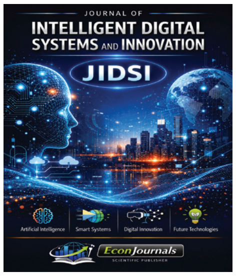

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The Roles of Blockchain Adoption and Smart Contract Automation in Improving Supply Chain Digital Efficiency

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ABSTRACT

This study investigates the relationship between blockchain application and smart contract automation (SCA) and their effect on supply chain digital efficiency (SCDE). The study is focused on logistics companies and food distribution companies in Jordan. They looked at both direct and indirect effects using SCA as the mediator. Purposive sampling was used in this study. A total of 408 respondents from logistics and supply chain firms in Jordan who were directly engaged in procurement, distribution and operations were used for this study. The analysis of data used in this research was structural equation modeling (SEM) to prove the direct and indirect effects in the research model. The results of the research indicate a direct and positive impact of blockchain and SCA on SCDE. Additionally, there is a positive indirect effect, with blockchain affecting SCDE, mediated by SCA. Finally, this study confirms the results of the previous studies, there are both direct and indirect implications for supply chain efficiency. The use of blockchain technology and SCA plays a crucial role in the transition to digital supply chains and its impact on operational accuracy, transparency, and transaction reliability. All these factors guarantee logistics performance and digital competitiveness in the long-term. This is unique research because of its research context. In this study, the researchers chose logistics firms and food distribution companies in Jordan as the subjects of the study, as they are most likely to be affected by SCDE influenced by blockchain and SCA. Digital supply chain transformation is a key element in achieving operational excellence and in being competitive in emerging markets.

Keywords: Blockchain Adoption, Smart Contract Automation, Supply Chain Digital Efficiency, Logistics Innovation, Business Performance
JEL Classifications: C8

1. INTRODUCTION

As supply chains evolve at unprecedented speeds, the need for transparency, efficiency, and security within digital infrastructures has also grown. Especially in emerging economies, where logistics inefficiencies are a significant obstacle to competitiveness (Xiong et al., 2025), transparent, efficient, and secure digital infrastructures are more in demand than ever before. In this context, blockchain has been a game-changing technology that has improved traceability, data integrity, and decentralized coordination in supply chain networks (Oriekhoe et al., 2024). In blockchain, the records of transactions are permanently recorded, which means that fraud cannot be prevented and it enhances the trust of the stakeholders in the operations (Shehadeh, 2025). On the other hand, SCA can facilitate self-executing contracts which can eliminate administrative delays, human errors, and provide higher efficiencies in logistics processes (Grida and Mostafa, 2023). The choice of these variables is based on their being the technological pillars of next generation digitalization of supply chains: being algorithmically executed rather than by humans, and being decentralized and validated through mechanisms (Agrawal et al., 2023).

This study employed an empirical context of the logistics and food distribution sector in Jordan as it serves as an important link in the national economic stability and facilitates trade. Despite the important role played by Jordan's logistics sector in the GDP and regional trade connectivity, there are ongoing problems in the sector, including poor supply chain integration, high operating costs, and the lack of digital integration (Ameyaw et al., 2023). Though the investment efforts in digital transformation initiatives have grown, many processes in the supply chain are still partly digitalized, which reduces efficiency and transparency in the chain (Weerapperuma et al., 2025). This structural imbalance is well poised for exploring the innovation in supply chain systems enabled by blockchain. The literature already available presents some weaknesses in the existing studies. Most of the previous studies are conceptual in nature with little attempt to provide empirical validation of blockchain using SEM approaches (Xiong et al., 2025) or concentrating on larger economies while neglecting smaller emerging economies despite the rising trend of digital transformation projects (Bandhu et al., 2023), and operational efficiency outcomes in real logistics environment, especially in food distribution systems (Kumar et al., 2025), where time sensitivity plays an important role.

The main purpose of this study is to investigate the direct effect of blockchain adoption on SCDE, and the indirect effect via SCA. Furthermore, the aim of the research is to give an empirical validation through the use of the SEM to increase the accuracy of the prediction in technological supply chain studies. The motive of this study is to overcome the technological inefficiencies in the Jordanian logistics industry and to add to the global conversation on the digital transformation of the supply chain. This study is unique because it is an integrated one that applies blockchain and smart contracts to an emerging economy context. It also applies to logistics and food distribution companies, where in real time coordination and transactional accuracy are essential for performance enhancement. Theories can be extended from this study as it forms part of the digital supply chain innovation literature, and the findings benefit managers, policy makers, and technology developers. It highlights the fact that the adoption of technology alone is not enough to achieve SCDE, but also the automation mechanisms that dictate how the transactions are executed. In summary, this study comes up with a structured framework in terms of understanding the potential of blockchain ecosystems in enhancing the performance of supply chains in the developing countries of the world, particularly Jordan when integrated with SCA.

