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Blockchain Technology in Supply Chain Management

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ABSTRACT

Blockchain technology (BCT) has gained prominence mostly because of the growing attention on Bitcoin, leading to its effect extending beyond the financial industry. The shift has led to a growing scholarly interest in applying Behavioural Contract Theory (BCT) in Supply Chain Management (SCM) in various business scenarios. This paper provides a comprehensive analysis of current advancements and probable future research directions by integrating two distinct perspectives on behavioural change strategies in supply chain management. The research thoroughly develops a framework for classifying various use cases of BCT in supply chain management by leveraging its unique qualities. The technique includes a comprehensive analysis of 53 cases of BCT implementation in supply chain management (SCM). This analysis is based on a systematic assessment of the literature and a dataset that demonstrates supply chain management advancements driven by blockchain technology. The five novel BCT application clusters discovered in supply chain management surpass traditional applications such as product tracking and tracing. This project aims to enhance our comprehension of the possible uses of blockchain technology in supply chain management and to explore new research opportunities in the evolving realm of blockchain-driven supply chain operations.

Key Words: Blockchain Technology, SCM applications, structured literature review, BCT in SCM.

INTRODUCTION

1. The introduction of Bitcoin and BCT by the mysterious individual known as Satoshi Nakamoto has generated significant interest in electronic payment systems, specifically those that utilise the decentralized nature of the internet. BCTeliminates the necessity for financial intermediaries and enables the secure direct interchange of value between participants; this results in the emergence of what is jokingly called the "internet of value." The blockchain operates as a decentralized ledger, facilitating the eternal retention of verified transaction data. 'The Economist' has appropriately designated BCT as the 'trust engine,' underscoring its capacity to serve as a dependable ledger of corporate undertakings. The significance of trust in supply chain partnerships as a foundation for collaboration renders BCT an indispensable participant in the domain of SCM. Significantly, recent progress has witnessed collaborations between IBM and Maersk with the objective of promoting BCTfor use in container transportation and international trade.

2. In recent years, there has been a discernible rise in the amount of scholarly interest that has been present in the literature about BCT and its applications in the commercial world. Despite the increase, the use of BCT in supply chain management has not garnered much focus. Previous studies have focused on aspects such as

incorporating data into digital supply chains and potential applications of Blockchain Technology in Supply Chain Management. Nevertheless, a full overview of the utilisation of BCT in SCM is still lacking. This article makes two important contributions: it uses a deductive technique to connect the unique features of BCT with specific uses in SCM, and it creates a detailed framework to place BCT and its potential uses in SCM. The methodology analyses a thorough literature research and a dataset of behaviour modification-facilitated supply chain improvements. This approach evaluates BCT-enabled SCM applications and identifies future developments.SCM and BCT fundamentals and a use case cluster framework are presented in Section 2. The systematic literature review and secondary dataset analysis are in Sections 3 and 4. The results are thoroughly examined in Section 5. Section 6 of the study summarizes the findings and suggests future research.

1.1. ConceptualFoundations

1.2. SupplyChainManagement

2.1 The BCT and Bitcoin, an innovative cryptocurrency, were initially unveiled to the public by an individual or collective acting under the alias Satoshi Nakamoto. Significant enthusiasm has been generated around these two pioneering concepts, especially in regard to electronic payment systems that utilise the peer-to-peer architecture of the internet. BCTfacilitates secure, direct value exchanges among participants, thereby obviating the necessity for conventional financial intermediaries and establishing the concept commonly referred to as the "internet of value."

2.2 The blockchain operates as a decentralised ledger, providing a repository for verified transaction data that is both secure and immutable. The 'trust machine' is an apt description of blockchain by The Economist, which underscores its critical function as a reliable ledger of corporate operations. The establishment of trust is recognised as a critical component in promoting cooperation among organisations involved in supply chain partnerships. The widespread recognition of the utility of BCT in SCM is supported by recent partnerships, including the one between IBM and Maersk, which seeks to establish BCTas a commercial enterprise for container transportation and international trade.

2.3 In recent years, there has been a significant surge in scholarly attention towards BCT and its business applications, as evidenced by numerous literature reviews. A comprehensive research framework for BCT has been contributed to by scholars such as Risius and Spohrer, whereas SCM has received comparatively less attention in various application domains. Previous research, including that of Korpela et al. (2019), which examined the utilisation of BCT for data integration in digital supply chains, and Sternberg and Baruffaldi (2020), which presented a preliminary analysis of possible BCT applications in SCM, emphasise the necessity for a more comprehensive examination of BCT applications in the field of Supply Chain Management.

