Challenges in adopting blockchain technology in supply chain management: a too far fetched idea?

Rohit Raj  
*Department of Business Administration, National Taiwan University of Science and Technology, Taipei, Taiwan*

Arpit Singh  
*Department of Information Systems and Analytics, Jindal Global Business School, OP Jindal Global University, Sonipat, India*

Vimal Kumar  
*Department of Information Management, Chaoyang University of Technology, Taichung, Taiwan, and*

Pratima Verma  
*Department of Strategic Management, Indian Institute of Management Kozhikode, Kozhikode, India*

**Abstract**

**Purpose** – Recent technological advancements, often linked to Industry 4.0, require organizations to be more agile and innovative. Blockchain technology (BT) holds immense potential in driving organizations to achieve efficiency and transparency in supply chains. However, there exist some insurmountable challenges associated with the adoption of BT in organizational supply chains (SC). This paper attempts to categorically identify and systematize the most influential challenges in the implementation of BT in SC.

**Design/methodology/approach** – This study resorts to an extensive literature review and consultations with experts in the field of supply chain management (SCM), information technology and academia to identify, categorize and prioritize the major challenges using VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) and Combined Compromise Solution method (CoCoSo).

**Findings** – The top three classes of challenges revealed in this study are privacy challenges (PC), infrastructure challenges (IC) and transparency challenges (TC). Maintaining a balance between data openness and secrecy and rectification of incorrect/erroneous input are the top two challenges in the PC category, integration of BT with sustainable practices and ensuring legitimacy are the top two challenges in the IC category, and proper and correct information sharing in organizations was the top most challenge in the TC category.

**Originality/value** – Future scholars and industry professionals will be guided by the importance of the challenges identified in this study to develop an economical and logical approach for integrating BT to increase the efficiency and outcome of supply chains across several industrial sectors.

**Keywords** Block chain technology, Supply chain management, Challenges, VIKOR, CoCoSo

**Paper type** Research paper

The authors would like to thank the two anonymous reviewers, Associate Editor and Editor-in-Chief for their valuable comments and suggestions that helped to improve the manuscript.

**Funding:** The authors received no financial support for the research, authorship and/or publication of this article.

**Declaration of conflicting interests:** The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.
1. Introduction
As a disruptive technology, BT has recently attracted a lot of interest and buzz. Because of its potential advantages, businesses are starting to think about implementing this technology (Attaran, 2022; Bhatt et al., 2023; Daim et al., 2020). Cost reductions, enhanced transparency and traceability, and sustainability enhancement are just a few of the possible advantages that have been proposed (Rajasekaran et al., 2022). Even though 82% of Fortune 100 businesses have investigated BT, the pace of investment in BT has shockingly declined in 2019 (Zhu et al., 2022).

With its potential to bring about substantial benefits, organizations are increasingly considering the integration of this disruptive technology into their operations (Chowdhury et al., 2023). BT is seen as a means to realize cost reductions, enhance transparency, enable traceability and bolster sustainability efforts (Saxena et al., 2023). Nevertheless, the rapid expansion of BT investment has not been consistent, raising questions about its true potential. Surprisingly, the pace of BT adoption plateaued in 2019, despite 82% of Fortune 100 companies exploring its implementation (Chang et al., 2022). Furthermore, recent investigations into BT’s influence on the circular economy, through various industrial case studies, revealed that these endeavors often remain in the demonstration and pilot study phases, with few reaching full implementation (Rejeb et al., 2022). Through the analysis of several case studies from various industrial sectors, recent research examined the impact of BT on the circular economy and discovered that none of the examples are at the complete implementation phase but are instead stuck at the demonstration and pilot study stages. The reason why this is happening is a fundamental question. What are the obstacles preventing businesses from investing in and implementing this technology?

