. A., Jayaraman, R., Debe, M. S., Hasan, H. R., Salah, K., & Omar, M. (2021). Supply chain inventory sharing using ethereum blockchain and smart contracts. *IEEE access*, *10*, 2345-2356.

Pal, A., Tiwari, C. K., & Behl, A. (2021). Blockchain technology in financial services: a comprehensive review of the literature. *Journal of Global Operations and Strategic Sourcing*, *14*(1), 61-80.

Philsoophian, M., Akhavan, P., & Namvar, M. (2022). The mediating role of blockchain technology in improvement of knowledge sharing for supply chain management. *Management Decision*, *60*(3), 784-805.

Pu, G., & Qiao, W. .(2025)Relational risk, knowledge sharing and supply chain resilience: the complementary role of blockchain governance and relational governance. *Journal of Knowledge Management*, *29*(2), 301-341.

Putra, P., & Fariz, M. (2022). Construct validity test of spirituality in sports test (SIST) using confirmatory factor analysis (CFA) method. *Ovidius University Annals, Series Physical Education & Sport/Science, Movement & Health*, *22*(2).

Raj, P. V. R. P., Jauhar, S. K., Ramkumar, M., & Pratap, S. (2022). Procurement, traceability and advance cash credit payment transactions in supply chain using blockchain smart contracts. *Computers & industrial engineering*, *167*, 108038.

Raja, J., Ashish, A., Boianapalli, S., & Rashid, S. Z. (2025). Blockchain Technology in Supply Chain Management Enhancing Transparency and Efficiency. ITM Web of Conferences,

Raja Santhi, A., & Muthuswamy, P. (2022). Influence of blockchain technology in manufacturing supply chain and logistics. *Logistics*, *6*(1), 15.

Ramkumar, M. S., Arun, M. ,Gopan, G., Giri, J., & Al-Qawasmi, K. (2025). Enhancing Supply Chain Resilience: Integrating Blockchain for Transparency and Risk Mitigation in Logistics. 2025 International Conference on Visual Analytics and Data Visualization (ICVADV),

Rejeb, A., Keogh, J. G., Simske, S. J., Stafford, T., & Treiblmaier, H. (2021). Potentials of blockchain technologies for supply chain collaboration: a conceptual framework. *The International Journal of Logistics Management*, *32*(3), 973-994.

Saidu, Y., Shuhidan, S. M., Aliyu, D. A., Aziz, I. A., & Adamu, S. (2025). Convergence of blockchain, IoT, and AI for enhanced traceability systems: A comprehensive review. *IEEE access*.

Salamah, E., Alzubi, A., & Yinal, A. (2023). Unveiling the impact of digitalization on supply chain performance in the post-COVID-19 era: the mediating role of supply chain integration and efficiency. *Sustainability*, *16*(1), 304.

Sarfraz, M., Khawaja, K. F., Han, H., Ariza-Montes, A., & Arjona-Fuentes, J. M. (2023). Sustainable supply chain, digital transformation, and blockchain technology adoption in the tourism sector. *Humanities and Social Sciences Communications*, *10*(1), 1-13.

Semenova, V. (2024). *Embracing Technological Advancements: Blockchain as a Driver for Innovation and Dynamic*

Capability Development Budapesti Corvinus Egyetem].
Shamsuzzoha, A., TEPPOLA, T., PIYA, S., KHADEM, M., & SHAMSUZZAMAN, M. (2025). Proof Reading: Design and Implementation of a Systematic Product-Service System Innovative Framework: A Case Study. *Management and Production Engineering Review*.
Sharma, A., Padmavathy, R., Obaid, S., Devi, T. A., Rao, C. M., & Patnaik, C. P. (2024). Blockchain-Based Smart Contracts for Enhancing Supply Chain Transparency. 2024 International Conference on IoT, Communication and Automation Technology (ICICAT),
Teng, L. J. (2024). Newly restructured SMRT targets market expansion, new verticals. *The Edge*, 18.
Thakur, V. K. (2024). Collaborative supply chain network: Confusion or way ahead.
Thekkoote, R. (2022). Understanding big data-driven supply chain and performance measures for customer satisfaction. *Benchmarking: An International Journal*, *29*(8), 2359-2377.
Tiwari, M. K., Bidanda, B., Geunes, J., Fernandes, K., & Dolgui, A. (2024). Supply chain digitisation and management. In (Vol. 62, pp. 2918-2926): Taylor & Francis.
Vazquez Melendez, E. I., Bergey, P., & Smith, B. (2024). Blockchain technology for supply chain provenance: increasing supply chain efficiency and consumer trust. *Supply chain management: An international journal*, .730-706 ,(4)29
Wamba, S. F., Queiroz, M. M., & Trinchera, L. (2020). Dynamics between blockchain adoption determinants and supply chain performance: An empirical investigation. *International Journal of Production Economics*, *229*, 107791.
Wu, Y. (2025). Blockchain-enabled sustainable supply chain management: a study on the impact of collaboration optimization. *Management Decision*.
Xu, S., Nupur, R., Kannan, D., Sharma, R., Sharma, P., Kumar, S., Jha, P., & Bai, C. (2023). An integrated fuzzy MCDM approach for manufacturing process improvement in MSMEs. *Annals of Operations Research*, *322*(2), 1037-1073.
Yadav, A. S., Singh, N., & Kushwaha, D. S. (2023). Evolution of Blockchain and consensus mechanisms & its real-world applications. *Multimedia Tools and Applications*, *82*(22), 34363-34408.
Yadav, K., Jasmin, M., Srikanth, G., Shnain, A. H., Anuradha, K., & Krishnakumar, K. (2024). Smart Contracts on Blockchain for Transparent Supply Chain Transactions. 2024 International Conference on IoT, Communication and Automation Technology (ICICAT),
Yigit, E., & Dag, T. (2024). Improving supply chain management processes using smart contracts in the ethereum network written in solidity. *Applied Sciences*, *14*(11), 4738.
Yousefi, S., & Tosarkani, B. M. (2023). Exploring the role of blockchain technology in improving sustainable supply chain performance: a system-analysis-based approach. *IEEE transactions on engineering management*, *71*, 4389-4405.
Zhao, W., Luo, Z., & Liu, Q. (2023). Does supply chain matter for environmental firm performance: mediating role of financial development in China. *Economic Change and Restructuring*, *56*(6), 3811-3837.
Zutshi, A., Grilo, A., & Nodehi, T. (2021). The value proposition of blockchain technologies and its impact on Digital Platforms. *Computers & industrial engineering*, *155*, 107187.