2.4 In an effort to address this deficiency, this study provides two essential contributions. Initially, a comprehensive framework is established to position BCT within the domain of SCM, and its potential applications are investigated. In contrast to previous investigations, this study utilises a deductive methodology to establish connections between the distinctive attributes of BCT and particular scenarios in SCM. The methodology entails the examination of results obtained from a systematic review of the literature and an additional dataset that includes supply chain innovations facilitated by behaviour change techniques. This methodology enables an evaluation of the present state of BCT-enabled applications in SCM and pinpoints potential developments in this ever-evolving field.

2.5 Part 2 of this article elaborates on the conceptual underpinnings of BCTand SCM, establishing a structure for use case clusters. The examination of the secondary dataset and the systematic literature review are detailed in Sections 3 and 4, respectively. Section 5 provides a thorough analysis of the results, whereas Section 6 presents a synopsis of the discoveries and proposes potential avenues for future investigation.

1.3. BCT

Decentralised blockchains are validated and disseminated over peer-to-peer networks. Each participant's node stores segments with timestamped records certified by a unique consensus procedure and secured by public-key

encryption. This decentralization reduces reliance on a central ruling authority, and the interlinking of blocks through hash codes ensures the immutability of data, allowing users to trace its historical evolution and origin. Blockchain Technology (BCT) utilizes "smart contracts," also known as "chaincode," for computational tasks. Smart contracts are reliable programs running on blockchain nodes. Access permissions differentiate between permissionless and permissioned blockchains, categorized as public or private based on control over data and infrastructure (51). Permissionless-public blockchains, like Bitcoin, are accessible to the public online, while permissioned-private blockchains, such as Hyperledger Fabric, require users to undergo an administrator-monitored approval process.

BCT ensures transparency and pseudonymity in transactions conducted between alphanumeric addresses. Valuable assets, whether physical or intangible, can be moved onto or off the ledger using BCT. 'Tokens' serve as digital representations of objects on the blockchain, contributing to operational efficiency enhancement (47). Scholars anticipate that Behavioral Contract Theory (BCT) will impact industrial organization, considering blockchain as an institutional tool for economic coordination. Blockchains are viewed as a novel form of institution, distinct from hierarchies (firms), markets, and relational contracts, functioning as decentralized collaborative groups facilitating the generation and exchange of value (36). In the context of Supply Chain Management (SCM), where relational contracts based on trust are common, blockchain's elimination of the need for trust becomes significant. This study seeks to explore the influence of Business Communication Technology (BCT) on SCM, considering its versatility and potential to reshape established supply chain dynamics.

1.4. LinkingSCMandBCT

BCTstands at the forefront, offering a robust suite of fundamental elements essential for the improvement of integration and coordination within intricate supply chain networks. These elements, namely transparency, validation, automation, and tokenization, collectively serve as the bedrock for establishing interconnected use case clusters within the realm of SCM [41,42,45].

Transparency in BCT involves gathering data from various entities throughout the blockchain network to create a collective data repository. BCT is notably used in Supply Chain Management to provide real-time information sharing throughout the supply chain. This effectively tackles the common issue of inadequate transparency across the entire process by enabling the monitoring of measurable factors such as product temperature or equipment availability using sensor technology and the Internet of Things integration. An increase in data accuracy leads to better collaborative planning, execution, and the use of preventative and reactive risk management strategies [40,44,39]. Validation, as enabled by BCT, hinges on the unchangeable nature of records and the verification process grounded in consensus. Its application in SCM unfolds in the ability to track assets to their origin, ensuring the integrity of assets through provenance information. This proves instrumental in scenarios where responsible sourcing is paramount, helping to combat counterfeiting. Moreover, BCT simplifies international trade paperwork by verifying the authenticity of goods documentation, thereby enhancing the integrity of assets post-sale, particularly in the context of warranty purposes [].

Automation, a pivotal element in the BCT arsenal, involves the execution of smart contracts using verifiable data hosted on the blockchain. The application in SCM manifests in the form of smart contracts that seamlessly blend transparency, validation, and automation. This amalgamation serves to enhance velocity and synchronization across the supply chain, allowing for the automatic execution of predefined criteria. Furthermore, automation provides the distinct advantage of ex-post enforceability of contracts, ensuring contractual parties are unable to retract their commitments. BCT's role in extending the Industry 4.0 smart factory concept to inter-company supply chains is particularly noteworthy [31,35,39].