Because of the dependability, traceability, data immutability and smart contract capabilities of BT, ecosystems without middlemen are becoming more common (Sahebi et al., 2022; Raj et al., 2023a). One of the most important BT uses is supply chain sustainability. Why supply chains, one could ask? The solution is straightforward: because of global SC networks, complexity has increased. The term “BT” refers to decentralized ledgers that store transactions as data blocks that are connected by a cryptographic reference (Bhatt et al., 2021a, b). The chain extends to the initial block that was the source. Every time a new block is added to the system, its predecessor is connected to it (Chan et al., 2020; Bhatt et al., 2020). Critical aspects include distributed consensus and safe, traceable, verifiable and transparent information (Anoop and Goldston, 2022). These traits encouraged several businesses, like Walmart and Glencore, to incorporate BT into their supply chains in order to boost productivity and efficiency (Mukherjee et al., 2022). According to a recent Deloitte poll, BT maturity has climbed 18% in the eyes of many executives and decision-makers (DM) over the past year, signaling a significant shift in the industry’s momentum (Junaid et al., 2022). This fact will serve as yet additional impetus for this study, encouraging us to identify crucial elements including the impediments that speed up the adoption of BT.

Over the past three decades, the sustainability of the SC has grown in significance and become a key factor in driving demand and client loyalty (Yu et al., 2022). The triple-bottom-line, usually referred to as sustainability, is the balancing of environmental, social and business considerations. Promoting sustainable supply chain management is important for social, competitive and legal reasons (Seuring et al., 2022). Customers want to check the sustainability of their products, and they need an easily available information source. To ensure that suppliers are following sustainable practices there are various information and auditing certification tools to validate the sustainable performance of suppliers (Kim et al., 2022; Raj et al., 2023b). Sustainability in the supply chain might be revolutionized by BT (Parmentola et al., 2022). Examples of use cases include Maersk (Kshetri, 2022), Provenance (Bager et al., 2022), Walmart (Luo and Pan, 2022) and recently in Mongolia (Mendjargal et al., 2022) for improving the sustainability of cashmere. Use cases also include companies that want to integrate BT into their supply chain operations for product traceability. Some companies, including Chipotle Mexican Grill, employ it to ensure the safety of their food (Ramabalan et al., 2022). An objective
of certain BT applications has also been to reduce fake goods. These instances of supply chain sustainability pertain to techniques that are secure, safe and ecologically friendly. Even though there are a lot of potential BT benefits for enhancing sustainability in a network, there aren’t many use cases of BT for sustainability, and businesses are still having trouble with the more comprehensive parts of sustainability (Friedman and Ormiston, 2022). With certain exceptions, as was already indicated, technological investment is declining.

Technology advancements have benefits and drawbacks. The consumption of energy in BT technology is a key challenge for sustainability (Appasani et al., 2022). Several hundred megawatts of energy are used by key “proof-of-work” consensus systems because of their high processing requirements. Carbon emissions rise along with energy use. To preserve data security and duplicate entries, decentralized ledgers also require more processing resources and electricity, which eventually results in increased energy consumption (Ahl et al., 2022; Raj et al., 2022). These are merely drawbacks in terms of sustainability; however, as our study will show, there are many more obstacles to the adoption of this technology in SC across industries. Additionally, a corporation must undergo disruptive changes in both its technical and non-technical procedures when using a new disruptive technology, such as BT (Ronaghi, 2022). Despite its promises, BT technology has been adopted gradually. The bulk of adopted cases was discussed in the literature stall during the pilot and planned usage stages. We’re interested in learning why this technology, which has so much promise for the future of the economy, society and environment, hasn’t advanced. Several obstacles that prevent BT from being widely adopted need that its impact is felt in the corporate sector. Many firms are still struggling with how BT performed in SC. Many academics and professionals are experimenting with the use of BT in SC. Due to multiple organizational, technological, operational and societal hurdles, the current state of BT adoption in SC is questionable. This research attempts to provide readers with a thorough knowledge of the numerous difficulties that BT adoption in SC confronts. We must thus be aware of any potential challenges or constraints that companies may encounter while implementing this technology.

