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ORIGINAL RESEARCH

Critical Role of Coopetition Among Supply Chains for Blockchain Adoption: Review of Reviews and Mixed-Method Analysis

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Abstract *The major purpose of this study is to investigate the role of coopetition among supply chains in blockchain adoption leading to sustainability in supply chains. This research uses a three-step process. First, a review of reviews is conducted to search the variables that would positively influence adoption of blockchain in supply chain. In the second step, total interpretive structural modeling (TISM) was utilized to understand the relationships among the enablers. Following the qualitative phase, an empirical study was conducted to test the hypotheses related to the mediating role of coopetition. Review of reviews identified 17 variables that can positively influence blockchain adoption in supply chain. The findings of TISM model revealed the hierarchical relationship among the enablers of blockchain adoption for supply chain management based on their relative importance. The results of the SEM-based study indicated that 'coopetition' plays a mediating role between the driver and dependent variables leading to sustainable supply chain. The research offers practical insights to integrate blockchain application in the supply chains leading to better supply chain transparency and ultimately sustainability. The research would support managers to develop suitable strategies to strengthen mechanism to enhance coopetition among competing supply chain to realize the benefits of emerging technologies. The originality of the study lies in the study of variables that influence blockchain adoption in supply chain using a mixed-method approach. Further, the research establishes the critical role of coopetition in achieving the benefits of blockchain adoption.*

Keywords Coopetition · Supply chain management · Blockchain · Sustainability

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Introduction

Blockchain (BC) is a fast-growing and emerging technology with significant benefits (Khanfar et al., 2021) and the potential to disrupt old business models (Chang et al., 2020). Attributes of BC like data security, real-time information sharing, transparency, and traceability help various industries to enhance their performance (Esmaeilian et al., 2020). In addition, it can help to manage fluctuating demands, reduce sales loss (Yoon et al., 2020), and even contribute to greenness (Vatankhah Barenji et al., 2020). BC can control information flow better and identify disruptions early (Dolgui et al., 2020) and can be applied to product design and innovations to prevent intellectual property issues (Rahmanzadeh et al., 2020). The adoption of BC enhances flexibility within the supply chain by reducing costs, improving efficiency, and increasing visibility, helping businesses respond more quickly to changes in demand and market conditions (Masudin et al., 2021). As indicated by Manupati et al. (2022), it has been confirmed that companies employing disruptive technologies have successfully reduced their losses. Mukherjee et al. (2021) and Klöckner et al. (2022) verified that organizations utilizing blockchain technology experienced fewer losses compared to those adhering to traditional supply chain designs, particularly in times of disruption.

A supply chain (SC) can be viewed as a complex system with many actors that require accurate real-time information to make decisions that would ultimately enhance the system's performance (Hong & Hales, 2021; Singh et al., 2019; Wadhwa & Rao, 2004). Therefore, the potential of BC to transform SC has been a focal point for many recent studies (Ada et al., 2021; Helo & Shamsuzzoha, 2020; Mathivathanan et al., 2021; Pongnumkul et al., 2021). BC adoption in SC can lead to real-time traceability of SCs (Helo & Shamsuzzoha, 2020), reduced risk of counterfeiting (Azzi et al., 2019), improved transparency (Banerjee, 2018; Faisal et al., 2023), improve and bring innovation (Nath et al., 2022), minimization of costs, more product visibility and accountability (Tan et al., 2023) and resilience (Al Naimi et al., 2022; Pattanayak et al., 2023). BC can be integrated with technologies like RFID for real-time food tracking, optimizing operations and enhancing the quality and safety of the produce (Saurabh & Dey, 2021).

Research in BC adoption has gained prominence so much that several reviews have appeared in the last five years alone. However, the research on BC adoption in SCs is in its embryonic stage, with only a few studies focused on identifying the adoption factors for the successful application of BC (Happy et al., 2023). Therefore, the most obvious research questions (RQs) are:

RQ1: Why is the application of BC in SCM still in theory with limited applicability?

RQ2: What needs to be added to ensure the widespread adoption of BC in supply chains across the globe?

The contribution of this paper is manifold. First, it is a novel attempt to systematically analyze all the systematic literature reviews published to identify the variables that influence the adoption of BC in a SC. Second, the variables identified through 'review of reviews' were modeled using the TISM approach to understand their interrelationships. Third, this study identifies and postulates a critical link for BC adoption in SC, i.e., coopetition. Research on coopetition has recently gained momentum, and scholars have published more high-quality studies from 2015 to 2020 than in the entire 25 years of the history of coopetition research (Gernsheimer et al., 2021). This paper comprehends the need for coopetition as a crucial linkage variable between factors responsible for adopting BC in SC. This is the most significant contribution of our study.

This paper is organized as follows. Section 2 focuses on the review of reviews to summarize and emphasize the concept. Section 3 discusses the methodology used in the paper. In Sect. 4, the TISM model is presented to understand the interaction among the enablers of BC adoption in the SC, followed by Sect. 5, which discusses the results of PLS-SEM explaining the mediating role of coopetition since it originated as a linking variable in TISM model. Section 6 is dedicated to discussion, theoretical and practical implications, and limitations of the study. Finally, Sect. 7 concludes the paper.

Review of Reviews

A review of systematic reviews was performed to understand how authors focusing on BC adoption in SC have operationalized SLRs and reported them in the literature. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA; Liberati et al., 2009) was used for reporting and conducting this review of reviews. SLRs published until September 20, 2021, in the SCOPUS database, focusing on the adoption of BC in SCM, were used to conclude the results of our analysis. A protocol was developed to document the inclusion criteria and the analysis method. We utilized SCOPUS to search for journal papers containing the term review in their titles, abstracts, and/or keywords with no restriction to date. Journal articles already published in the English language were included. The initial search string was *(TITLE-ABS-KEY (blockchain OR blockchain AND technology) AND TITLE-ABS-KEY (adoption OR enablers OR barriers) AND TITLE-ABS-KEY (supply AND chain OR supply AND chain AND management)).*

The initial search string resulted in 308 papers. Two independent reviewers screened the records, and papers without systematic reviews, such as conceptual, descriptive, and empirical papers, were excluded. All review papers that explicitly used the SLR approach in their paper and selected the literature that was without prior assumptions and reproducible were included. Journal papers that discussed literature review but used a narrative approach were also excluded. Such reviews identify and select literature based on the author's judgment without mentioning the reason or inclusion/exclusion criteria used to search. We have also identified papers that were systematic reviews but did not mention 'systematic' in their titles, abstracts, and/or keywords (for example, Ada et al., 2021) but whose methods resembled that of SLRs. Finally, the full text of selected papers was analyzed to extract the desired information. The selection process for our study, summarized in Fig. 1, finally resulted in 23 systematic literature review papers.