2. THEORETICAL BACKGROUND

The theoretical foundation of this study mainly focuses on resource based view (RBV) theory and transaction cost economics (TCE) Theory, which can explain the improvement of SCDE in the field of logistics and food distribution by blockchain technology and SCA. According to RBV Theory, the valuable, rare, inimitable and non-substitutable organizational resources create competitive advantage, which lead to organizational performance (Barney, 1991). Digital supply chains are seen as a strategic intangible resource to improve transparency, traceability, and data integrity within multi-stakeholder networks (Natanelov et al., 2022). Blockchain systems effectively implemented by firms provide better coordination, less information asymmetry, and greater operational efficiency (Khan et al., 2023). SCA also further empowers this resource capability because it allows for the execution of agreements without manual input, which adds to process reliability. (Brahmi et al., 2025) Therefore, RBV theory is chosen as a theoretical framework because it addresses the issue of technological resources in blockchain ecosystems that create long-term digital efficiency benefits in supply chain operations (Hussain, 2022). TCE complements the RBV by emphasizing the efficient gains in terms of cost minimization in exchange processes. According to TCE, the goal of firms is to minimize the costs of negotiation, monitoring and enforcement of contracts (Williamson, 1985). These expenses can be significantly reduced by implementing blockchain, which offers decentralized verification mechanisms without the need for intermediaries and decreases trust-related expenses (Grida and Mostafa, 2023). Furthermore, SCA decreases transaction costs by enabling the automatic enforcement of contractual obligations, which helps to reduce delays and disputes in the logistics processes (Bandhu et al., 2023).

This theoretical framework is especially applicable to the context of the supply chain in developing countries, such as Jordan, where inefficiencies and coordination costs persist (Natanelov et al., 2022). That is why it is worth studying the combined capability of blockchain and smart contracts to maximize operational efficiency, minimize transactional frictions, and, ultimately, provide a compelling justification for the use of the technology. This is why the effects of the joint application of blockchain and smart contracts on operational efficiency, reducing transactional frictions, is worth studying. Empirical studies conducted in the past have found that these theories can be integrated and use these theories to explain digital supply chain transformation. This aligns with the RBV assumptions that blockchain adoption has a significant impact on supply chain transparency and operational efficiency as Singh and Kumar (2022), Natanelov et al. (2022) found. Likewise, Grida and Mostafa (2023) and Kumar et al. (2025) showed that blockchain decreases uncertainty and increases the efficiency of coordination in logistics systems. Blockchain reduces the costs of transactions by reducing the number of verifications and the need to trust, as shown by Bandhu et al. (2023) and Ameyaw et al. (2023) from a TCE perspective. In addition, Brahmi et al. (2025) and Xiong et al. (2025) highlighted the role of smart contract automation in improving execution efficiency and minimizing contractual friction in digital ecosystems.

However, several studies like Eletter et al. (2022) pointed out that without the inclusion of automation mechanisms, blockchain does not necessarily optimize performance of the supply chain, theoretically. Further research in emerging countries Kumar et al. (2025) found that the usefulness of the blockchain is limited without the implementation of automated systems if it is not supported by digital infrastructure. Hussain (2022) and Khan et al. (2023) emphasized the importance of integrated digital mechanisms for supply chain resilience instead of single technologies being adopted. Likewise, Weerapperuma et al. (2025) and Oriekhoe et al. (2024) pointed out that complete transaction cost reduction benefits can only be obtained through the use of automation. Together, these findings support the joint application of RBV and TCE as complementary lenses: RBV helps to understand the strategic value of blockchain resources, while

TCE helps to understand how cost reduction mechanisms can help achieve efficiency gains. So, RBV can be combined with TCE to offer a full theoretical framework, which encompasses both the value creation and cost minimization aspects of blockchain and SCA. This dual-theory approach enhances the explanatory power of the study model, and bridges the gap in previous literature, which examined technological adoption and operational efficiency as two separate processes and not as intertwined mechanisms in digital supply chain systems.

