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The Role of Blockchain Technology in the Supply Chain Performance of the Oil and Gas Industry

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ABSTRACT

When examining the potential of blockchain technology in the oil and gas industry, one of its most significant application areas is supply chain management. In terms of purpose, this study is applied research, and in terms of methodology, it adopts a causal-correlational approach using a questionnaire as the data collection instrument. A total of 254 questionnaires were distributed through simple random sampling among senior experts and information technology specialists in 2025. Reliability was assessed using Cronbach's alpha, while face validity was evaluated through pilot testing. Content validity was calculated and confirmed using the Content Validity Index (CVI) and Content Validity Ratio (CVR). To determine the relationships between the independent and dependent variables within the conceptual research model, Structural Equation Modeling (SEM) and the AMOS software package were employed. The findings indicate that blockchain technology, particularly in the oil and gas industry, can facilitate process integration through decentralization and participatory decision-making, foster trust, and enhance transparency. Nevertheless, many large oil and gas companies continue to perceive investment in this technology as risky and have largely limited their actions to monitoring and evaluating the experiences and outcomes of leading organizations in this field.

Keywords: *Information and Communication Technology (ICT), Supply Chain, Oil and Gas Industry, Blockchain Technology.*

1. Introduction

The oil and gas industry remains one of the most strategically significant sectors of the global economy, providing the primary energy resources required for industrial production, transportation, electricity generation, and economic development. Despite its critical role, the industry faces persistent challenges related to operational complexity, fragmented supply chain structures, information asymmetry, lack of transparency, inefficiencies in interorganizational coordination, and increasing pressure to improve sustainability and resilience. The supply chains of oil and gas companies encompass a wide range of upstream, midstream, and downstream activities involving numerous stakeholders, suppliers, contractors, logistics providers, regulators, and customers. Managing these interconnected networks requires advanced technological solutions capable of improving visibility, traceability, trust, and collaboration among all participants (Behi Far et al., 2023, 2025a, 2025b).

In recent years, digital transformation has emerged as a key strategic priority for oil and gas organizations seeking to enhance operational performance and maintain competitiveness in increasingly volatile markets. Technologies such as artificial intelligence, the Internet of Things, big data analytics, cloud computing, and blockchain have gained considerable attention as enablers of next-generation supply chain management systems. Among these technologies, blockchain has attracted particular interest due to its ability to facilitate secure, transparent, decentralized, and tamper-resistant information exchange across organizational boundaries (Korpela et al., 2017; Lee & Pilkington, 2017; Treiblmaier, 2018).

Blockchain technology can be defined as a distributed ledger system in which transactions are recorded chronologically, cryptographically secured, and validated through consensus mechanisms among network participants. Unlike traditional centralized databases, blockchain eliminates the need for a single trusted intermediary by creating a shared and immutable record accessible to authorized stakeholders. This feature significantly enhances data integrity, accountability, and reliability while reducing opportunities for fraud, manipulation, and unauthorized alterations (Angelis & Ribeiro da Silva, 2018; Turk & Klinc, 2017; Zhang et al., 2018).

The increasing attention devoted to blockchain adoption is closely linked to the growing need for transparency throughout modern supply chains. Globalization has expanded supply networks across geographical regions, creating greater complexity and increasing the difficulty of monitoring product flows, information exchanges, and financial transactions. Organizations are therefore seeking technologies that can improve visibility and provide real-time access to reliable information. Blockchain offers a promising solution by enabling transparent recordkeeping and facilitating traceability throughout the entire product lifecycle (Bai & Sarkis, 2020; Francisco & Swanson, 2018; Uvet et al., 2025).

Transparency is particularly important in industries characterized by high-value assets and complex operational networks. The oil and gas industry involves extensive interactions among exploration companies, drilling contractors, engineering firms, transportation providers, refineries, distributors, and regulatory agencies. Information fragmentation across these entities often creates inefficiencies, delays, disputes, and increased operational risks. Blockchain technology has the potential to address these challenges by creating a unified and trusted source of information accessible to all authorized participants within the supply chain ecosystem (Chang et al., 2019; Raja et al., 2025; Yi, 2021).