Results of 'Review of Reviews'

The systematic reviews on the topic are increasing and finding space in reputed journals (Fig. 2). Most systematic reviews have been conducted using a generalized approach to BC adoption in SC. Few studies have focused their reviews on BC adoption for food and agriculture SC (Duan et al., 2020; Liu et al., 2021; Longo et al., 2020; Mishra & Maheshwari, 2021; Tharatipyakul & Pongnumkul, 2021). At the same time, few other systematic reviews spoke about the importance of BC in SC for industries like cyber security (Bayramova et al., 2021), electrical equipment SC (Bressanelli et al., 2021), and airport operations (Di Vaio & Varriale, 2020). Recently, systematic reviews for understanding the impact of BC adoption on SC have a centralized theme in the context of Industry 4.0 (Ada et al., 2021; Bhatt et al., 2021; Bressanelli et al., 2021; Khanfar et al., 2021;) and circular economy (Ada et al., 2021; Böckel et al., 2021; Bressanelli et al., 2021).

A systematic review conducted by Alkhudary et al. (2020) highlighted the importance of collaboration among competitors as one of the factors that could make a difference in understanding the BC adoption literature in SCs. Although cooperation between various stakeholders has been highlighted as one of the crucial enablers for BC adoption in SC by systematic reviews done by many authors, the importance of collaboration among competitors, as one of the facilitators for BC adoption, has been mentioned only by Saberi et al. (2019). In addition, pressure from trading partners and knowledge sharing play a vital role in adopting BC in SC (Tan et al., 2023). The

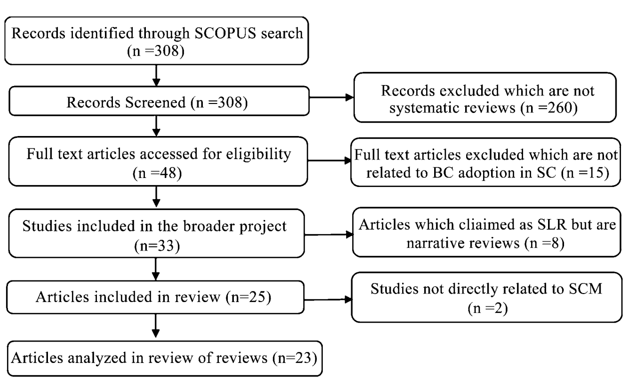

Fig. 1 PRISMA methodology for the 'review of reviews'

adoption factors (enablers) identified in systematic reviews are presented in Table 1.

An analysis of keywords using VOS Viewer was performed (Fig. 3) to find the associations within the literature to understand BC adoption in SC. Figure 3 shows that the research on BC and SCM in very close clusters and systematic literature reviews have been done in this area. The concept of circular economy, sustainability, and industry 4.0 in BC adoption in SCM are at the initial stages, and opportunities for future research are present. BC adoption has been a pivotal area of research for SCs, and the application of BC in SC is closely studied in the literature.

Methodology

The exploratory mixed-method research methodology used in this study has a sequential design. A qualitative method was utilized to understand the relationships among enablers of BC adoption in the SC. Further, the findings of qualitative phase were employed in the quantitative phase, which included a large-scale questionnaire-based investigation. The two approaches employed in the present study are briefly outlined below.

Total Interpretive Structural Modeling (TISM)

TISM is a useful technique for examining correlations between variables, particularly in new fields of study. The TISM technique enables managers to prioritize the firm's resources by assisting them in understanding the interrelationships among the factors affecting a given issue (Dwivedi et al., 2021; Jabeen et al., 2018; Prabhu & Srivastava, 2023; Shekhar & Das, 2023; Sushil, 2017). Section 4 explains various TISM methodology steps.

Questionnaire Study

For the current study, partial least squares structural equation modeling (PLS-SEM) was used as it can estimate extremely complex models with a limited number of observations and does not make assumptions on the distribution of the data (Hair et al., 2022). A two-phased analysis is used to examine PLS-SEM models (Chen & Li, 2020). The measurement model, also known as the outer model, is the first step in determining the validity and dependability of the connections between the latent variables and the corresponding observable variables. Second the structural model (also called inner model), which requires an assessment of relationships among the exogenous and endogenous constructs.

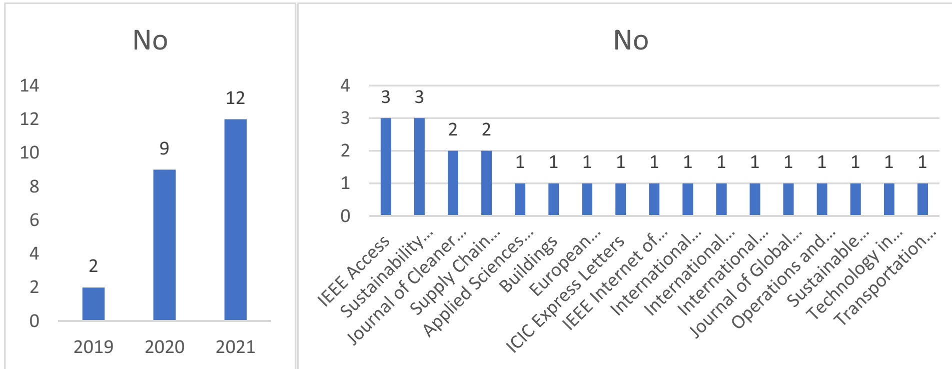

Fig. 2 Summary of SLRs published for BC adoption in SC

Data Analysis and Results for TISM Model

Identification of Variables

Majority of the publications on TISM are based on systematic literature review; however, our research takes a different approach by conducting a review of reviews. This approach of identification of variables is novel (Pahlevan-Sharif et al., 2019) and provides a better support to the variables that would be subsequently used. The variables identified through review of reviews are summarized in Table 1.

Structural Self-Interaction Matrix (SSIM)

To understand the relationships between any two enablers (*i* and *j*) and the direction of this relationship, experts' opinions were solicited. The correlations between the variables were constructed by examining the beneficial influence of any two variables and thus SSIM matrix was developed.

Reachability Matrix

The SSIM comprising the enablers is turned into a binary matrix by replacing V, A, X, and O with 1 and 0 according to the standard TISM technique rule. Furthermore, transitive relationships are investigated, and final reachability matrix is developed.

Level Partitions

In this step, final reachability matrix is partitioned to obtain the interrelationships and hierarchy of the variables affecting the system. For every variable, an entry in its row in reachability matrix constitutes the reachability set, while an entry in the column is part of antecedent set. Finally, an intersection set is developed, and the variable for which the intersection set and the reachability set are identical is assigned a level and removed from other variables reachability set. This iterative process is continued until all the variables are assigned to a hierarchy as shown in Table 2.