Following a study of the extensive literature, 15 challenges to the adoption of BT in SC are identified. These challenges are further categorized into five clusters: privacy challenges (PC), transparency challenges (TC), organizational challenges (OC), regulatory challenges (RC) and infrastructure challenges (IC). Since each of these elements has a large impact on SC, choosing amongst them is difficult and unclear. Multi-criteria Decision Making (MCDM) methods have been used in this circumstance (Yalcin et al., 2022). To identify major challenges to the adoption of BT in SC, the discovered challenges are prioritized using the VIKOR and CoCoSo approach.

The remainder of the paper is structured as follows. Section 2 presents a recent literature review in the context of Blockchain adoption in SC. Section 3 illustrates the research methodology adopted to conduct the research including a detailed explanation of the MCDM method based on VIKOR, and Section 4 presents the results and the data analysis. Section 5 discusses the key findings by comparing them with the studies conducted on the related subject matter. This is followed by the theoretical and managerial implications in Section 6. The paper concludes with Section 7 also listing out the major limitations and future course of action.

2. Literature review
Blockchain has just become a new method of trading money. Blockchain technology is being increasingly adopted as a means for conducting financial transactions. Blockchain is a distributed ledger technology originally designed to support cryptocurrencies like Bitcoin. However, it has since evolved to be used in a wide range of applications, including financial services. Blockchain’s appeal lies in its security, transparency and decentralization, which can potentially reduce the need for intermediaries like banks in financial transactions. This technology is gaining prominence and is transforming the way people handle financial transactions.
transactions and manage their money. It’s worth noting that blockchain technology has already been growing in popularity in the financial sector, and its adoption is expected to continue evolving (Chuah, 2023). Blockchain remains closely associated with cryptocurrencies, which have continued to gain mainstream recognition and investment. Bitcoin and Ethereum, as well as numerous other cryptocurrencies, have become established assets for trading and investment (Brasse and Hyun, 2023). Decentralized Finance (DeFi) is a major application of blockchain technology that has seen explosive growth. DeFi platforms enable users to lend, borrow, trade and earn interest on cryptocurrencies without the need for traditional financial intermediaries. This has introduced a new way of trading money through decentralized exchanges and lending protocols. Non-fungible tokens (NFTs), which are unique digital assets often representing art, collectibles, or virtual real estate, have become a significant part of the blockchain ecosystem. NFTs have created new opportunities for artists, creators and collectors to trade digital assets using blockchain technology (Tong, 2022). Blockchain-based smart contracts, such as those on the Ethereum network, allow for automated, self-executing agreements. They are increasingly used in various financial applications, including lending, insurance and decentralized autonomous organizations (DAOs) (Ullah and Al-Turjman, 2023).

The techniques employed by such technology, however, are fundamentally altering social and economic dynamics. Blockchain is one of the top ten strategic technologies for 2020, according to Gartner (Bouraga et al., 2021). However, the same assessment said that the technology was in the “Trough of Disillusionment” phase since interest had waned due to failures in trials and implementations to provide useful results (Kietzmann and Archer-Brown, 2019). Despite this, blockchain may be viewed as a new paradigm for exchanging information and data, which is important in many fields. As a result, interest has increased in several industries, including supply chains. One of the main benefits of adopting blockchain in SC is its ability to create a secure distributed ledger for monitoring products that is continually updated. Stuart Haber and W. Scott Stornetta initially proposed the idea of BT in 1991 (Modani et al., 2021). The original plan was to create a system that recorded timestamps that couldn’t be changed or retroactively dated.