Tokenization, the final foundational element, entails the creation of tokens symbolizing ownership of valued assets and facilitating their transfer among participants. The application in SCM takes a unique form, extending beyond the mere transfer of ownership. Tokenization allows for the trading of claims related to capacity or ordering alternatives independently of regular contractual agreements. This virtualization of physical supply

chain assets offers a novel avenue for improving capacity utilization and contract flexibility, ushering in enhanced efficiency and adaptability within supply chain management practices [32,33,34].

Apart from these four fundamental components, BCT applications pertaining to Supply Chain Finance (SC Finance) have their own unique use case cluster. By utilising BCT's inherent connections to cryptocurrencies and recognising the crucial role of financial intermediaries in international trade, SC Finance applications are positioned to have a big influence. These applications facilitate the resolution of intricate financial transactions in supply chains, arising from collaborative value generation among blockchain participants. Transparent and authenticated records, along with automated transactions and tokenized financial claims, make it easier to finance working capital, ultimately lowering total financing expenses. SC assets can be used as collateral by creating financial claims with tokens, enhancing the financial complexity of supply chain management procedures. In essence, these use case clusters within BCT underscore the remarkable versatility of this technology in addressing a spectrum of challenges within SCM. From enhancing transparency and validation to enabling automation and introducing financial applications, BCT emerges as a transformative force, revolutionizing the efficiency and reliability of supply chain processes. The interconnected nature of these elements, while retaining the specific values and details, positions BCT as a linchpin for the evolution of modern supply chain practices [42].

2. SystematicLiteratureReview

2.1. Approach

2.6 We meticulously followed the established criteria outlined by Webster and Watson [49] to guarantee the methodological rigour of our systematic literature review (SLR). The adherence to these criteria was crucial in maintaining the integrity and reliability of our research approach. Adhering to the methodology prescribed by Webster and Watson, our approach transpired in a rigorous three-step sequence. We initiated the process by identifying key terms that were essential to achieving our research objectives. The preliminary stage established the groundwork for our ensuing database inquiry, which sought to encompass an extensive range of pertinent literature. By carefully choosing specific and pertinent keywords, we were able to guarantee that our search methodology adequately encompassed the entire academic domain that pertained to our area of study.

2.7 The implementation of an exhaustive database search followed suit. The articles obtained via this automated procedure were subjected to a comprehensive evaluation. The critical evaluation played a crucial role in identifying articles that made direct contributions to our research objectives. In light of the potential drawbacks associated with an exclusive reliance on a database-driven methodology, we supplemented our approach by conducting a manual search. The purpose of this supplementary procedure was to reveal further sources that the automated database search may not have identified, thus guaranteeing a more comprehensive investigation of the existing literature.The final product of our methodological strategy was the methodical consolidation and organisation of the chosen collection of papers. The objective of this concluding stage was to condense the most important observations obtained from the research, resulting in a cohesive and synthesized depiction of the combined discoveries. By strictly adhering to the methodological standards established by Webster and Watson, we enhanced the dependability of our systematic literature review and showcased our dedication to conducting an exhaustive and all-encompassing investigation of the relevant academic landscape.

2.2. DatabaseSearchandPaperSelection

We used the Journal Quality List (JQL) to find reputable publications in General Management & Strategy, Innovation, Management Information Systems & Knowledge Management, Operations Research, Management Science, and Production and Operations Management. Association of Business Schools Academic Journal Quality (ABS) and 'Verband der Hochschullehrer für BetriebswirtschaftJOURQUAL 3' rankings determined journal selection. We chose 214 high-quality early blockchain journals with a minimum score of 1 (ABS) or C (VHB).

Hawaii International Conference on System Sciences (HICSS), European Conference on Information Systems (ECIS), International Conference on Information Systems (ICIS), Pacific Asia Conference on Information Systems (PACIS), International Tatung Wirtschaftsinformatik (WI), and American Conference on Information

Systems (AMCIS) were also included.