Generating an TISM-Based Model

A digraph is created using the hierarchy from Table 2. Finally, the transitive linkages are also shown, and the TISM model describing hierarchy and variable interrelationships is created, as illustrated in Fig. 4. The important transitive links are also provided with interpretation (Appendix A).

The TISM model in Fig. 4 reflects the hierarchy of relationships among variables. Based on the model in Fig. 4, it can be hypothesized that 'Coopetition among SCs' is a crucial link (linkage variable) among two clusters of variables. In the first cluster, variables like 'Regulatory Support,' 'Top Management Vision,' 'Pressure from Stakeholders,' 'Privacy and Anonymity,' 'Collaboration and Trust,' Digitalization,' and 'Audibility' have high driving power and low dependence. In contrast, the second cluster is of variables that lie at the top of the model and have high dependence. This cluster includes variables like, 'Reduction of Capital Investments,' 'Interoperability and Standardization,' 'Technical Skills Development,' 'SC Immutability,' 'Risk Management,' 'Reduced Transaction Costs,' 'Transparency and Traceability,' and 'Supply Chain Sustainability.' It is clear from the TISM model that the impact of driver variables on dependent variables passes through or in other words is mediated by the variable 'Coopetition among Supply Chains.' Therefore, the research moves to the next stage, which requires the validation of the mediating role of 'Coopetition among Supply Chains' for effective block chain adoption in supply chains. We propose to use a questionnaire-based study and analysis using the PLS-SEM technique.

Table 1 Adoption factors identified through 'Review of Reviews'

S. no	BC adoption factors	Definition	Systematic reviews
1	SC transparency and traceability	Blockchain technology ensures that SC records cannot be manipulated, which is essential for data integrity Traceability allows all stakeholders to track the movement of goods throughout the SC in real time, which enables fraud detection and prevention	Pongnumkul et al. (2021), Bhatt et al. (2021), Bayramova et al. (2021), Duan et al. (2020), Queiroz et al. (2020), Chang and Chen (2020), Varriale et al. (2020)
2	Reduced transaction cost	BC can result in SC disintermediation and, as a result, a reduction in transaction costs. BC can instantly modify data, allowing rapid development of processes and products while minimizing transaction times and human errors	Mishra and Maheshwari (2021), Tharatipyakul and Pongnumkul (2021), Queiroz et al. (2020), Dutta et al. (2020), Surjandy et al. (2019)
3	SC immutability	Smart contracts that use digital signatures, prohibits imitation of data hence providing security to the whole SC. All transactions are timestamped and cannot be changed once recorded thereby eliminating fraud and tampering	Thakker and Bakshi (2021), Böckel et al. (2021), Mishra and Maheshwari (2021), Queiroz et al. (2020), Varriale et al. (2020), Wang et al. (2018)
4	Reduction of capital investments for BC adoption	Currently the cost of adopting BC technology is not affordable to many organizations	Pongnumkul et al. (2021), Khanfar et al. (2021), Queiroz et al. (2020), Alkhudary et al. (2020), Surjandy et al. (2019), Wang et al. (2018)
5	Interoperability and standardization	Lack of standardization hinders the adoption of BC solutions. Integration among various BC systems can only be possible if interoperability and standardization are given due importance	Liu et al. (2021), Khanfar et al. (2021), Tharatipyakul and Pongnumkul (2021), Dutta et al. (2020), Varriale et al. (2020)
6	Technical Skills development for successful BC adoption	BC is a disruptive technology and requires new systems, which may change organizational hierarchy or culture and need technological skill development. It may lead to hesitation and resistance from organizations as well as individuals	Liu et al. (2021), Ada et al. (2021), Böckel et al. (2021), Mishra and Maheshwari (2021), Duan et al. (2020), Alkhudary et al. (2020), Dutta et al., (2020, p. 31), Varriale et al. (2020), Wang et al. (2018)
7	Coopetition among SCs	Coopetition is a business situation where independent parties coordinate and cooperate and simultaneously compete among themselves and with other firms. It influences standardization, interoperability, and enhancement of technical skills by mutual collaboration among SCs	Duan et al. (2020), Saberi et al. (2019)
8	Blockchain culture and ease of use	The adoption of BC requires new responsibilities, roles and expertise to support such adoption leading to many changes by top management to create a BC culture across the SC	Ada et al. (2021), Tharatipyakul and Pongnumkul (2021), Queiroz et al. (2020), Varriale et al. (2020), Surjandy et al. (2019)
9	Auditability	Blockchain improves auditability of a SC and those who are accountable can be identified in case of any corruption. The whole SC will be auditable and will result in efficient, corruption-free system	Thakker and Bakshi (2021), Böckel et al. (2021), Mishra and Maheshwari (2021), Dutta et al. (2020), Surjandy et al. (2019)
10	Collaboration and trust	Relationships that are trustworthy can result in improved data and information sharing. Therefore, collaboration and trust are important factors that influence blockchain adoption in SCs	Ada et al. (2021), Khanfar et al. (2021), Böckel et al. (2021), Batwa and Norrman (2021), Bhatt et al. (2021), Bayramova et al. (2021)
11	Privacy and anonymity	If the BC system is not secure, it could result in privacy breach and attacks like DNS, DDoS, selfish mining etc. The anonymity is also considered as a factor, which helps in establishing privacy in the SC using BCT	Liu et al. (2021), Thakker and Bakshi (2021), Böckel et al. (2021), Mishra and Maheshwari (2021), Bhatt et al. (2021), Bayramova et al. (2021)
12	Regulatory support	As SC spans across geographical boundaries, stakeholders in the SC may have different government regulations, which would make the adoption of BC incredibly challenging	Liu et al. (2021), Ada et al. (2021), Bressanelli et al. (2021), Alkhudary et al. (2020), Surjandy et al. (2019), Wang et al. (2018)

Table 1 continued

S. no	BC adoption factors	Definition	Systematic reviews
13	Top management vision and support	Lack of commitment and awareness of top management may lead to a situation where the resource allocation is a challenge and it may impact financial performance as well	Ada et al. (2021), Bhatt et al. (2021), Duan et al. (2020), Alkhudary et al. (2020), Dutta et al. (2020), Varriale et al. (2020),
14	Pressure from stakeholders	This includes pressure from external entities like governments, institutions and other stakeholders to adopt BC technology considering the benefits it brings to the final consumer	Bressanelli et al. (2021), Duan et al. (2020), Alkhudary et al. (2020), Dutta et al. (2020), Chang and Chen (2020), Surjandy et al. (2019)
15	Digitalization	If the basic infrastructure for digitalization is not available, technologies like BC will not be useful and may impact the overall performance of the SC	Bressanelli et al. (2021), Bhatt et al. (2021), Alkhudary et al. (2020), Chang and Chen (2020), Wang et al. (2018)
16	Risk management	Application of BC would facilitate SC auditing and also lower the cost of preventing the data from capricious and deliberate alterations within the SC leading to reduced SC risks	Bayramova et al. (2021), Tharatipyakul and Pongnumkul (2021)
17	Sustainability	BC can improve SC transparency, traceability, and sustainability by monitoring environmental impacts and ensuring social responsibility	Tharatipyakul and Pongnumkul (2021), Duan et al. (2020), Bressanelli et al. (2021), Varriale et al. (2020)