A blockchain also has a decentralized system (peer-to-peer network) that allows every participant to have a complete copy of the chain, allowing each node to verify that the chain is unbroken. The majority of nodes check the addition of a new block to the chain before adding it to their chains. Through consensus, these nodes build a secure network (Kaur et al., 2021). In other words, the validity of a block is agreed upon by all parties. A blockchain, in essence, is a platform that is secured by proof-of-work, consensus and the blocks themselves (Schinckus, 2021). After defining the words supply chain and blockchain, we look at how they could work together and pinpoint certain important functions. There is a need for simplification since a SC structure is complicated and involves several players, both upstream and downstream. The difficulties presented by supply networks can be effectively addressed by blockchain. According to Iansiti and Lakhani (2017), blockchain enhances current business processes rather than replacing them. Due to its distributed ledger, blockchain enables individuals to communicate electronic information within predetermined bounds, independent of their location. Data mistakes are a prevalent and enduring issue in the supply line. Many of these mistakes are made during the entry process. Due to the reduction in labor required, blockchain can eliminate data input mistakes (Nofer et al., 2017). Since everyone has access to the same information, redundant employment may be eliminated. Trustworthiness in the supply pipeline is guaranteed by the fact that information is time-stamped and unchangeable after it has been generated (Francisco and Swanson, 2018). The pharmaceutical industry’s supply chain serves as a concrete illustration of the need for openness. Patients and the industry as a whole are put in danger by fake and subpar pharmaceutical items (Maloney, 2022). The smart contract is another distinctively important component of block chain
technology. According to Chen et al. (2021), who researched the supply chain’s smart contract-based tracking mechanism, the supply chain sector will undergo significant reengineering as a result of blockchain technology. If all prerequisites are satisfied, an electronic contract causes the procedure to advance to the following stage (i.e. the payment process). Thus, vendors can make sure that the proper money is paid at the right time and buyers can be guaranteed that the things are in a predefined state (Iyengar et al., 2022). Thus, blockchain applications can enhance functionality and regulatory controls while resolving supply chain problems.

2.1 Blockchain adoption in supply chains

Centralized supply chains are susceptible to dishonesty, corruption, distorted information flow and loss of productivity (Alabi and David, 2022). Block chain technology (BT) with the inherent characteristics of being distributed, tamperproof and an immutable platform provides a solution to the aforementioned problems with associated centralized SC (Sangari and Mashatan, 2022). BT with its outstanding characteristics has the ability to completely transform supply chains across many industries (Chang et al., 2022). However, the implementation of BT in supply chains still faces some obstacles and has to go a long path before it is embraced holistically across industries (Kucukaltan et al., 2022; Almutairi et al., 2023; Li et al., 2022b). There are some cases highlighting the benefits brought about by the implementation of BT in SC along with the challenges in the implementation. In a study conducted with five leather garment manufacturing companies to identify the major challenges in BT adoption, it was found that the top five issues encountered by the leather garment manufacturing organizations include a lack of understanding of BT, the absence of a common legal framework, new organizational rules, reputation-based attacks and vulnerability to cyberattacks. The results of this study give managers structural support by outlining the cause-and-effect group issues with BT adoption (Karuppiah et al., 2023). The four main issues facing the food industry—lack of traceability, food fraud, food recalls and food waste—were explored in this article along with how BT may help food supply chains in terms of food safety and quality. The practical advantages of BT were also covered, including how they might reduce transaction costs and time, boost revenue and enhance supply chain performance in the context of food SC. Finally, Li et al. (2021b) examined the technical, financial, governance, regulatory, awareness and educational barriers to BT implementation in the food SC. The potential of blockchain technology in the food sector has drawn interest. However, the lack of successful initiatives and detailed studies hampered its gradual implementation in food supply chains. The adoption determinants, impediments, applications and stages were identified by a systematic examination of 69 high-quality studies. Scalability and restrictions emerged as ongoing problems in the adoption of BT in food supply chains. The implementation of BT in food supply chains was suggested using a three-stage structure, to assist food chain managers and practitioners in determining its applicability and offering recommendations for adoption (Vu et al., 2023). In the study investigating the employee intentions in the retail supply chain, it was found that the retail store employees exhibit a favorable attitude toward adopting BT. However, perceived behavioral control and effort expectancy do not appear to drive BT adoption in the retail sector (Mukherjee et al., 2023). This paper introduces a framework to identify and assess these challenges in supply chain management. Initially, 40 key adoption challenges were identified using the fuzzy Delphi technique. Case studies involving five leather garment manufacturing companies were conducted to validate this approach. The findings reveal that the top five challenges faced by these companies include a lack of knowledge about blockchain technology, the absence of universal regulatory binding, new organizational policies, reputation-based attacks and vulnerability to cyber-attacks (Karuppiah et al., 2023). The
study delves into the impact of blockchain technology on supply chain factors and how these contributions influence its adoption among small and medium-sized enterprises (SMEs). Grounded in contingency theory, it also explores how market turbulence may moderate these effects. Data from 204 SMEs in Malaysia’s manufacturing sector were analyzed using the partial least squares technique. The findings reveal that SME managers’ intention to adopt blockchain is influenced by its contributions to supply chain transparency and agility. These supply chain factors – transparency, alignment, adaptability and agility – are interconnected. Market turbulence positively moderates the relationship between agility and the intention to adopt blockchain (Iranmanesh et al., 2023). The major challenges in the adoption of BT in food SC as highlighted in the study conducted with the food industry were the issues about scalability, regulations, privacy and incentivization (Vu et al., 2023). Cryptocurrency volatility, poor regulatory provisions, technology immaturity, dependence on external agencies for inputs, scalability and bandwidth issues, and smart contract issues were some of the key challenges identified in the adoption of BT in supply chain cybersecurity (Etemadi et al., 2021). Lack of government support and encouragement in incorporating BT in SC and integration of sustainability with BT are revealed as the critical barriers to the adoption of BT in Moroccan sustainable SCM (Boutkhoum et al., 2021). The key challenges in the implementation of BT in SC are shown in Table 1.