2.1. Blockchain Adoption and Supply Chain Digital Efficiency

In the context of the modern supply chain, blockchain has proved to be a core digital infrastructure to transform transparency, traceability, and trust in today's supply chain environment (Singh and Kumar, 2022). In logistics and food distribution, the absence or incompleteness of the data exchange and information asymmetry can significantly affect the performance of the systems, in which blockchain integration can be considered a key strategic asset for optimizing the overall system performance (Natanelov et al., 2022). Through blockchain, validation and record keeping are decentralized, and there is no need for trust in intermediaries, leading to more accurate, real-time data across supply chain participants (Khan et al., 2023). This technological capacity improves the efficiency of coordinating and reduces delays in procurement, transportation, and distribution (Agrawal et al., 2023). Furthermore, the use of blockchain enhances trust between the stakeholders by securing and verifying transactions in multi-tier supply chain networks (Khan et al., 2023). Empirical research also shows that blockchain-supported organizations have better transparency and lower operational uncertainty, resulting in better supply chain performance (Hussain, 2022; Ameyaw et al., 2023). But it is important to note that the impact of blockchain can be largely influenced by supporting automation mechanisms that enable the operationalization of digital transactions fully (Shehadeh, 2025). In complex logistics environments, blockchain may not be able to fully optimize efficiency without the structured execution systems (Eletter et al., 2022). Hence, blockchain is a strategic technological capability that can help organizations improve the capabilities of SCDE, specifically by increasing data integrity, decreasing coordination costs, and supporting greater inter-organizational collaboration, especially in increasingly digital global markets (Bandhu et al., 2023).

H_1: Blockchain positively affects SCDE.

2.2. Blockchain Adoption and Smart Contract Automation

In today's supply chain landscape, which is defined by advanced digital coordination mechanisms, blockchain is increasingly seen as a backbone supporting logistics-intensive and data-heavy industries (Xiong et al., 2025). Its biggest downside is the facilitation and acceleration of SCA, turning the traditional contract process into a self-executing digital contract within a distributed ledger system (Hussain, 2022). The blockchain-based infrastructures lower the need for manual verification and an intermediary approval before transaction is triggered, and hence enable more accurate procedures with greater responsiveness of the system due to the ability of smart contracts to execute transactions automatically when necessary conditions are met (Rauniyar et al., 2023). The empirical literature indicates that the conditions of data reliability and secure transaction environments are leading to the use of automated contractual systems by organisations using blockchain frameworks (Nalawade et al., 2024). Moreover, the decentralization of blockchain also promotes trust among the stakeholders in the supply chain, a crucial prerequisite for the implementation of automated execution systems in multi-party systems (Brahmi et al., 2025). In logistics business, where the need for real-time coordination and accuracy is paramount, SCA can seamlessly integrate with blockchain-powered systems, minimizing administrative tasks and streamlining logistics processes (Hussain, 2022). Research also shows that blockchain integration improves system interoperability, enabling smart contracts to operate across different and varying supply chain platforms (Singh and Kumar, 2022). Thus, blockchain not only provides a technological backbone but also a catalyst to facilitate the creation and implementation of automated contractual processes in the digital supply chain.

H_2: Blockchain positively affects SCA.

2.3. Smart Contract Automation and Supply Chain Digital Efficiency

SCA has become a game-changing tool for blockchain-based supply chain systems, improving operation accuracy, execution speed, and transaction reliability (Rauniyar et al., 2023). Smart contracts, written in digital code, can incorporate specific terms and conditions into the agreement, eliminating the need for manual execution and thus minimizing risks of human error, administrative delays, and coordination inefficiencies in logistics networks (Khan et al., 2023). In a supply chain with multiple stakeholders and high transactions, these automation solutions can help to ensure that procurement, shipment tracking, and other processes are carried out in real time, enhancing overall digital efficiency (Hussain, 2022). Empirical research shows that automated contractual systems can improve the consistency and transparency of data, a crucial factor for ensuring the smooth coordination of the supply chain (Khan et al., 2023). In addition, smart contract automation minimizes reliance on third parties, thus minimizing transaction expenses and enhancing the speed of response in intricate logistics systems (Eletter et al., 2022). By incorporating blockchain infrastructure, smart contracts further enhance their reliability, guaranteeing secure, tamper-proof, and verifiable data inputs for automated execution procedures (Agrawal et al., 2023). Research also indicates that automation improves the scalability of supply chain activities by allowing them to be executed in tandem in a distributed network that lacks a central control unit (Natanelov et al., 2022). Therefore, the importance of SCA in making the structural power of blockchain measurable efficiency gains and ensuring that digital supply chains function more quickly, accurately and effectively in the increasingly dynamic global markets (Khan et al., 2023).