Trust represents another critical factor affecting supply chain performance. Traditional supply chain systems frequently rely on centralized authorities or intermediaries to verify transactions and ensure compliance among participants. Such mechanisms can increase costs, create delays, and introduce vulnerabilities. Blockchain offers an alternative trust architecture based on cryptographic verification and distributed consensus. By reducing reliance on intermediaries and ensuring data immutability, blockchain can foster stronger trust relationships among supply chain actors, even in environments characterized by limited prior collaboration or geographical dispersion (Kshetri, 2018; Saberi et al., 2019; Xia & Yongjun, 2017).

The importance of trust becomes even more pronounced in industries where contractual obligations, regulatory compliance, and asset ownership records must be continuously monitored and verified. Researchers have argued that blockchain-based systems can substantially improve trust by increasing information accuracy, reducing opportunistic behavior, and enhancing accountability among stakeholders. Consequently, trust has emerged as one of the most frequently examined outcomes of blockchain implementation within supply chain contexts (Bernabe et al., 2019; Pearson et al., 2019; Toyoda et al., 2017).

Beyond transparency and trust, blockchain technology is increasingly recognized as a catalyst for process integration.

Effective supply chain management depends on the seamless coordination of activities across organizational boundaries. However, many supply chains continue to suffer from isolated information systems, duplicated processes, inconsistent records, and limited interoperability. Blockchain can support process integration by enabling synchronized information sharing and facilitating collaborative decision-making among supply chain partners. The decentralized nature of blockchain networks allows organizations to maintain autonomy while participating in a shared operational framework (Chang et al., 2019; Falazi et al., 2019; Korpela et al., 2017).

The integration of supply chain processes has important implications for operational efficiency, responsiveness, and overall organizational performance. When information flows efficiently among supply chain participants, organizations can reduce transaction costs, improve resource utilization, accelerate decision-making, and enhance service quality. Blockchain-enabled integration therefore offers substantial opportunities for improving supply chain effectiveness across diverse industrial sectors (Centobelli et al., 2020; Francisco & Swanson, 2018; Mondragon et al., 2018).

The relevance of blockchain technology has been demonstrated across numerous application domains. In food supply chains, blockchain has been used to improve traceability, monitor product quality, and enhance food safety management. These applications became particularly important during periods of disruption and uncertainty, such as the COVID-19 pandemic, when organizations sought more reliable mechanisms for tracking products and ensuring supply continuity (Mao et al., 2018; Rizou et al., 2020; Tse et al., 2017). Similar benefits have been reported in healthcare, manufacturing, construction, international trade, and consumer electronics industries, where blockchain has contributed to improved information management, transaction security, and operational transparency (Lee & Pilkington, 2017; Turk & Klinc, 2017; Zhang et al., 2018).

International trade has emerged as another important area for blockchain implementation. Conventional trade processes often involve extensive documentation requirements, multiple intermediaries, and lengthy verification procedures. Blockchain-based systems have been proposed as mechanisms for streamlining documentation workflows, enhancing transaction security, and reducing administrative burdens. Such applications demonstrate the broader potential of blockchain technology to transform complex business processes and improve organizational performance across diverse contexts (Angelis & Ribeiro da Silva, 2018; Chang et al., 2019; O'Byrne, 2019).

Although blockchain offers considerable advantages, its implementation is not without challenges. Organizations frequently encounter technological, organizational, regulatory, and financial barriers when adopting blockchain solutions. These challenges include concerns regarding scalability, interoperability, privacy protection, implementation costs, governance structures, and uncertainty about return on investment. Consequently, despite growing interest in blockchain, many organizations remain cautious about large-scale adoption (Bernabe et al., 2019; Queiroz & Wamba, 2019; Treiblmaier, 2018).

The oil and gas sector faces several additional barriers associated with blockchain implementation. The industry's legacy information systems, highly specialized operational processes, strict regulatory requirements, and extensive stakeholder networks create significant complexities for technological transformation. Nevertheless, growing competitive pressures and increasing demands for supply chain resilience continue to motivate organizations to explore blockchain-enabled solutions capable of improving operational visibility and reducing systemic risks (Behi Far et al., 2025b; Ivanov et al., 2019; Wang et al., 2018).