2.1.1 Privacy challenges (PC). BT is considered a secure platform owing to its immutable and transparent characteristics and additionally, cryptocurrencies that are based on BT offer pseudonymity. However, many applications on BT require smart transactions and contracts that are intricately linked to known identities poses serious concerns regarding the security and privacy of sensitive information supplied to the networks of blockchains. The confidential and sensitive information, if uploaded on a public ledger becomes immediately available to the public and hence becomes vulnerable to misuse and tampering (Latif et al., 2021). This is the most critical challenge that impedes the adoption of BT in supply chains across organizations. Additionally, BT is not immune to incorrect input being supplied to it. If there are discrepancies in the input data then the error propagates throughout the blockchain and can corrupt the entire system (Ghonge et al., 2023). Thus, extra care has to be exercised while inputting data to avoid problems in the later stages.

2.1.2 Transparency challenges (TC). When organizations collaborate on areas of “shared suffering or shared opportunity,” the blockchain adds the most value to such enterprises. The issue with many of the present methods is that they are stand-alone; businesses are creating their blockchains and the apps that will operate on top of them (Homoliak et al., 2020). Therefore, many different chains are being established by many different organizations to many various standards in any given business area. This can be less effective than existing methods and goes against the intent of distributed ledgers by failing to capitalize on network effects (Catalini and Gans, 2020). However, the emergence of so-called blockchain consortia, intended to address industry-wide concerns like standards, critical mass, etc., is a welcome development (Zheng et al., 2021). The primary issue facing businesses using blockchain, particularly small and medium-sized businesses, is that most people are unaware of the technology and don’t fully comprehend how it operates. Many businesses are unaware of what BT is or what it can achieve (Sinha and Dhanalakshmi, 2022).

2.1.3 Organizational challenges (OC). The adoption of a new technological platform has always been met with serious resistance from the workforce as well as management (Abbate et al., 2022). There are multiple reasons why people at organizations are skeptical about embracing new technology; the first of which is to get themselves educated to operate on the new platform. With time, people get accustomed to using legacy systems and feel comfortable using them. The incorporation of new technology challenges them to step out of their comfort zone and invest time and resources in learning a new way of working (Walsh et al., 2021). Also, there are serious questions from the management about the return on
investment (ROI) of the new technologies (Saheb and Mamaghani, 2021). The output as a result of the new technologies takes quite some time from the point it is put to work. In most situations, organizations do not feel ready to invest that time in anticipation. Another challenge for organizations to adopt new technology such as BT is the varied perceptions of suppliers along supply chains in understanding the importance and working of new technologies (Friedman and Ormiston, 2022). Not every supplier in a typical supply chain, especially in developing countries such as India completely comprehends the potential of BT