We looked for publications with 'blockchain' and a supply chain (SC) keyword in the title or abstract. Thirteen keywords were derived from the CSCMP definition of supply chain management. 'Supply chain', 'network', 'business process', 'operations', 'procurement','sourcing','manufacturing', 'production', 'logistics', 'transport', 'distribution', and 'warehouse' were used Specific journals were searched using a meta-search engine that includes 202 databases, including EBSCO Business Source Complete. The AIS electronic Library provided conference proceedings. The search was time-free and limited to English-language works. On June 15, 2018, we got 61 results. This developing topic's early study may explain the lack of literature. The systematic literature evaluation included only full articles and excluded research that did not address Behaviour Change Techniques in Supply Chain Management. Only seven relevant articles remained. This group of papers was manually searched backward and forward to locate related publications not found in the database. Ten more papers were published using this method, totaling 17.

Table1.ResultsoftheStructured Literature Review

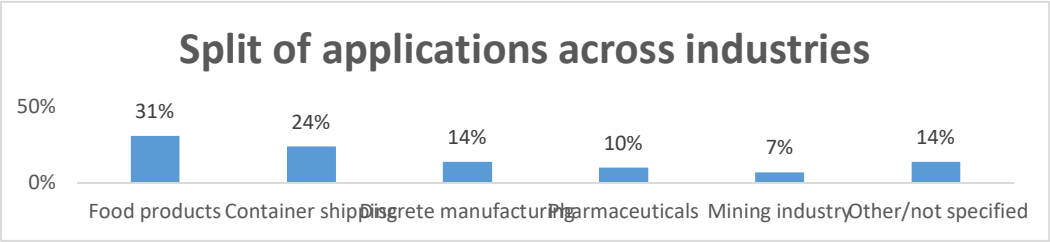
S.No.	Search type	References	Count
1	Database	**[51][19][52][53][54] [55][20]**	7
2	Manual	[59][60][61][62][63] [56][42][57][58][21]	10
	Total		17

2.7.

2.3. PaperCategorization

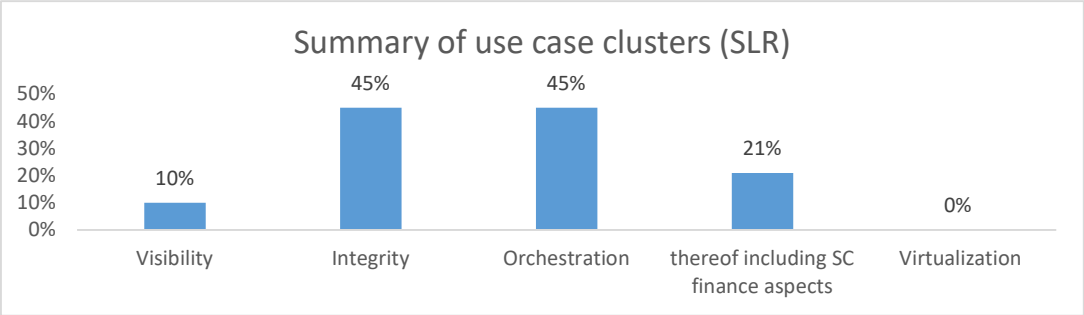
The search included 214 journals and six conference papers from 220 sources. Only the Proceedings of the Hawaii International Conference on System Sciences published three of the 13 pieces. Supply Chain Management Behavioural Contract Theory was awarded in 2016. Four papers in 2016, seven in 2017, and six by June 15, 2018, show that this research topic is still developing.35% of the sample papers were journal articles, 65% were conference proceedings. 65% of papers employed conceptual methods to investigate Behavioural Contract Theory (BCT) applications and implementation. Three studies employed expert interviews, while three used Ethereum blockchain modelling. None of the studies used quantitative empirical research methods.

Table2.Splitofapplicationsacrossindustries



This study examines a collection of articles that offer details on 29 applications of BCT. More than half of the cases involve food products and container shipments, primarily related to track and trace applications. The sample considered applications in discrete manufacturing, the pharmaceutical industry, and mining to be less important. Table 2 has comprehensive results. Next, we assigned the applications to the five use case clusters mentioned earlier. We focused on the predominant feature, recognizing that apps may belong to more than one category. This is particularly applicable to the clusters SC visibility and integrity, which are tightly connected and usually serve as the basis for more sophisticated use cases. Inter-rater reliability was ensured by having two authors independently complete the categorization, with disagreements resolved by involving the third author. Table 3 provides a summary of the results for each use case cluster.