Recent research has highlighted the strategic importance of combining blockchain technology with advanced risk management practices. Blockchain-based systems can improve risk identification, monitoring, and mitigation by providing real-time access to accurate operational data. Emerging applications in supply chain financing and decision-support systems suggest that blockchain may contribute not only to operational efficiency but also to more effective strategic decision-making and risk governance (Raja et al., 2025; Xu et al., 2025; Zhang ،et al., 2025).

Furthermore, contemporary studies indicate that blockchain adoption may generate broader organizational benefits extending beyond operational performance. Improved transparency can strengthen corporate social responsibility initiatives, enhance stakeholder confidence, and support sustainable supply chain development. As organizations increasingly pursue environmental, social, and governance objectives, blockchain technology is being viewed as a potential enabler of sustainable value creation and long-term competitive advantage (Bai & Sarkis, 2020; Centobelli et al., 2020; Saberi et al., 2019; Uvet et al., 2025).

From a methodological perspective, the investigation of complex relationships among blockchain technology, transparency, trust, process integration, and organizational performance requires robust analytical techniques capable of simultaneously examining multiple direct and indirect effects. Structural equation modeling has become one of the most widely used approaches for testing such multidimensional relationships because it enables researchers to evaluate measurement validity and estimate complex causal structures within a unified analytical framework (Behi Far et al., 2025a; Ghasemi, 2021; Hair et al., 2019).

Despite the growing body of literature on blockchain applications in supply chain management, empirical evidence regarding its role in the oil and gas industry remains relatively limited, particularly in developing economies and technologically evolving industrial environments. Existing studies have often focused on conceptual frameworks, technological architectures, or applications in manufacturing and food supply chains, leaving important gaps in understanding how blockchain influences transparency, trust, process integration, and performance within oil and gas supply networks. Addressing these gaps is essential for supporting evidence-based decision-making and guiding future investments in digital transformation initiatives within the industry (Behi Far et al., 2023; Kshetri, 2018; Queiroz & Wamba, 2019; Yi, 2021).

Therefore, the present study aims to investigate the role of blockchain technology in enhancing supply chain performance in the oil and gas industry through the mediating effects of transparency, trust, and process integration.

2. Methods and Materials

This study was conducted as an applied research project employing a quantitative approach with a survey research strategy. The research aimed to investigate the role of blockchain technology in enhancing supply chain performance within the oil and gas industry. The target population consisted of senior experts, managers, and information technology specialists working in organizations and companies associated with the oil and gas sector. Data were collected during 2025 through a cross-sectional survey design. A simple random sampling technique was utilized to ensure that all eligible members of the target population had an equal opportunity to participate in the study. Based on the sampling framework and the accessibility of respondents, a total of 254 participants were selected and completed the survey questionnaires. Participation was voluntary, and respondents were informed about the academic purpose of the study and the confidentiality of their responses. The collected data provided a suitable basis for examining the relationships among blockchain technology capabilities, supply chain integration, transparency, trust, and overall supply chain performance in the oil and gas industry.

Data were collected using a structured questionnaire developed based on the existing literature on blockchain technology and supply chain management. The questionnaire consisted of two sections. The first section gathered demographic information about the respondents, including their professional background, organizational position, and experience in information technology and supply chain operations. The second section measured the research constructs related to blockchain technology and supply chain performance. All items were assessed using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), allowing respondents to express the extent of their agreement with each statement.

To ensure the quality of the measurement instrument, several validity and reliability procedures were employed. Face validity was evaluated through pilot testing with a group of experts and practitioners familiar with blockchain applications and supply chain management. Their feedback was incorporated to improve the clarity, relevance, and comprehensibility of the questionnaire items. Content validity was assessed using the Content Validity Ratio (CVR) and the Content Validity Index (CVI), and the obtained values confirmed the adequacy and representativeness of the instrument for measuring the intended constructs. Reliability was examined using Cronbach's alpha coefficient, and the results demonstrated satisfactory internal consistency for all measurement scales, indicating that the questionnaire was a reliable tool for data collection.