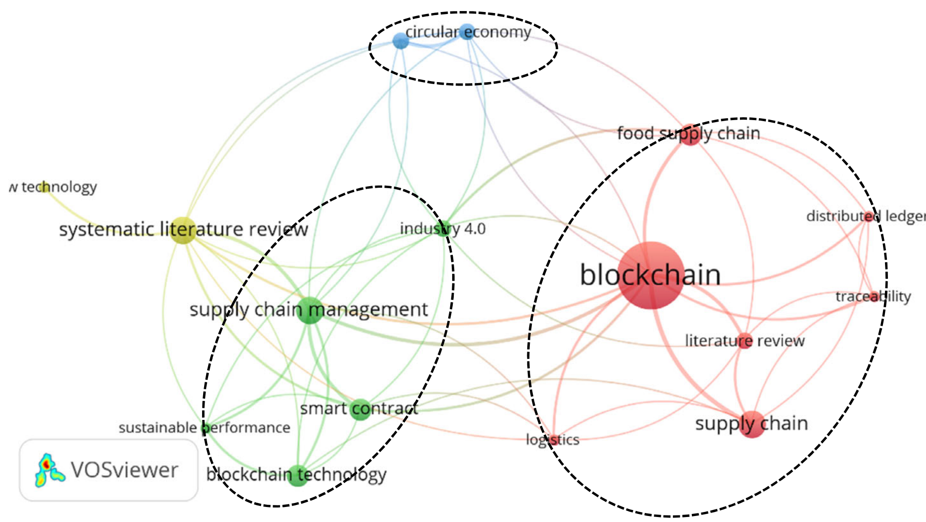

Fig. 3 Bibliometric analysis of the keywords

The Linkage Variable: Coopetition in Supply Chains

Recognized as a new kind of interfirm relationship, coopetition is a new form of interaction among different actors who compete and concurrently create value by cooperation (An et al., 2020; Smiljic et al., 2022). Zineldin (2004) stated that coopetition could be a business situation where independent parties coordinate and cooperate while simultaneously competing within themselves and other firms. In terms of SC, where competition and cooperation are concurrently intertwined, it is apprehended as a new way to deal with complex dynamic situations (Dagnino and Rocoo, 2009; Nigam et al., 2009). There are two types of coopetition: horizontal (between firms at the same position of the SC) and vertical (involving firms that belong to different stages of a SC) (Chai et al., 2020).

Cooperative relationships create a harmonious alignment to achieve common interests and goals (Mierzejewska, 2022; Seepana et al., 2020) and maximize gains by

Table 2 Iteration i–iv

Enabler e_i	Reachability set $R(e_i)$	Antecedent set $A(e_i)$	Intersection set $R(e_i) \cap A(e_i)$	Level
8	8	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17	8	I
1	1, 10, 15, 16	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17	1, 10, 15, 16	II
10	1, 10, 15, 16	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17	1, 10, 15, 16	II
15	1, 10, 15, 16	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17	1, 10, 15, 16	II
16	1, 10, 15, 16	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17	1, 10, 15, 16	II
4	4	2, 3, 4, 5, 7, 9, 11, 12, 14, 17	4	III
6	6	2, 3, 5, 6, 7, 9, 11, 12, 14, 17	6	III
13	13	2, 3, 5, 7, 9, 11, 12, 14, 17	13	III
3	3	2, 3, 5, 7, 9, 11, 12, 14, 17	3	IV
17	17	2, 5, 7, 9, 11, 12, 14, 17	17	V
2	2, 7, 9, 11	2, 5, 7, 9, 11, 12, 14	2, 7, 9, 11	VI
7	2, 7, 9, 11	2, 5, 7, 9, 11, 12, 14	2, 7, 9, 11	VI
9	2, 7, 9, 11	2, 5, 7, 9, 11, 12, 14	2, 7, 9, 11	VI
11	2, 7, 9, 11	2, 5, 7, 9, 11, 12, 14	2, 7, 9, 11	VI
5	5	5	5	V
12	12	12	12	V
14	14	14	14	V

establishing a competitive relationship (Crick & Crick, 2020). By developing a shared knowledge base, firms can be more innovative (Markovic et al., 2020). Coopetition has been found beneficial in the context of the security of the SC (Nandi et al., 2021), supply chain management practices (Ho & Ganesan, 2013), logistics (Bouncken et al., 2015; Marić & Opazo-Basáez, 2019), knowledge co-creation, multi-technology innovations (Rauniyar et al., 2022), sustainable supply chains (Sarker et al., 2021), relationship building among subsidiaries (Salgado et al., 2022), and closed-loop supply chains (Chen & Chang, 2012).

Considering the benefits of coopetition, the TISM model (Fig. 4) indicates that it can be a critical factor for adopting BC in SCM practices, which has not been considered in the SC literature. BC can be easily deployed within a SC if various firms/competitors cooperate, and it may deliver much more value to the participating SCs. Since the adoption factors are studied in the literature, we want to focus on this coopetition concept, which may be a game changer. BC is established on the network's principle of simultaneous competition and cooperation (Narayan & Tidström, 2020). Therefore, it should be further explored as a critical enabler for BC adoption in SCs. Based on the role of 'coopetition' in the TISM model, the hypotheses are proposed as follows:

H1: 'Coopetition among SC' mediate the relationship between 'Blockchain Culture' and 'Interoperability and Standardization.'

H2: 'Coopetition among SC' mediate the relationship between 'Blockchain Culture' and 'Reduction of Capital Investments for BC Adoption.'

H3: 'Coopetition among SC' mediate the relationship between 'Blockchain Culture' and 'Technical Skills Development for BC Adoption.'

Data Analysis and Results for PLS-SEM Model

In the previous section, the TISM method was applied to understand the interaction among the enablers of BC adoption in the SC derived using the 'review of the reviews' method. Coopetition originated as a linking variable in TISM terminology and can be viewed as a mediator between two groups of variables, i.e., the drivers and the dependents. As a result, the study used the PLS-SEM technique to investigate the mediating role of coopetition. The impact of an exogenous construct (X) on an outcome construct (Y) is mediated when it passes via a third mediating construct (M) (Latif et al., 2020). Our study used the PLS-SEM technique to investigate the mediating role of coopetition. PLS-SEM is widely used in operations management research (Akter et al., 2017; Al Naimi et al., 2021). It has been increasingly chosen used for its superiority as a predictive and explanatory method (Hair & Sarstedt, 2021; Sabol et al., 2023).