<table>
<thead>
<tr>
<th>Challenges</th>
<th>Criteria</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Privacy challenges (PC)</td>
<td>PC1</td>
<td>Ghiasi et al. (2021), Guha Roy and Srirama (2021), Prakash et al. (2022)</td>
</tr>
<tr>
<td></td>
<td>PC2</td>
<td>Fan et al. (2022), Mamun (2022), Pradhan et al. (2022), Junejo et al. (2021)</td>
</tr>
<tr>
<td></td>
<td>PC3</td>
<td>Tsuchiya and Hiramoto (2021), Choudhari and Das (2021), Yoo (2021), Abduljabbar et al. (2021)</td>
</tr>
<tr>
<td>Transparency challenges (TC)</td>
<td>TC1</td>
<td>Utz et al. (2022), Biswas et al. (2023), Yahaya et al. (2022), Long et al. (2022)</td>
</tr>
<tr>
<td></td>
<td>TC2</td>
<td>Chiu et al. (2021), Kumar and Chopra (2022), Wu and Zhang (2022), Al-Farsi et al. (2021)</td>
</tr>
<tr>
<td></td>
<td>TC3</td>
<td>Sugandhi et al. (2022), Rabby et al. (2022), Sushma et al. (2022), Bakare et al. (2021), Fonseca Cacho et al. (2021)</td>
</tr>
<tr>
<td>Organizational challenges (OC)</td>
<td>OC1</td>
<td>Omar et al. (2021), Hellani et al. (2021), Li et al. (2022a), Lim et al. (2021a)</td>
</tr>
<tr>
<td></td>
<td>OC2</td>
<td>Bakhtiarizadeh et al. (2021), Nath et al. (2022), Li et al. (2021b), Saihi et al. (2021), Maganga and Taifa (2022)</td>
</tr>
<tr>
<td></td>
<td>OC3</td>
<td>Das et al. (2021), Prashar (2022), Abbate et al. (2022), Agrifoglio and de Gennaro, (2022)</td>
</tr>
<tr>
<td>Regulatory challenges (RC)</td>
<td>RC1</td>
<td>Millard (2018), Fernandez-Vazquez et al. (2019), Batubara et al. (2018), De Filippi et al. (2022), Gan et al. (2021)</td>
</tr>
<tr>
<td></td>
<td>RC2</td>
<td>Teng et al. (2021), Lu et al. (2021), Bhubalan et al. (2022), Nandi et al. (2021), Malik et al. (2021), Paliwal et al. (2010)</td>
</tr>
<tr>
<td></td>
<td>RC3</td>
<td>Treiblmaier et al. (2021), Salcedo and Gupta (2021), AlShamsi et al. (2022), Kouhizadeh et al. (2021)</td>
</tr>
<tr>
<td>Infrastructure challenges (IC)</td>
<td>IC1</td>
<td>Khan et al. (2021), Chauhan and Patel (2022), Fotohi and Aliee (2021), Kumar et al. (2021), Thiekkoote (2022)</td>
</tr>
<tr>
<td></td>
<td>IC2</td>
<td>Böckel et al. (2021), Liu and Ye (2021), Khanfar et al. (2021), Yildizbasi (2021)</td>
</tr>
<tr>
<td></td>
<td>IC3</td>
<td>Trollman et al. (2022), Bhubalan et al. (2022), Nandi et al. (2021), Prashar (2022)</td>
</tr>
</tbody>
</table>

Source(s): Authors’ own work

Table 1. List of associated challenges in the adoption of BT in supply chains
in refurbishing the operational output and workers’ productivity. Thus, bringing every participant in a supply chain on the same page is another critical challenge confronting organizations in embracing BT.