After collection, the completed questionnaires were coded and entered into Microsoft Excel 2020 for preliminary organization and data screening. The dataset was subsequently transferred to IBM SPSS Statistics version 25 and AMOS for statistical analysis. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were calculated to summarize the characteristics of the respondents and the main study variables. Inferential statistical analyses were then conducted to examine the proposed relationships among the research constructs.

Structural Equation Modeling (SEM) was employed as the primary analytical technique to test the conceptual model and evaluate the direct and indirect effects among the variables. The measurement model was first assessed to verify the adequacy of the latent constructs and their indicators. Subsequently, the structural model was analyzed to determine the significance and strength of the hypothesized relationships. Model fit was evaluated using commonly accepted goodness-of-fit indices, including the Chi-square statistic, Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), Goodness-of-Fit Index (GFI), Adjusted Goodness-of-Fit Index (AGFI), and Root Mean Square Error of Approximation (RMSEA). The use of SEM enabled a comprehensive examination of the relationships between blockchain technology dimensions and supply chain performance outcomes, providing robust empirical evidence regarding the role of blockchain technology in improving transparency, trust, integration, and operational effectiveness within the oil and gas supply chain.

3. Findings and Results

To examine the distribution of the data, the skewness and kurtosis values were assessed. Skewness is a measure of the symmetry or asymmetry of a data distribution. In a perfectly symmetrical distribution, the skewness value is zero. A positively skewed distribution has a longer tail toward larger values, whereas a negatively skewed distribution has a longer tail toward smaller values. Kurtosis indicates the peakedness of a distribution and serves as a measure of the height of the distribution curve at its maximum point. A normal distribution has a kurtosis value of 3. Positive kurtosis indicates that the distribution peak is higher than that of a normal distribution, whereas negative kurtosis indicates a lower peak. In general, if skewness values fall outside the range of -2 to +2 and kurtosis values fall outside the range of -5 to +5, the data cannot be considered normally distributed.

Table 1

Descriptive Statistics of the Research Variables

Variable	Minimum	Maximum	Skewness	T Statistic	Kurtosis	T Statistic
Blockchain	2.000	5.000	0.271	1.766	-0.934	-3.039
Transparency	2.000	5.000	0.047	0.309	-1.162	-3.780
Process Integration	2.000	5.000	0.063	0.409	-1.147	-3.732
Trust	2.000	5.000	-0.059	-0.381	-1.129	-3.672
Performance	2.000	5.000	0.003	0.020	-1.242	-4.039
Multivariate	—	—	—	—	-5.401	-5.144

The descriptive statistics calculated for all study variables indicate that the skewness values for all variables fall within the acceptable range of -2 to +2, while the kurtosis values fall within the acceptable range of -5 to +5. Therefore, it can be concluded that the distributions of the study variables do not significantly differ from a normal distribution and can be considered normally distributed.

Model fit indicates the extent to which the sample variance-covariance data support the proposed structural equation model. Absolute fit indices are based on the discrepancy between the observed variances and covariances and those predicted by the specified model parameters. In this category, model evaluation is neither based on comparisons with competing models nor dependent on the number of parameters specified by the researcher. Common absolute fit indices include the Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), Goodness-of-Fit Index (GFI), and Normed Chi-Square.

Comparative fit indices complement absolute fit indices by comparing the proposed theoretical model with one or more baseline models. These indices indicate whether the proposed model demonstrates superior, inferior, or equivalent statistical fit relative to alternative models. Comparative fit indices reflect the relative position of the model between the worst possible fit (0) and the best possible fit (1). Common comparative fit indices include the Tucker–Lewis Index (TLI), Normed Fit Index (NFI), Relative Fit Index (RFI), Incremental Fit Index (IFI), and Comparative Fit Index (CFI).