H_3: SCA positively affects SCDE.

2.4. Mediating Role of Smart Contract Automation

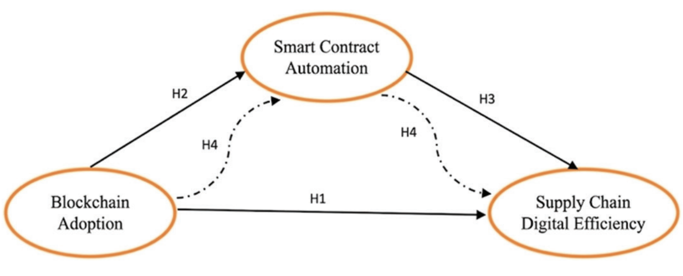
The use of blockchain is known to be a game-changer in the digital landscape, offering increased transparency, traceability, and coordination efficiency within the modern supply chain ecosystem (Kumar et al., 2025). Its decentralized design minimizes the need for intermediaries and ensures data integrity, fostering an environment that is conducive to automated digital processes (Grida and Mostafa, 2023). But the advantages of blockchain come when it connects with SCA, which translates the blockchain data into actions in the supply chain network (Nalawade et al., 2024). This integration allows blockchain-based systems to validate and execute logistics transactions in real time, minimizing delays and improving the responsiveness of logistics operations (Xiong et al., 2025). The findings of empirical studies show that organizations that implement blockchain-based structures have better levels of trust and coordination, and this in turn enhances the effectiveness of automated contractual mechanisms (Natanelov et al., 2022). Smart contracts, on the other hand, convert the verified data on the blockchain into automatic execution processes, thereby maintaining seamless workflow continuity throughout the procurement, distribution and payment processes (Singh and Kumar, 2022). It is also found that this integrated digital structure would help to lower the transaction cost, increase scalability and eliminate operational inefficiencies in complex logistics scenarios (Nalawade et al., 2024). Furthermore, blockchain's robust and transparent ledger system bolsters the trustworthiness of executing smart contracts as only verified and tamper-proof data activates automated actions (Khan et al., 2023). Therefore, the interaction between blockchain adoption and SCA has a synergistic effect that greatly boosts SCDE, as it increases transparency, lowers friction, and allows for a synchronized coordination of multiple actors in global logistics processes (Shehadeh, 2025). The conceptual model of the study is presented in Figure 1.

H_4: Blockchain has an indirect positive effect on SCDE, mediated by SCA.

3. METHODS AND DATA

This research used an exploratory research methodology and viewed the implications and influences among the variables (Rauniyar et al., 2023). Blockchain and SCA were treated as exogenous variables and SCDE was treated as endogenous variable. SCA was a mediator between blockchain and SCDE. Assumptions of direct and indirect effects on the implementation of SCDE were explained in the research model. The research process involved in the study was an examination of the size of implications between variables indicated by indicators. This

Figure 1: Conceptual model



study was carried out in the field on some logistics companies and food distribution companies in Jordan. Digital coordination, transparency and speed of operation was critical to the businesses' ability to meet market needs and adjust to disturbances in the supply chain. A Google Form was used to collect the data. The study was similar to previous research (Bandhu et al., 2023) and the implications were done by literature review. The study results will differ according to the goal of the study and the availability of data for the study, as they constitute the basis of information in the study.

3.1. Sampling

Purposive sampling was the sampling technique used in this study. The method of purposive sampling involves using certain criteria or classifications based on the research need (Eletter et al., 2022). The research sample comprised employees from logistics, procurement and distribution operations in supply chain companies. To determine the qualification of the respondents (first stage in the sampling process), a minimum of 2 years of professional experience, operational or managerial level positions and at least a diploma as the minimum educational requirement are required. Number of respondents is 520. But, the data analysis and research work is done after a questioner eligibility selection process. This is for the purpose of equating the qualifications of the respondents and the quality of the answers given for every research indicator. The use of research database was preceded by filtering in the research questionnaire which resulted in the identification of 408 respondents that were eligible and were selected. This process guarantees the validity, reliability and representativeness of the population. The research base is expected to deliver extensive information, and a foundation for recommendations for optimization of the logistic chain and supply chain in terms of digital efficiency.