2.1.4 Regulatory challenges (RC). Another obstacle to the widespread use of the underlying BT is the absence of legislative certainty (Čižmešija and Vrček, 2021). Regulations and technological advancements have always been at loggerheads with each other. Blockchain also operates similarly. The blockchain approach’s main drawback is that it minimizes supervision, which was also one of its initial goals. BT is being developed by several businesses as a transactional method. However, there are currently no particular laws governing it. Therefore, there is still no security because no one adheres to any set norms when it comes to the blockchain (Taherdoost, 2022). Certain fields, like the aforementioned smart contracts, call for regulatory assistance. If smart contracts are not covered by the legislation, adoption and investment in the blockchain sector will be hampered (Alam et al., 2021).

Undeniably, centralized systems play a pivotal role in absorbing shocks, especially in the financial sector. On the other hand, decentralized systems are much less useful in absorbing sudden shocks when compared with centralized systems (Bhayani et al., 2021). Thus, BT-based applications should operate within the purview of already existing regulatory institutions so that the users are safeguarded against sudden “shocks”. Government agencies and industries with strict controls may need to develop blockchain legislation to eliminate these associated challenges. However, this implies that regulations across each industry must comprehend the technology and how it affects both corporations and consumers.

2.1.5 Infrastructure challenges (IC). Scalability, a crucial factor in blockchain networks, refers to a network’s ability to support higher transaction throughput (Zhou et al., 2020). Scalability is therefore essential for Blockchain’s further development. The performance of a fully scalable blockchain cannot be hampered by the growth in use cases and acceptance of the technology. Blockchains may not be scalable if their performance declines as a result of growing usage (Kim et al., 2018). Public blockchains’ incapacity to scale is limiting the availability of the best solutions for businesses and sectors. Scalability has been identified as the largest barrier to the construction of public blockchains in many real-world business settings (Yang et al., 2020). Blockchain’s scalability issue mostly manifests as a result of an increase in nodes and transactions. In well-known global blockchain systems like Bitcoin, this issue arises because each node is required to store and carry out a computational activity to verify each transaction (Khan et al., 2021). According to the blockchain trilemma paradox, achieving greater scalability would mean sacrificing decentralization and security (Schaaf et al., 2021). However, it is crucial to keep in mind that blockchain networks can only successfully compete with established, centralized platforms if they are scalable. As a result, public blockchains always need a lot of processing power, quick Internet connectivity and storage space (Li et al., 2021a). The two often contested blockchain performance metrics, transaction throughput and latency have not yet reached a suitable quality-of-service (QoS) level in many noteworthy recent public blockchains (Gracy and Jeyavadhanam, 2021).

3. Methodology
The proposed revolutionary decision-making model is presented in this part by fusing a new integrated data-driven weighting system with VIKOR and the CoCoSo model (Figure 1). As was already said, the purpose of this study is to identify the associated difficulties that may arise while using a blockchain to address supply chain interruption problems. When making decisions using multiple criteria, the VIKOR (ViseKriterijumska Optimizacija I Kompromisno Resenje) and CoCoSo (Combined Compromise Solution method) are used (MCDM). These techniques are useful when decision-makers and experts are unable to convey their opinions up front.
The VIKOR and CoCoSo methods are straightforward, simple to comprehend and practical to use. It offers a systematic and convincing method to address the issues and arrive at the best conclusion. VIKOR and CoCoSo provide a complete comparison score that combines all criteria and their assessment, which is different from previous MCDM techniques. The compromised result of this strategy can also serve as the basis for discussions over the decision-maker’s preferred criteria weights.

When evaluating the associated difficulties and criteria affecting blockchain adoption in supply chain operations, VIKOR and CoCoSo are suitable tools to use. The interested reader
may refer to these publications for additional CoCoSo technique and VIKOR applications (Opricovic and Tzeng, 2004, 2007; Yazdani et al., 2019). Experts in management control and operations research identify VIKOR and CoCoSo as one of the most effective efficiency assessment methods in the world.