Table 2

Measurement Model Fit Indices

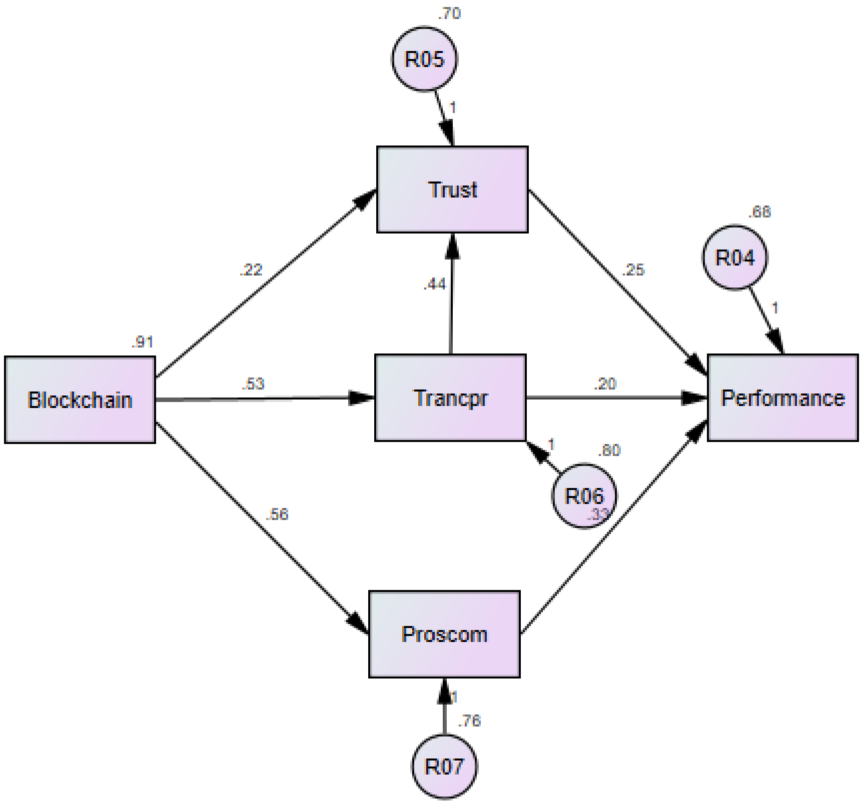
Fit Index	Acceptable Threshold	Obtained Value
Chi-Square / df	< 3.00	2.721
RMSEA	< 0.08	0.026
PNFI	> 0.50	0.802
GFI	> 0.80	0.941
AGFI	> 0.80	0.894
NFI	> 0.90	0.901
TLI (NNFI)	> 0.90	0.909
CFI	> 0.90	0.920
RFI	> 0.90	0.908
IFI	> 0.90	0.906

Based on the reported fit indices, it can be concluded that the measurement model demonstrates an acceptable and satisfactory level of fit.

A structural model was employed to examine the relationships between the independent and dependent variables and to test the conceptual framework of the study. The Maximum Likelihood Estimation (MLE) method was used to estimate the parameters of the structural equation model.

Figure 1

Structural Model with Standardized Path Coefficients



The results of the hypothesis testing are presented in Table 3.

Table 3

Structural Equation Modeling Results

Dependent Variable	Independent Variable	Unstandardized Path Coefficient	Standardized Path Coefficient	P-Value
Direct Effects				
Transparency	Blockchain	0.527	0.489	***
Trust	Blockchain	0.217	0.203	***
Process Integration	Blockchain	0.555	0.519	***
Trust	Transparency	0.444	0.446	***
Performance	Transparency	0.203	0.206	0.001
Performance	Process Integration	0.329	0.331	***
Performance	Trust	0.245	0.247	***
Indirect Effects				
Dependent Variable	Independent Variable	Unstandardized Path Coefficient	Standardized Path Coefficient	P-Value
Trust	Blockchain	0.234	0.218	***
Performance	Blockchain	0.400	0.377	***
Transparency	Performance	0.109	0.110	***

Given that the P-value for the effect of blockchain technology on transparency is less than 0.05, the direct effect of blockchain technology on transparency is statistically significant at the 95% confidence level. The standardized path coefficient is 0.489, indicating a positive and relatively strong effect. Therefore, improvements in blockchain technology are associated with increased transparency.