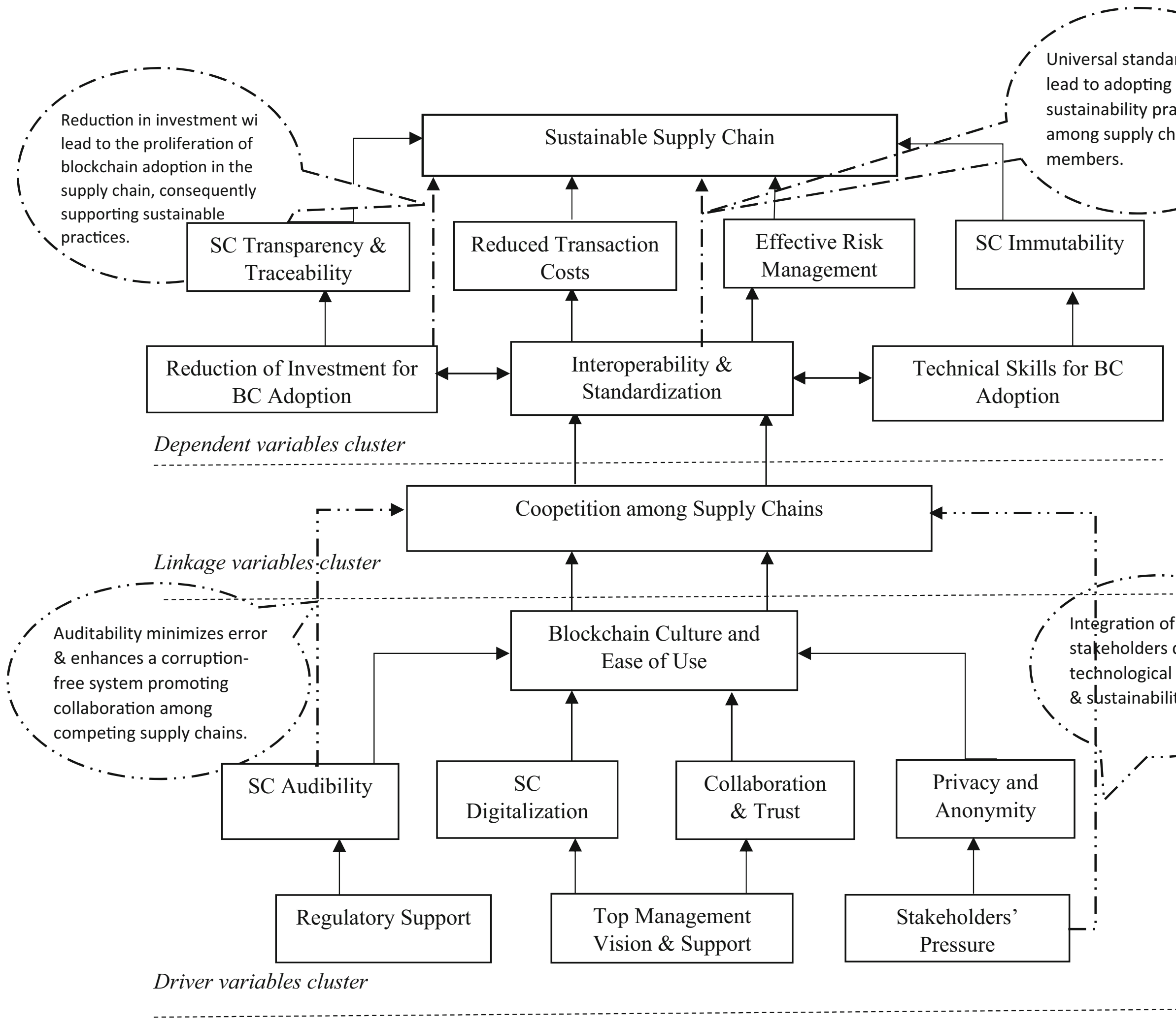

Fig. 4 TISM-based model for the enablers of BC adoption in SC

Measures

A structured questionnaire was developed based on previous studies. The questionnaires incorporated scales derived from prior studies for the constructs under consideration and demographic information. All characteristics in the study were evaluated using a five-point 'Likert Scale' (where 1 stands for strongly disagree and 5 stands for strongly agree). To measure 'Coopetition' ($\alpha = 0.952$), a 5-item scale was used, based on Duan et al. (2020). To measure 'Blockchain Culture' ($\alpha = 0.932$), we used a 4-item scale based on Queiroz et al. (2020) and Varriale et al. (2020). We used a three-item scale to measure 'Interoperability and Standardization' ($\alpha = 0.860$), based on Khanfar et al. (2021) and Dutta et al. (2020). A three-item scale was used to measure 'Capital Investments for BC Adoption' ($\alpha = 0.877$), adapted from Queiroz et al. (2020) and Pongnumkul et al. (2021). Finally, we used a 4-item scale to measure 'Technical Skills Development for BC Adoption' based on Duan et al. (2020) and Alkhudary et al. (2020).

Data Collection

The data were obtained from 179 managers working in the SC, logistics, purchasing, operations, and manufacturing sectors of India's food and pharmaceutical industries. The significance of SC integrity and transparency due to its impact on health and well-being was the main factor in selecting these industries. Online distribution of the questionnaire took place between February and April of 2022.

Common Method Bias (CMB)

Since survey method was employed, we took measures to overcome the effects of common method bias. We used ex ante approaches to reduce frequent method bias. Respondents were assured that that their participation would be well-looked after as anonymous and confidential (Uddin & Khan, 2018). In order to restrict respondent's capability of deciphering the research items which construct they related to, the items were presented in a randomized manner. Second, we kept the questions short and straightforward to reduce uncertainty. Similar approach was employed by studies in the past (Li et al., 2020). Empirically, the absence of CMB was confirmed though Harman's single-factor test. The single factor explained 29.6% of the variance, which is below the cut-off value of 50% (Podsakoff et al., 2003).