3.2. Research Instrument

In this study, the main data collection method used is questionnaire. The research questionnaire has 19 questions. Blockchain is known for its transparency, traceability, and data integrity, along with decentralized transaction verification (Grida and Mostafa, 2023). The operational speed, the accuracy of coordination, the reduction of costs, and the flow of information in real-time were the characteristics of SCDE (Eletter et al., 2022). SCA was analyzed using automated execution indicators, error reduction, process synchronization and reliability of transactions (Brahmi et al., 2025). The number of questions in the following groups were used to assess blockchain, SCA, and SCDE adoption: 6, 6, and 7, respectively (Table 1). In the study, the research questionnaire used was a Likert scale to measure the perceptions of the respondents. The response was scored on a 5-point scale: 1 = strongly disagree, 2 = disagree, 3 = neither, 4 = agree, and 5 = strongly agree. The questions were sent via Google forms, so that they could be tabulated and analysed.

3.3. Data Analysis

The SEM technique was used in this research to analyze the direct and indirect relationship between variables. Using variance based SEM, which is geared towards testing the predictive influence of each variable. The idea of variance-based SEM is to check

Table 1: Questionnaire instrument

Variable	Indicators	Sample questionnaire items	No. of items
Blockchain adoption	Transparency, traceability, data integrity, decentralization	(1) Blockchain provides transparent transaction records in supply chain operations. (2) Blockchain ensures traceability of goods across the logistics network. (3) Blockchain improves data integrity in supply chain transactions. (4) Blockchain reduces dependency on central intermediaries. (5) Blockchain enhances trust among supply chain partners. (6) Blockchain improves real-time information sharing in operations.	6
SCA	Automated execution, error reduction, synchronization, reliability	(1) Smart contracts automatically execute supply chain agreements. (2) Smart contracts reduce manual errors in transactions. (3) Smart contracts improve synchronization between supply chain partners. (4) Smart contracts ensure reliable execution of logistics processes. (5) Smart contracts reduce delays in procurement and delivery. (6) Smart contracts improve operational efficiency in digital supply chains.	6
SCDE	Speed, accuracy, cost efficiency, real-time flow	(1) Supply chain processes operate faster with digital technologies. (2) Digital systems improve accuracy in logistics operations. (3) Digital transformation reduces operational costs in supply chains. (4) Real-time data improves decision-making efficiency. (5) Digital systems enhance coordination across supply chain actors. (6) Technology improves overall logistics performance. (7) Digital tools support continuous supply chain optimization.	7

the predictive relationship between constructs, that is, whether constructs are related or whether there is an influence between constructs (Kumar et al., 2025). SEM is a regression or path analysis technique built around measurement and structural models that is used to explore direct or indirect relationships between research variables (Oriekhoe et al., 2024). Blockchain was regarded as exogenous variable, SCA was regarded as mediating variable and SCDE was treated as endogenous variable. The first step is to analyze the research indicators with outer loading value of 0.6 or 0.7. The second stage involves the evaluation of validity and reliability elements and the Cronbach's Alpha, Rho-a and the value of composite reliability is taken as 0.7 and above (Agrawal et al., 2023). The third step is to explore discriminant validity and to compare AVEs against cross-loadings in terms of Fornell-Larcker's criterion (Rauniyar et al., 2023). If the indicators make the criteria of validity - reliability and indicator suitability, then the discussion continue on the implications of the research model. The fourth step is to interpret the coefficient of determination (R-square), which between 0% and 100%, which explain the variance in the model (Shehadeh, 2025). Thus there is a high correlation between the two variables. In the fifth stage, hypothesis testing was performed using the $P < 5\%$ and T value > the T-table, meaning that the hypotheses can be accepted so that the influence expected in the research formulation (Hair et al., 2022) is found.

4. RESULTS

4.1. Respondent Profile

In this study, there were 408 respondents. In this study, respondents are employees of logistics and supply chain companies in Jordan, and the SCDE is studied according to the blockchain adoption and implications of SCA. The following Table 2 shows the profiles of the respondents.

Table 2: Respondent profile

Category	Dimensions	Percentage
Gender	Male	57
	Female	43
Age	21-25 years	22
	26-30 years	28
	31-35 years	19
	Above 35 years	31
Field of education	Supply chain management	34
	Information technology	30
	Business administration	26
	Others	10
Academic level	Diploma	38
	Bachelor's degree	36
	Master's degree	22
	Doctoral degree	4
Work experience	0-5 years	30
	6-10 years	27
	11-15 years	23
	Above 15 years	20
Digital system usage	High	44
	Moderate	39
	Low	17