The P-value associated with the effect of blockchain technology on trust is also below 0.05, indicating a statistically significant direct relationship at the 95% confidence level. The standardized coefficient of 0.203 demonstrates a positive effect, suggesting that enhanced implementation of blockchain technology contributes to higher levels of trust among supply chain stakeholders.

Similarly, the effect of blockchain technology on process integration is statistically significant, with a P-value below 0.05. The standardized coefficient of 0.519 indicates a positive and relatively strong influence. Consequently, greater adoption of blockchain technology leads to improved integration of supply chain processes.

The results further reveal that transparency has a significant positive effect on trust. Since the P-value is below 0.05, the relationship is statistically significant at the 95% confidence level. The standardized path coefficient of 0.446 indicates that increased transparency substantially enhances trust among supply chain participants.

4. Discussion and Conclusion

The present study investigated the role of blockchain technology in improving supply chain performance in the oil and gas industry through the mediating mechanisms of transparency, trust, and process integration. The findings demonstrated that blockchain technology exerted significant positive effects on transparency, trust, and process integration. Furthermore, transparency, trust, and process integration were found to significantly enhance supply chain performance. The results also revealed significant indirect effects of blockchain technology on trust and overall performance, indicating that the benefits of blockchain extend beyond direct technological improvements and operate through organizational and relational mechanisms within the supply chain. Overall, the structural model exhibited satisfactory explanatory power and confirmed the strategic importance of blockchain technology as a transformative tool for enhancing the effectiveness of oil and gas supply chains.

One of the most important findings of the study was the significant positive effect of blockchain technology on transparency. The results showed that blockchain adoption substantially improves transparency within the supply chain network. This finding is consistent with previous studies that identified transparency as one of the primary advantages of blockchain implementation in supply chain environments (Bai & Sarkis, 2020; Francisco & Swanson, 2018; Uvet et al., 2025). The decentralized architecture of blockchain enables all authorized participants to access synchronized and immutable records of transactions, thereby reducing information asymmetry and increasing visibility across the entire supply chain. In the context of the oil and gas industry, where operations often involve multiple contractors, suppliers, logistics providers, and regulatory agencies, transparent information sharing becomes particularly valuable. The ability to monitor transactions in real time minimizes opportunities for data manipulation and strengthens accountability among stakeholders.

The positive relationship between blockchain technology and transparency can also be explained through information governance theory. Traditional supply chains frequently suffer from fragmented databases and disconnected information systems that limit visibility and delay decision-making. Blockchain creates a unified digital infrastructure in which all parties can access validated information without relying on centralized intermediaries. Similar conclusions were reported by Chang et al. in international trade applications and by Yi in logistics systems, where blockchain facilitated information accuracy and improved operational visibility (Chang et al., 2019; Yi, 2021). Likewise, Angelis and Ribeiro da Silva emphasized that blockchain serves as a value-generating mechanism by increasing information accessibility and reducing uncertainty among stakeholders (Angelis & Ribeiro da Silva, 2018). Consequently, the present findings provide additional empirical evidence supporting the notion that blockchain technology is a powerful enabler of transparency in complex industrial supply chains.

Another significant finding was the positive effect of blockchain technology on trust. The results indicated that blockchain adoption contributes directly to higher levels of trust among supply chain participants. This finding aligns with prior studies that have highlighted trust as a fundamental outcome of distributed ledger technologies (Kshetri, 2018; Saberi et al., 2019; Xia & Yongjun, 2017). Trust has historically been established through contractual agreements, audits, third-party verification, and long-term business relationships. However, blockchain introduces a technological trust mechanism in which transaction validity is ensured through cryptographic protocols and consensus procedures. Because records cannot easily be altered after validation, stakeholders become more confident in the reliability and integrity of shared information.