Assessment of Measurement Model

- Assessment of Reliability: According to Chin (2010), values for all outside loadings must be greater than 0.7 in order to prove reliability. Additionally, Cronbach's α, rho_A, and composite reliability (CR) were used to establish dependability. Values of Cronbach α, rho_A, and CR > 0.7 (Ringle et al., 2020) suggest good reliability. As shown in Table 3, all reliability indicator values for the current investigation are within acceptable limits.
- Convergent validity: It is next evaluated using average variance extracted (AVE), which is the following step. Convergent reliability is guaranteed by values of AVE > 0.5 (Katiyar et al., 2018; Kirmani et al., 2022). Table 3 presents the results for the validity and reliability analysis.
- Discriminant validity: The Fornell–Larcker criterion and the Heterotrait–Monotrait (HTMT) ratio are used to establish discriminant validity, which is the degree to which each construct is genuinely distinct from other constructs in the model (Latif et al., 2020). The square root of AVE for each construct should be greater than the correlation with any other constructs to establish discriminant validity using the Fornell–Larcker criterion, whereas the HTMT value for each construct should be lower than either 0.85 or 0.9 to clearly discriminate between two factors (Rasoolimanesh et al., 2021). Table 4 presents the values for the two criteria, proving discriminant validity for the current study.

Assessment of structural model

The R^2, Q^2 values for the endogenous constructs and the significance of the routes are used to evaluate the structural model (Latif et al., 2020). This calls for the use of bootstrapping, which was carried out using 5000 subsamples. If a route coefficient's confidence interval excludes zero or its p value is lower than the predetermined α-level, it is deemed significant (i.e., unlikely to be the only result of sampling error). Lately, researchers recommend using confidence intervals; however, reporting p values still

Table 3 Reliability and validity analysis

Construct	Item	Loading	Alpha	rho_A	CR	AVE
Coopetition in Supply Chains (COPT)	COPT1	0.728	0.778	0.715	0.798	0.547
	COPT2	0.783				
	COPT3	0.821				
	COPT4	0.843				
	COPT5	0.812				
Blockchain Culture (BCCL)	BCCL1	0.775	0.763	0.737	0.776	0.611
	BCCL2	0.718				
	BCCL3	0.763				
	BCCL4	0.805				
Interoperability and Standardization (INTS)	INTS1	0.779	0.795	0.762	0.823	0.675
	INTS2	0.766				
	INTS3	0.841				
	INTS4	0.817				
Capital Investments Reduction (CINV)	CINV1	0.847	0.786	0.729	0.754	0.627
	CINV2	0.785				
	CINV3	0.747				
Technical Skills Development (TSKD)	TSKD1	0.723	0.763	0.758	0.783	0.529
	TSKD2	0.818				
	TSKD3	0.739				

Table 4 Fornell–Larcker criterion and Heterotrait–Monotrait (HTMT) ratio

Construct	COPT	BCCL	INTS	CINV	TSKD
COPT	*0.739*	0.391	0.502	0.356	0.387
BCCL	0.319	*0.782*	0.393	0.457	0.401
INTS	0.276	0.413	*0.822*	0.368	0.263
CINV	0.412	0.275	0.253	*0.792*	0.443
TSKD	0.278	0.423	0.187	0.344	*0.727*

Diagonal and italicized are the square roots of the AVE and below diagonal values are the correlations between the constructs. Above the diagonal values represents the Heterotrait–Monotrait ratio values

seems to be more common in business research (Henseler et al., 2015). R^2 is typically used as a criterion of predictive power, which indicates the variance explained in each of the endogenous constructs (Chin et al., 2020). Chin (2010) recommended values of 0.67, 0.33, and 0.19 as indicators of R^2 strength, moderateness, and weakness, respectively. R^2 for COPT is 0.679, indicating that the hypothesized constructs account for 67.9% of the variance in COPT. Similar to this, after bootstrapping, the R^2 values for INTS, CINV and TSKD are 0.379, 0.425 and 0.492, respectively, all of which are higher than 0.33.

To ensure the model's predictive accuracy and relevance, the values of Q^2 are analyzed. According to Hair et al. (2022) as a rule of thumb, Q^2 values higher than 0.00, 0.25 and 0.50 suggests small, medium and large predictive relevance of the PLS structural model. In the present study, the value of Q^2 was 0.57, 0.41, 0.39 and 0.36 for Coopetition, Interoperability and Standardization, Capital Investments Reduction, and Technical Skills Development, respectively, which are considered very high to assess predictive reliance of endogenous constructs (Latif et al., 2020; Rasoolimanesh et al., 2021).

Mediation Analysis

According to the methodology followed by Zhao et al. (2010), the mediating role of competition in the adoption of BC in the SC was examined in the current study. Hypotheses are not supported if the bias-corrected confidence interval has a value of 0 (Gannon et al., 2020). The findings of the mediation analysis are presented in Table 5, and they show that all the hypotheses concerning the mediation effect of coopetition are validated.

Discussion

In the present study, the purpose of 'review of reviews' is to provide a snapshot of existing knowledge and ensure rigorous review. Recently, the focus of BC research in SC has shifted from the conceptual framework to understanding adoption factors. With more and more systematic reviews published in high-impact journals, the overall snapshot of the adoption factors is provided by the 'review of reviews.' Once the factors identified by systematic reviews are taken into consideration, subsequent modeling becomes more comprehensive, applicable, and practical. Focusing on our prime objective, i.e., to model the enablers of BC adoption in SCs, we systematically analyzed 23 systematic literature reviews and distilled 17 enablers of BC adoption in SCs.

TISM modeling was done to understand the interrelationships among the factors, resulting in eight driver variables, eight dependent variables, and one linkage variable. The seven-level TISM model was obtained with Regulatory support, Top Management vision, and stakeholder pressure at the lowermost level, having maximum driving power. SC audibility, SC digitalization, Collaboration and Trust, Privacy, and Anonymity are at level six. With digitalization, the need for collaboration among various stakeholders is becoming critical. Level 5 is addressed by BC culture, which needs to be inculcated into the organization to achieve the desired results. One of the most important outcomes of this paper is to highlight the importance of the linkage variable, i.e., coopetition. The importance of coopetition has been studied in the literature in different contexts, e.g., circular economy (Narayan & Tidström, 2020), tourism SCs (Fong et al., 2021), pharmaceutical SCs (Sodhi & Tang, 2021), SC resilience (Durach et al., 2020), but its role has not been explored in detail for the adoption of BC in SCs. This paper highlights its critical role and provides a concrete basis to establish

Table 5 Mediation analysis

Hypothesis	Path Coefficient	*t* value (bootstrap)	*p* values	Confidence Interval (95%) Bias Corrected	Supported
H1: BCCL → COPT → IOST	0.471	5.219	< 0.01	[0.212, 0.378]	Yes
H2: BCCL → COPT → CINV	0.382	4.397	< 0.01	[0.269, 0.424]	Yes
H3: BCCL → COPT → TSKD	0.356	3.917	< 0.05	[0.082, 0.249]	Yes

BCCL Blockchain culture, *COPT* supply chain coopetition, *IOST* interoperability and standardization, *CINV* reduction in capital investments, *TSKD* technical skills development

coopetition among supply chains for the fruitful implementation of BC in SCs.