Table3.Summaryofusecaseclusters(SLR)



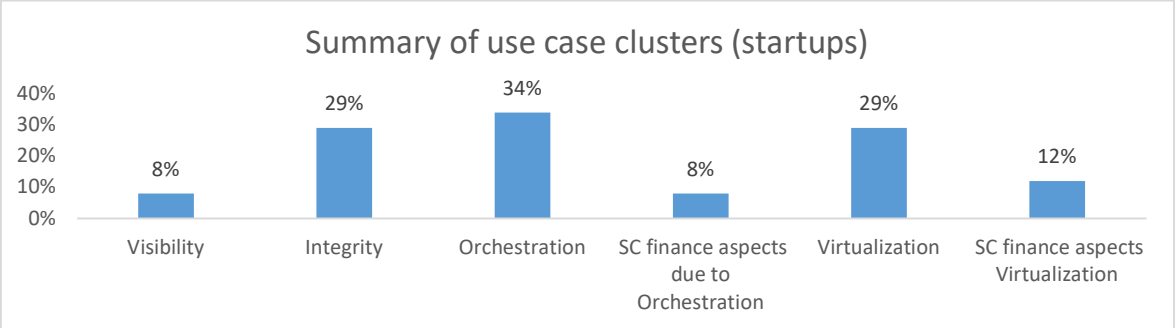
The literature emphasises supply chain integrity (45%) and orchestration (45%), with visibility (10%) less important. None of the sample apps demonstrate SC virtualization's benefits. Supply chain visibility tools enable communication and accurate monitoring of materials and goods, which is essential for corrective action.

SC integrity cluster applications fall into two categories. The first group comprises food safety traceability apps. A transparent chain of custody helps authorities discover and prevent fraud and quickly handle food-related illnesses. Diamond origin can be verified using BCT. Applications that trace conflict minerals or enable ethical sourcing need similar things. International shipping apps that digitise bill of lading documentation to reduce errors and fraud make up the second largest category. SC orchestration applications are often coupled to tracking and tracing apps, which automatically start actions when sensors identify a state or condition. Kshetri et al. [55] created an app to help pharmaceutical companies track temperature-sensitive deliveries. Pharmaceutical products will be immediately banned if they don't fulfil requirements. Nearly 50% of supply chain orchestration applications include finance. These smart contracts initiate financial transactions or enable working capital provision among partners.

3. CurrentTrendsofBCT-enabled Applications in SCM

We examined the newest Business Continuity Technologies (BCT) in Supply Chain Management (SCM) utilising angel.co data [64]. On June 15, 2018, we collected data on 515 blockchain and blockchain/cryptocurrency startup enterprises. To set a performance baseline, we only considered moderate or higher performance firms with a'signal strength' of 3 out of 5. The 24 applications were categorised by Supply Chain Management's five BCT-enabled use case clusters. Identification of Supreme Court financial cases was correct. Two raters independently classified the data and addressed conflicts with a third author for reliability. Table 4 shows the results. Startups lacking Supply Chain (SC) tags or weak SC descriptions were excluded. Financial payment systems in international trade and asset-based finance platforms unrelated to supply chain operations were excluded. 54% (13) of the 24 initial enterprises were in the Americas, 33% (8) in Europe, and 13% (3) in Asia. The companies were listed on the marketplace from January 2012, averaging 34 months. Two of the 24 submissions covered fashion, retail, and pharmaceuticals.

Table4.Summaryofusecaseclusters(startups)



SC visibility apps make up 8%, SC integrity 29%, and SC orchestration 34%. Startups are going beyond supply chain transparency for sophisticated applications. SC visibility solutions let fashion and retail supply chains share information. Supply chain integrity solutions fall into two groups. Four solutions target anti-counterfeiting and

provenance monitoring, while three help with electronic document management for global commerce needs (bill of lading) and pharmaceutical sector rules. These programmes aim to cut costs by improving efficiency. Many inter-company supply chain processes use paper, which increases information collection and confirmation costs. Automation of supply chain orchestration is a major industry 4.0 application cluster and creative Internet of Things sensor technology utilisation. Smart contracts enable machine connectivity, automating supply chain tasks. We found two supply chain finance-orchestration apps. One option involves machines coordinating physical and monetary exchanges. The second solution automates supply chain invoicing and payment. BCT improves intelligent SC actions beyond business boundaries.

3. Asset tokenization accelerates the process of converting assets into digital tokens that may be used in smart contracts. The samples we have provide options for utilising smart contract-enabled distributed manufacturing in applications. Tokenized production capacity can be exchanged among participants in the blockchain network in this situation. This method also has the ability to optimise the use of excess capabilities in logistics. The idea is consistent with past conversations in the supply chain field, such the Physical Internet, which encompasses collaborative and extensively automated supply chain systems. Three applications in the sample combine supply chain virtualization with supply chain finance to enhance asset-based lending and trade financing amongst supply chain partners. The combination of virtualization and financial factors improves the effectiveness and adaptability of supply chain operations, demonstrating a harmonious blend of technology and financial procedures.