The significance of trust is particularly evident in the oil and gas industry, where projects often involve substantial financial investments, geographically dispersed operations, and extensive interorganizational cooperation. Blockchain reduces uncertainty regarding transaction authenticity, asset ownership, and compliance records, thereby enhancing confidence among business partners. The findings are consistent with those of Toyoda et al., who demonstrated that blockchain can improve product ownership verification and reduce counterfeiting risks, and with Pearson et al., who reported that distributed ledger technologies strengthen stakeholder confidence through enhanced traceability (Pearson et al., 2019; Toyoda et al., 2017). Furthermore, Bernabe et al. argued that blockchain's secure architecture can significantly enhance trust while maintaining data protection and privacy requirements (Bernabe et al., 2019). The present study extends these findings by demonstrating that similar trust-enhancing mechanisms operate effectively within oil and gas supply chains.

The study also found that blockchain technology significantly improves process integration. Among the direct effects examined, the impact of blockchain on process integration was one of the strongest relationships identified in the model. This result is highly consistent with the theoretical foundations of blockchain-enabled supply chain management and corroborates previous empirical findings (Falazi et al., 2019; Korpela et al., 2017; Mondragon et al., 2018). Process integration refers to the extent to which organizational activities, information flows, and operational procedures are coordinated across supply chain partners. Blockchain facilitates such integration by creating a shared platform through which transactions and operational data can be exchanged seamlessly.

In conventional supply chains, process fragmentation often results from incompatible information systems, duplicated documentation, and communication barriers among stakeholders. Blockchain addresses these challenges by establishing a single source of truth that synchronizes information across organizational boundaries. As noted by Korpela et al., blockchain supports digital supply chain transformation by enabling collaborative business processes and reducing administrative redundancies (Korpela et al., 2017). Similarly, Falazi et al. demonstrated that blockchain-aware business processes improve coordination and execution efficiency through automated and transparent workflows (Falazi et al., 2019). Therefore, the present findings reinforce the argument that blockchain serves as an important technological foundation for supply chain integration and operational alignment.

The results further indicated that transparency significantly enhances trust. This finding suggests that transparency functions not only as an outcome of blockchain implementation but also as a mechanism through which trust is strengthened among supply chain stakeholders. The relationship between transparency and trust has been widely recognized in supply chain management literature. When stakeholders have access to accurate, timely, and verifiable information, uncertainty decreases and confidence in partners increases. This finding is consistent with studies emphasizing the interconnected nature of transparency and trust in blockchain-enabled environments (Bai & Sarkis, 2020; Saberi et al., 2019; Uvet et al., 2025). In the oil and gas industry, transparent access to operational and transactional information may reduce disputes, facilitate compliance verification, and promote collaborative decision-making, all of which contribute to stronger trust relationships.

The findings also demonstrated that transparency positively influences supply chain performance. This result supports previous research indicating that transparency improves operational efficiency, accountability, responsiveness, and decision quality (Bai & Sarkis, 2020; Francisco & Swanson, 2018; Raja et al., 2025). Transparent supply chains enable managers to identify bottlenecks more rapidly, monitor supplier performance more effectively, and respond more efficiently to disruptions. The importance of transparency has become increasingly evident in the context of global supply chain uncertainties and disruptions, where visibility plays a critical role in maintaining operational continuity (Ivanov et al., 2019; Rizou et al., 2020). Therefore, the positive relationship observed in the present study underscores the strategic value of transparency as a driver of organizational performance.

Similarly, process integration was found to have a significant positive effect on performance. This finding is consistent with established supply chain management theories that emphasize coordination and collaboration as key determinants of operational success. Integrated processes reduce delays, eliminate redundant activities, improve resource allocation, and facilitate synchronized decision-making across organizational units. Previous studies have likewise reported that blockchain-enabled integration contributes to improved supply chain effectiveness and operational excellence (Centobelli et al., 2020; Mondragon et al., 2018; Treiblmaier, 2018). In the oil and gas sector, where activities are highly interdependent and operational disruptions can generate substantial financial consequences, process integration becomes particularly critical for achieving superior performance outcomes.