4.2. Statistical Results

The first step is to investigate the research indicators containing outer loading values. This process is done to analyze the suitability of indicators for every variable in the research model. Based on the research model, the table below presents the outer loading which has been obtained in the study: Table 3 indicates that all indicators are considered appropriate as the basis of information for the research model. All indicators are >0.7, which is the outer loading criteria. This make sure that all indicators are capable of representing their respective variables in research implications analysis. Table 3 shows that all variables are valid and reliable based on the values of Cronbach's Alpha, rho-a, composite reliability and AVE. This can be seen in the Cronbach's Alpha, rho-a and composite reliability values that are all >0.8. An explanation for the presence of a determination effect between the mediating variable and the endogenous variable is shown in Table 3. SCA is the mediating variable that can simultaneously account for 49.9% of the relationship between blockchain adoption and SCDE. Both Blockchain and SCA can account for 49.9% of the variance of SCDE. The variance of SCDE can be fully explained by both Blockchain and SCA. All entering construct variables affect both determination coefficients, which is in the moderate range, for R-Square. Therefore, there is scope to add more variables which can be included in research model beyond the variables used.

Table 3: Measurement research model

Variables	Indicator	Outer loading	Cronbach's alpha	rho_A	Composite reliability	Average variance extracted	R-square
Smart contract automation	SCA1	0.721	0.821	0.835	0.872	0.572	0.499
	SCA2	0.812					
	SCA3	0.718					
	SCA4	0.779					
	SCA5	0.768					
	SCA6	797					
Blockchain	BA1	0.879	0.928	0.931	0.944	0.732	-
	BA2	0.886					
	BA3	0.818					
	BA4	0.833					
	BA5	0.889					
	BA6	0.822					
Supply chain digital efficiency	SCDE1	0.865	0.954	0.956	0.962	0.753	0.489
	SCDE2	0.877					
	SCDE3	0.866					
	SCDE4	0.885					
	SCDE5	0.786					
	SCDE6	0.873					
	SCDE7	0.891					

4.3. Discriminant Validity and Hypothesis Testing

Also, the AVE values are >0.5. A successful discriminant validity of the scales has been found by comparing the AVE values with the cross-loading values in the Fornell-Criterion. The discriminant validity value is shown in the following table. Table 4 elaborates why Fornell's cross loading values are more important than the AVE values. This suggests the research variables have the discriminant validity criterion. The research data, which became the basis of the information, have succeeded in fulfilling the requirements in terms of validity and reliability. All research indicators are able to move on to hypothesis testing. The last step was to test the hypotheses, whose results are presented in Table 5.

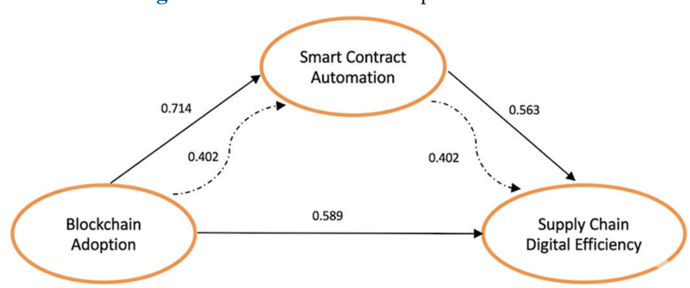
Table 5 provides the explanation of all variables being in the positive direction, which is consistent with the hypotheses. All hypotheses were accepted, meaning that there was a positive relationship between the variables. The first result is accepted as it has P-values below 0.05 and the T-statistic is higher than the T-table value (13.084 > 1.98), showing that blockchain has the positive impact on SCDE. The second result shows that the blockchain has a positive impact on SCA, which is statistically significant. The third result is accepted; it shows a positive influence of SCA on SCDE thus demonstrating the operational significance. The fourth result has a P-value smaller than 0.05, and a T-statistic that is larger than the T-table value (1.98). In the indirect effect, SCA serves as a key predictor, enhancing the impact of blockchain on SCDE. The results of the research suggest that blockchain and SCA can have a direct and indirect impact on SCDE. A representation of the results of the structural model is shown below.

Figure 2 shows that the research model which includes the direct and indirect influences can solve the implications for each research variables. The blockchain, SCA, SCDE, affects one another in the formulation of each of the relationships. This study suggests a SCDE needs to be characterized by transparency via blockchain

Table 4: Discriminant validity

Variables	SCA	Blockchain adoption	SCDE
SCA	0.761		
Blockchain	0.714	0.862	
SCDE	0.698	0.589	0.871

Figure 2: Research model Implication value



and automated execution systems. Smart contracts provide balance in operational coordination and improve efficiency results. This is a confirmation that innovation have to be incorporated continuously within supply chain processes, with high accuracy and transparency. Blockchain for logistics and food distribution companies should be operation-focused. As a mediator, SCA has established that the effective implementation of a digital approach must be based on regular execution processes. Blockchain builds trust and reliability within the supply chain network. With this, it can be concluded that SCDE is formed by direct and indirect mechanisms, and the most important place is occupied by blockchain in maximizing the mechanism of the operational transformation.