The results of the TISM model were validated using a questionnaire-based study considering coopetition as a linkage variable. The questionnaire study results confirm the mediating role of coopetition among variables BC culture and interoperability and standardization, reduction in capital investments, and technical skill development. It adds to the existing literature (see Ada et al., 2021; Bayramova et al., 2021; Chang & Chen, 2020; Khanfar et al., 2021; Mishra & Maheshwari, 2021; Varriale et al., 2020) by offering complementary TISM and PLS-SEM-based strategic framework which was developed through literature analysis, experts' opinion and questionnaire study. This suggests that coopetition among SCs helps to reduce investments in BC and improve interoperability as single SCs are replaced by a network that improves learning through collaboration. For example, smart contracts are one of the applications of BC in SCM. Intelligent contracts deliver transparency and traceability to the SC and promote standardization. With fewer tiers, BC can help SC reduce the overall transaction cost and waste.

Firms can share resources and skills in transportation, distribution networks, and manufacturing facility utilization, boosting flexibility. Coopetition also entails information sharing, and this exchange can have a significant influence on the adoption of technologies like BC through efficient decision-making, thus boosting SC flexibility. Companies that collaborate can adapt more quickly. Also, supply interruptions, legislative changes, natural catastrophes, and other factors impose a cost. As a result, contingency plans such as collaboratively solving a need, risk mitigation, backup manufacturing, and more robust SCs may be implemented (Bonel et al., 2008). Cooperative SC operations can be faster, more responsive, and impact performance (Mierzejewska, 2022). Companies may utilize each other's capabilities to expedite processes, minimize lead times, and increase overall agility when collaborating (Kim et al., 2013). Therefore, it posits an excellent opportunity for implementing BC and creating a sustainable system. Companies can adapt more swiftly to changes in consumer demand, market trends, or technology breakthroughs by aligning their aims and working together, resulting in enhanced flexibility in addressing changing market requirements. Within the SC, coopetition may encourage a culture of creativity and cooperation (Knein et al., 2020). This collaborative innovation can enable the development of new goods, services, or processes that adapt to changing market conditions and client preferences, hence increasing flexibility.

Minimization of transaction times, and human errors, preventing deliberate alterations of data and keeping data safe and authentic help reduce risks in the SC and develop reliability. However, the lack of universal standards makes BC adoption quite cumbersome in many situations. In such cases, coopetition in the system will ensure the development of standardized protocols and, in turn, improve interoperability for the whole system. With standardization, complexity will be high, and the system will become simple overall. BC has the power to disrupt existing businesses (Avasant, 2019), and it would influence the organizational hierarchy; therefore, a skilled workforce is necessary to tackle the demands of change due to BC. Coopetition among SCs helps knowledge sharing and improves the workforce's learning, positively influencing the BC's acceptance and implementation in SCs.

The significant outcome of implementing BC in SCs is improved sustainability across the SC. Researchers (Varriale et al., 2020) have taken up the importance of BC in developing a sustainable SC due to improved transparency and traceability. The present research establishes that the competitors can mutually benefit from implementing BC in SC, resulting in performance improvement and sustainable outcomes (Narayan & Tidström, 2020). Cooperating with competition in some activities while competing in others is crucial for value creation strategy (Gernsheimer et al., 2021) and creating efficiency (Chai et al., 2020). Reniers et al. (2010) supported coopetition as a sustainable solution facilitator. Dagnino and Padula (2002) used coopetition to address interconnected and complex issues while developing circular model business strategies. Such transitions would require a transdisciplinary understanding of the issues and facilitating a collaborative approach from various stakeholders of the SC while keeping competition over the best possible ideas.

Theoretical Implications

This research provides multifold implications to the theory of BC adoption concerning SCs. Although the literature has discussed factors responsible for adopting BC in SC, our paper utilizes a systematic literature review approach (PRISMA) for the systematic reviews to encapsulate all the relevant variables concerning the adoption of BC into SC. It was done to ensure that all the relevant factors should be included in this study irrespective of industry. Also, this research explores and elucidates relationships among the enablers of BC adoption in SCs using a mixed-method approach. Our research proposes a contextual linkage between the enablers of BC adoption in SCs using TISM and proposes a framework with a linkage variable, i.e., coopetition. Using PLS-SEM, the importance of coopetition as a linkage variable was further established.

For academia, this paper opens a new dimension for mobilizing future research to better understand BC applicability in SC. It helps researchers to appreciate the importance of cooperation among the competitors as a new enabler for BC adoption in SCs. This research has classified the enablers of BC adoption into three categories, i.e., driver, linkage, and dependent variables. The driving and dependence power was also evaluated based on the SLR and experts' opinions. This study also contributes to the existing literature on coopetition research by relating it to the transition of SCs to sustainable SCs with BC as an enabling technology. Furthermore, various levels of the enablers in the proposed TISM model and their interconnections across different hierarchies would help the researchers understand the challenges of the SCs in BC adoption with a sense of interrelationships between enablers.

Managerial Implications

A significant practical implication of this research is that it helps SC managers appreciate coopetition's critical role in adopting technological innovations in managing SCs. The present research establishes coopetition as a linkage or mediating variable, implying that adopting BC in SCs is best if cooperation/collaboration goes beyond established lateral echelons to more horizontal levels across SC boundaries. In order to adopt BC in managing SCs, managers need to clearly understand the interrelationships among variables that positively influence BC implementation. Covid 19 exacerbated fault lines in SCs, and organizations are still unable to recover from its after-effects. This study proposes coopetition as a significant variable, which, to our knowledge, should have been taken up earlier in previous studies in the context of BC adoption for developing sustainable SCs. In addition, the proposed hierarchal framework developed using TISM would help SC managers focus on key variables in adopting BC solutions in SCs.

Our research also establishes that collaboration, trust, regulatory support, and top management vision are essential in developing BC culture in the organization. Therefore, managers should consider improving significant driver variables to crystallize the benefits of BC adoption. This also requires updating the staff's technical skills, which demands appropriate training programs for the workforce. Another critical enabler for BC adoption in SC is effective risk management. Managers should understand how this new technology could reduce transaction times, minimize human errors, improve data safety, prevent data breaches, and reduce risk in the SCs. Our research also helps managers appreciate that BC adoption in the SC leads to transparent, traceable, and flexible systems, ultimately leading to sustainable SCs.