The positive effect of trust on performance represents another important contribution of this study. Trust facilitates cooperation, knowledge sharing, conflict resolution, and long-term partnership development among supply chain actors. Organizations operating within high-trust environments generally experience lower transaction costs and greater willingness to engage in collaborative innovation. These findings align with prior research highlighting the role of trust as a foundational element of supply chain effectiveness and sustainability (Kshetri, 2018; Saberi et al., 2019; Xia & Yongjun, 2017). In blockchain-enabled supply chains, trust emerges not only from interpersonal relationships but also from confidence in the underlying technological infrastructure, creating a dual mechanism through which organizational performance can be enhanced.

An especially noteworthy finding concerns the indirect effects of blockchain technology on trust and performance. The results revealed that blockchain influences performance not only directly but also through intermediary variables such as transparency and trust. This finding supports contemporary perspectives suggesting that the value of blockchain technology extends beyond technical functionality and encompasses broader organizational transformations (Queiroz & Wamba, 2019; Raja et al., 2025; Treiblmaier, 2018). The implementation of blockchain alters information-sharing practices, governance structures, and stakeholder relationships, thereby creating conditions that foster improved performance outcomes. Such indirect pathways may explain why organizations that successfully integrate blockchain into their operational processes often experience benefits that exceed initial expectations.

The findings are also consistent with emerging research on blockchain-supported risk management and decision-making systems. Studies have demonstrated that blockchain can improve the quality of managerial decisions by providing reliable, real-time information and enhancing visibility across complex supply networks (Xu et al., 2025; Zhang ،et al., 2025). In the oil and gas industry, where uncertainty, operational complexity, and risk exposure are particularly high, such capabilities can significantly strengthen organizational resilience and strategic agility. Moreover, blockchain adoption contributes to the development of dynamic capabilities that enable firms to adapt more effectively to environmental changes and maintain competitive advantage over time (Behi Far et al., 2025a, 2025b).

Taken together, the findings of this study provide strong empirical support for the strategic role of blockchain technology in transforming supply chain operations within the oil and gas industry. By enhancing transparency, strengthening trust, facilitating process integration, and ultimately improving performance, blockchain represents a powerful technological innovation capable of addressing many of the longstanding challenges associated with complex industrial supply chains. The results contribute to the growing body of literature demonstrating that blockchain should be viewed not merely as an information technology tool but as a comprehensive organizational enabler that supports collaboration, efficiency, resilience, and sustainable competitive advantage.

Several limitations should be considered when interpreting the findings of this study. First, the research employed a cross-sectional design, which limits the ability to establish causal relationships over time. Second, the study relied on self-reported questionnaire data, creating the possibility of common method bias and respondent subjectivity. Third, the sample consisted primarily of senior experts and information technology specialists, which may restrict the generalizability of the findings to other stakeholder groups within the oil and gas industry. Finally, the study focused on a specific industrial context and did not account for differences in organizational size, technological maturity, or regional regulatory environments that may influence blockchain adoption outcomes.

Future studies may adopt longitudinal research designs to examine how the effects of blockchain technology evolve throughout different stages of implementation. Researchers could also investigate additional mediating and moderating variables such as organizational culture, technological readiness, innovation capability, digital transformation maturity, and environmental uncertainty. Comparative studies across different industries or countries would provide valuable insights into contextual factors affecting blockchain effectiveness. Furthermore, future research may integrate objective operational performance indicators alongside perceptual measures to obtain a more comprehensive assessment of blockchain-related outcomes.

Managers and policymakers in the oil and gas industry should consider blockchain technology as a strategic investment rather than merely a technological upgrade. Organizations should prioritize pilot projects that focus on enhancing transparency, trust, and process integration across critical supply chain activities. Investments in employee training, digital infrastructure, and stakeholder collaboration mechanisms are essential for maximizing the benefits of blockchain implementation. Companies should also establish clear governance frameworks and interoperability standards to facilitate information sharing among supply chain partners. Finally, decision-makers should integrate blockchain initiatives into broader digital transformation strategies to ensure alignment with long-term organizational objectives and sustainable competitive advantage.

Authors' Contributions

Authors contributed equally to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

In this research, ethical standards including obtaining informed consent, ensuring privacy and confidentiality were considered.

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