5. DISCUSSION AND IMPLICATIONS

Based on the results of this study, it is very clear that blockchain technology and SCA play an important role in improving the performance of SCDE in logistics and food distribution companies

Table 5: Hypothesis testing

Relationship	Path coefficient (O)	T-statistic	P-value	Result
Blockchain→SCDE	0.589	13.084	0.000	Accepted
Blockchain→SCA	0.714	27.118	0.000	Accepted
SCA→SCDE	0.563	9.642	0.000	Accepted
Blockchain→SCA→SCDE (Indirect effect)	0.402	8.957	0.000	Accepted

in Jordan. The first significant result shows that blockchain has a substantial positive impact on SCDE. This discovery aligns with Ameyaw et al. (2023), and Shehadeh (2025), who claimed that blockchain providing transparency, traceability and coordination in supply chain systems. In the same way, both Rauniyar et al. (2023) and Agrawal et al. (2023) have determined that blockchain minimizes information disparity and enhances operability in logistics settings. The current outcome also supports the findings of Khan et al. (2023) that blockchain has proved to be beneficial for the supply chain responsiveness in emerging economies. But, some research like Singh and Kumar (2022) has posited that performance optimization is not complete if blockchain is used without the digital mechanisms of some other types of research, thus making it partially context-dependent. The second key result is that blockchain has a great impact on SCA. This was corroborated by Kumar et al. (2025) and Brahmi et al. (2025) who viewed smart contracts as an integral part of the blockchain architecture. Brahmi et al. (2025) and Oriekhoe et al. (2024) additionally established that blockchain infrastructure can be used to create execution systems that are automatic, secure, and verifiable, as it ensures that data inputs are secure and verifiable. Likewise, Weerapperuma et al. (2025) and Bandhu et al. (2023) highlighted the importance of blockchain for generating a decentralized environment for automation processes. Some studies, however, like that of Eletter et al. (2022), expressed that the organizational readiness can moderate the relationship and that this relationship may differ across industries, with different levels of effectiveness of the adoption. The third result indicates that SCA has a positive impact on SCDE. This observation is similar to that made by Khan et al. (2023) and Natanelov et al. (2023) where they emphasized the fact that automation minimizes human involvement and enhances accuracy in transactions. Agrawal et al. (2023) and Xiong et al. (2025) also showed that automated systems can help to improve the synchronization and operational speed of logistics networks.

In an analogous manner, Hussain (2022) and Grida and Mostafa (2023) also established that automation can improve cost efficiency and minimize delays in the implementation of the supply chain. Khan et al. (2023) suggested that excessive automation can lead to system rigidity, causing loss of adaptability in changing situations. The fourth finding - and most integrative - is that blockchain exerts a significant indirect effect on SCDE via SCA. This discovery is consistent with Shehadeh (2025) and Eletter et al. (2022) who highlighted that the potential benefits of blockchain are most clearly realised when linked to automation mechanisms. Similarly, Kumar et al. (2025) and Khan et al. (2023) claimed that digital supply chain performance is entirely dependent on the integration of technological ecosystems instead of standalone innovations. Agrawal et al. (2023) and Hussain (2022) also corroborated the benefits of blockchain-powered automation in terms of providing greater visibility and coordination across the supply chain. But the indirect evidence from Singh and Kumar (2022) and Hussain (2022) indicates that full implementation of indirect effects could be hindered by infrastructural constraints in developing countries.

The overall results reinforce previous studies since they tested both direct and mediated relationships in a single structural model, using an empirical approach. Previous studies primarily looked at blockchain or smart contracts separately (Khan et al., 2023; Singh and Kumar, 2022), but this study combines both to provide a comprehensive understanding of SCDE. This approach is in response to the lack of comprehensive models that capture interaction effects called for by Khan et al. (2023) and Agrawal et al. (2023). The findings further illustrate that digital transformation in supply chains is not about technology alone but is born out of synergistic integration of blockchain infrastructure and automation technologies in operational environments.