Furthermore, the utilization of cooperation in developing a flexible system is an important managerial implication of this study. There are several ways in which cooperation may increase SC flexibility. For starters, it can assist in lessening the likelihood of disturbances. When businesses collaborate, they may share knowledge and resources, reducing the effect of interruptions. For example, if one firm in a SC suffers a supplier interruption, the other companies in the chain may be able to assist in filling the void. Second, collaboration can assist in enhancing the reaction time to changes in demand. When businesses collaborate, they exchange information about demand and supply, allowing them to make more timely choices regarding production and inventory levels. This can assist in guaranteeing that items are accessible when customers need them, which can lead to higher levels of customer satisfaction. Third, collaboration can aid in cost reduction. Businesses collaborating may pool resources and negotiate lower rates with suppliers. This can assist in lowering the overall cost of products sold, improving profitability.

Another important aspect of BC is decentralization. In case of any disruption, tradition SCs are the most vulnerable as they rely on a centralized control (Li et al., 2023).

BC is a decentralized technology which is helpful in managing the SCs in times of disruption as it shares data across multiple nodes. Therefore, the risk of failure at single point can be reduced and SCs can become more resilient to crisis. Adding coopetition as one of the critical elements, this property of BC can be exploited manifold adding to more resilient and sustainable SCs.

Overall, coopetition can be a helpful method for increasing SC flexibility. Cooperation may help organizations become more flexible and responsive to market changes by decreasing risk, boosting reaction time, and lowering costs. With the help of technological inputs like BC, this relationship within the SC may be more reliable and trustworthy. Smart contracts can be used to design the coopetition strategy and maximize the benefits of a SC. Coopetition is a business strategy involving cooperation and competition between two or more companies. This can be a valuable strategy for SCs, as it can help to improve flexibility and efficiency. Researchers may further explore the impact of coopetition on the system's flexibility with BC as enabling technology. How coopetition will reduce the risk of disruptions, improve traceability and facilitate the use of information technology (like BC) in the SC can be further explored and accessed.

Limitations and Future Research Directions

This paper uses the TISM model to identify the enablers of adopting BC in SCs. The impact is subjectively analyzed and can be further tested using mathematical quantification. The linkage variable identified can be further analyzed using more responses from SC professionals, and the linkage can be further discussed in depth using techniques like fuzzy-set qualitative comparative analysis (fs/QCA). Future researchers can use fuzzy theories to remove any bias due to limited responses from the experts and managers of SCs. Additionally, hybrid techniques such as DEMATEL-based analytic network process (D-ANP) can be developed to analyze the enablers and quantify their mutual dominance. Also, the recently popularized approach, approximate fuzzy decision-making trial and evaluation laboratory (AFDEMATEL), which is an improvisation of fuzzy DEMATEL, may be operationalized to gauge the remaining issues. Regarding the use of PLS-SEM, authors in the future should remember that PLS-SEM and other SEM tools are designed to attain different objectives and depend on different measurements. Therefore, it is pertinent for the authors to be aware of the conceptual differences between various SEM models and apply the methods according to the objectives framed.

Conclusions

This research provides a hierarchical relationship model of factors responsible for adopting BC in SCs and, if adequately addressed, could provide a platform for companies to adopt BC in SCs. The paper identifies 17 critical enablers for BC adoption in SCs using the PRISMA approach and describes their interrelationships using TISM. Eight driver variables, eight dependent variables, and one linkage variable were identified, along with their driving power and dependence. A valid, comprehensive, and hierarchical model was developed using the TISM technique, and PLS-SEM hypotheses for linkage variables were tested. The dynamic interactions, transitive linkages, and appropriate behavior have been depicted for each enabler to understand BC adoption in SCs.

Further, this paper identifies significant enablers that must be addressed and adopted to implement BC in SCs effectively. The mediation role of coopetition was established as a critical variable that needs to be realized, and PLS-SEM confirmed the impact of the linkage variable. As a result, this paper provides a comprehensive view of the model and portrays the relationships among the factors to achieving BC adoption. This research helps reach rational conclusions for BC adoption and minimizes the need for more clarity among enablers. The paper offers a complementary TISM and PLS-SEM-based strategic framework, which was developed through literature analysis, experts' opinions, and questionnaire study. The identification and empirical justification provided for the linkage variable, i.e., coopetition, enables a deeper understanding of the system and opens up a new dimension for future research. Adopting a new technology by understanding the enablers helps eliminate barriers to successful implementation. Once new technology is adopted and factors critical for successful implementation are embraced, the chances of success become high.

Appendix A

See Table 6.

Table 6 Interpretive matrix

	V1	V2	V3	V4	V5	V6	V7	V8	V9
V1								Enable companies to identify and mitigate risks related	
V2									Trust within the SC can result in improved data and information sharing
V3				Competing firms share resources		Competing firms come together to develop necessary skills			
V4	Affordability to track and trace within SCs							Reduction in investment will lead to the proliferation of SC adoption in the SC	
V5		Top management will lead toward collaboration with competition							Readiness to digitalize the SC
V6									
V7			Minimizes errors & enhances a corruption-free system						Auditable SC will be useful technology adoption
V8									
V9		Easy access to the stakeholders					Digitalization will lead to more checks and greater transparency		
V10								Improved efficiency and improved economic condition	
V11		More confident transaction and information sharing							
V12		Regulations will standardize process and procedures					Easy to follow standards along with timely checking of results		Standard protocol for building a digitalization network
V13				Integration among various BC systems		Training for Standards are important for developing technology like BC		Standardize data, assess asset performance, and enhance compliance	
V14			Technological advancements & sustainability focus						
V15								Security to the whole supply chain will result in sustainability	
V16								Reduced risk will help in developing sustainable SCs	

Table 6 continued

	V1	V2	V3	V4	V5	V6	V7	V8	V9
V17			Important relationships can be developed among competitors						

	V10	V11	V12	V13	V14	V15	V16	V17
V1								
V2		Trustworthy collaborations can result in improved data and information safety						Collaboration and trust will result in developing BC culture
V3				Competing firms need more standard protocols to coordinate				
V4				Capital investments will lead to more standard products				
V5								
V6	Technical skills are required for smooth functioning of the system			Training for Standards is important interpret technology like BC		Prohibits imitation of data hence providing security to the whole SC	Prohibits imitation of data hence reducing risk	
V7								More confidence among SC actors and helps developing BC culture
V8								
V9								More SCs joining in will develop BC culture
V10								
V11								boost confidence of SCs to join
V12		Help developing protocols for privacy issues						
V13	Lead to more standardization of BC					BC technology needs permission from various stakeholders	BC technology needs permission from various stakeholders	
V14		Helps in establishing privacy in the SC using BCT						
V15								
V16								
V17								

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Key Questions

1. What is Coopetition and why it is relevant for blockchain adoption in supply chains?
2. What are various variables that influence blockchain adoption in supply chains?
3. What is the current status of research in blockchain adoption in supply chains?

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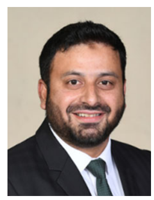

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