4. Discussion

4. This section reviews BCT in SCM and offers future study. Given the shared ledger's main benefit, tracking and tracing are obvious applications. Applications in document-intensive domains like global trade and regulated industries like health and food are ubiquitous. Digital technologies enable automated supply chain coordination, creating new applications. On-demand smart contracts using tokenized smart contract assets will be the next phase. This is consistent with industrial service transformation [25]. However, this is an intermediate step towards completely digitalized smart contracts, as recommended in the literature (see [19]). The Physical Internet, which applies dispersed network principles to supply chain architecture and operation, and other related concepts should be examined for similarities and synergies. Due to BCT's strong relationship to cryptocurrencies, we expected more SC financial cluster applications. BCT enterprises use electronic payment methods extensively. Financial activities like asset-based financing are mostly unrelated to supply chains. SC finance and trade financing comprise a large export sector market with 12 trillion USD in trade credits.

5. BCT applications mostly concentrate on enhancing efficiency and reducing risks from the viewpoint of a single company. This aligns with the perspective that BCT is a versatile technology that overlooks the advantages of enhanced economic coordination resulting from new institutional structures. SCs could be restructured as blockchain networks to facilitate collaborative value creation and capture the value potential of ecosystems. Therefore, additional research should investigate innovative ecosystem-centered business models and related applications that could be facilitated by BCT (BCT).

6. BCThas the capacity to significantly improve current supply chain (SC) procedures and might potentially result in the development of novel organisational frameworks in the future. Yet, one must recognise certain challenges that must be resolved to offer a thorough view of this technology in the supply chain context. While data on the blockchain is unchangeable, faults in the first data input might lead to the 'garbage in, garbage out' issue. Additionally, there is no assurance that the physical representation of the data has not been altered [67]. As a result, Business Continuity Testing (BCT) can enhance business operations, but it will not render quality checks and audits unnecessary due to the inadequate data quality in supply chains. Another area that needs more research is the concept of data ownership in a decentralised system like a blockchain.

5. ConclusionandOutlook

7. This article explores the uses of BCTand its advantages for SCM. A complete structure of use case clusters

was designed to correlate to essential elements of BCT. We utilised the framework to examine 53 instances of Behaviour Change Techniques in Supply Chain Management sourced from both academic literature and real-world business operations. This allowed us to analyse the existing cutting-edge technology and to formulate future outlooks.

8. This paper's findings can be summarised as: Initially, applications of Behavioural Contract Theory in Supply Chain Management can be categorised into five use case groupings. Primary use cases involve tracking the origin of goods and automating supply chain activities, with financial components of supply chains being covered less frequently in blockchain applications. Virtual on-demand supply chains will represent the next stage of development in BCT inside supply chain management, aligning with the current shift towards service-oriented strategies in the industrial sector. Secondly, applications of BCT concentrate exclusively on harnessing the advantages of introducing a new versatile technology. Yet, this viewpoint overlooks the capacity of blockchains to innovate institutions by restructuring supply chains to facilitate collaborative ecosystem-driven value generation. Thirdly, BCT is constrained by certain technical limits, particularly in the context of SC-focused applications. The challenges are to the governance paradigm of data ownership and the generally poor data quality in supply chain contexts.

9. Due to the nascent nature of this research topic, conclusions should be considered preliminary. The study's weaknesses mostly concern the sample of applicants and the methodological methodology. This research utilises two distinct sources, comprising 53 applications, to present comprehensive evidence and minimise bias. The findings' generalizability relies on the chosen scope of applications. The reliability and validity of the results were ensured by a rigorous content analysis approach, however the interpretation of the results relies on the coder's individual appraisal of the data.

10. This article primarily addressed manufacturing and logistical challenges in SCM. There are several applications enabled by Behaviour Change Technology in service operations management domains including healthcare and retailing. A similar study might be undertaken for these industries to broaden the scope of operations management. Moreover, there is limited literature that utilises empirical research methodologies, particularly quantitative approaches are rare. Similar methods could be employed to understand the actual advantages, success factors, and obstacles encountered while implementing blockchain technologies in the supply chain environment.

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