5.1. Theoretical Contributions

This study is theoretically strong in incorporating RBV and TCE Theory in the context of blockchain and SCA in SCDE. According to RBV, competitive advantage is created by the use of valuable, rare and inimitable technological resources (Barney, 1991). In this research, blockchain is perceived as a strategic digital resource that boosts transparency, traceability, and coordination capability within the supply chains. SCA further enhances this resource by turning the blockchain infrastructure into operational capability in the form of executable code. TCE complements RBV with the explanation of efficiency gains brought about by lower transaction costs, less uncertainty, and the elimination of middlemen. What blockchain does is lower the costs associated with verification and coordination and smart contracts are responsible for enforcing these mechanisms. The combination of both theories extends the previous research by establishing that SCDE arises from the two theories as well, resource capability and minimizing transaction costs. These theories were previously studied individually (Weerapperuma et al., 2025; Oriekhoe et al., 2024), but this study is combined into one explanatory model. This theoretical blending of the fields helps to understand how blockchain ecosystems add value during operation in the context of logistics in a developing economy such as Jordan, where digital transformation has not yet reached its full potential.

5.2. Practical Implications

The results of this study have significant practical implications for logistics managers and supply chain practitioners. Blockchain should be seen as a key digital infrastructure for supply chain, in the sense that it can be used to improve transparency and operational traceability throughout the supply chain process. Jordan's logistics companies need to connect with technology vendors to tackle infrastructure challenges and drive digitalization forward. Employees should also be educated on various blockchain and automation tools to further enhance their technical understanding and proficiency in handling such systems. Logistics firms should invest in smart contract automation systems to minimize manual operations and enhance execution precision in procurement, shipping, and payment processes. In summary, the study leads practitioners toward the creation of integrated digital ecosystems, enabling faster, more reliable, and more cost-effective operations in supply chains.

5.3. Social and Policy Implications

The findings of this study have implications for policy makers and society in the context of digital transformation. Establish national frameworks for the adoption of blockchain to harmonize transparency in the supply chain and streamline the logistics processes. Policy support is needed to encourage investment in smart contract technologies to enhance automation in trade and distribution systems. Regulatory bodies should ensure the legality of blockchain transactions and smart contracts to create institutional trust. Socially, the gains in supply chain efficiency leads to reduced product costs, better service delivery and consumer confidence in the digital system. In developing countries such as Jordan, these policies could help improve the competitiveness of the country in international trade networks. In addition, public-private partnerships should be encouraged in the development of digital infrastructure. In conclusion, the study highlights the need for harmonization between technology innovation and regulatory and social structures to foster sustainable digital transformations.

5.4. Teaching and Academia Implications

This study offers relevant suggestions for business, information systems and logistics education. Blockchain and smart contracts should be included in universities' education related to supply chains and information technology. The application of digital supply chain system should be explained by using case learning. Technical and managerial knowledge of blockchain ecosystems should be imparted to students. Academic programs should also focus on interdisciplinary learning and integrate economics, technology and logistics management. In addition, research-informed teaching should be promoted to introduce students to new technologies that are influencing the world's supply chains. This study also brings attention to the development of simulation-based learning tools that aid students to understand the automated digital systems in practice. Academia has an important role in preparing the future professionals for the blockchain supply chain context.

6. CONCLUSION

The findings of this study reveal that blockchain and SCA are crucial in improving the SCDE. The results validate a blockchain as a basic framework of digital infrastructure that enhances transparency, traceability, and trustworthiness, and SCA turns the digital infrastructure into operational efficiency by executing it automatically. The integrated model proves that the performance of the supply chain is greatly enhanced both directly and indirectly. The study also finds that a combination of blockchain systems with automation technologies also has a synergistic effect on the efficiency of operations, and that digital transformation is most effective when combined. The study, based on RBV and TCE theories, emphasizes the importance of competitive advantage in contemporary supply chains from both strategic digital resources and transaction cost reduction mechanisms. Summation, the study offers ample empirical evidence on the role integrated digital technologies plays in the supply chain system transformation in emerging economies.

The study has following shortcomings: It is cross-sectional and does not capture long-term effects of blockchain. The study is geographically limited to Jordan which may limit the generalizability of the results to other regions and does not include other sectors like manufacturing or healthcare, and the study does not include external moderating factors like the regulatory environment or technological readiness. Longitudinal studies are recommended for future studies to better identify dynamic effects over time. To increase external validity, comparative studies across countries are suggested. Other moderating factors such as organisational readiness, digital maturity or regulatory support could also be included in future research. Further, qualitative methods might be used to gain a greater understanding of any implementation difficulties. Incorporating sustainability or resilience measures would further enhance the academic understanding on the transformation of a digital supply chain.

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