3.1 Data collection and sample
The data was collected from auditors, service engineers, inventory managers and research and business development personnel through a Google questionnaire-based survey. As indicated in Table 2, all respondents hold a variety of jobs, including chief executive, manager, supervisor and senior manager. This study underlines that a stringent criterion of knowledge within the arena of BT was used to choose responders for our study. Each of the ten responders has an impressive background working with blockchain and cryptocurrency, and both academic and professional communities regard their opinions as highly credible. To accomplish our research goals, we intended to get in-depth opinions from a group of reputable specialists. This allowed us to delve into subtle issues that are frequently hard to reach via larger-scale surveys (Kumar et al., 2023). As these experts have a wealth of expertise and knowledge that significantly enhances our study, it was intended to give priority to the quality of responses rather than the quantity of responses (Raj et al., 2023c). The statement regarding the 10 respondents is true, and the study’s results can be more robust and reliable because of the small sample size. The sample must be representative and should adequately reflect the population of interest. Expert counsel could prove helpful in concluding. The results are prone to reflect the real characteristics of the study group. It is crucial to be aware of the constraints and possible repercussions of the study’s confined sample size.

<table>
<thead>
<tr>
<th>Profile</th>
<th>Classification</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Female</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>4</td>
</tr>
<tr>
<td>Age</td>
<td>20–30</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>31–40</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>41–50</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Above 50</td>
<td>0</td>
</tr>
<tr>
<td>Denomination</td>
<td>Executive</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Supervisor</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Manager</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Senior manager</td>
<td>1</td>
</tr>
<tr>
<td>Education</td>
<td>Diploma</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Bachelors</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Post Graduate</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Doctoral in technical education</td>
<td>0</td>
</tr>
<tr>
<td>Present company tenure (in years)</td>
<td>1–7</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>8–14</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>15–21</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>above 22 years</td>
<td>1</td>
</tr>
<tr>
<td>Department of respondents</td>
<td>Audit</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Service engineer</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Inventory</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Logistics</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Research and Development</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 2. Respondent’s demographic details

Source(s): Authors’ own work
3.2 VIKOR
A tool for making multiple-criteria decisions was introduced as VIKOR (Opricovic and Tzeng, 2004, 2007). Exploring “negative and positive ideal solutions” and determining the options with the lowest (negative) and highest (positive) values constitute the core principle of VIKOR. Through a linear standardization process, the multi-criteria ranking tool VIKOR determines how close a solution is to being the optimal one. A sensible compromise is then chosen as the best option from a group of workable options with competing requirements. It has provided the “majority” with the highest cluster value and the “rival” with the lowest distinct guilt.

The evaluation solution is a workable one, positioned between the optimistic perfect and the unfavorable ideal solutions. The ranking metric is formulated using L₁, L₂, and Lₘₐₓ,ₑᵢ. You can see the required steps for applying VIKOR (Opricovic and Tzeng, 2004, 2007). The best, (xₑᵢ)ₘₐₓ, and the worst, (xₑᵢ)ₘᵢₙ, values for each of the criteria are first calculated for the decision matrix, and they are then assigned the values Eᵢ, Fᵢ, and Pᵢ.

The maximum and minimum values are represented by Eᵢₘₐₓ, Eᵢₘᵢₙ, Fᵢₘₐₓ, and Fᵢₘᵢₙ. The measurement value of v between 0 and 1 is considered to represent “the majority of qualities” by experts and decision-makers. Three possibilities are taken into consideration, with v > 0.5 (first), v < 0.5 (second), and v = 0.5 (third). The first case represents the basic term in the provided equation (5), consequently, the second case is the opposite of the first case concerning the substitutes’ overall presentation concerning all of the criteria, and the third case would be taken into consideration once both of these viewpoints are taken into account in a way that is balanced and shows relevance. The best replacement is determined in the following phase by the lowest Pᵢ value sorted in ascending order. Equations (1) to (5) are used to calculate the relevant parameters:

\[ L_p,i = \left\{ \sum_{j=1}^{n} \left( w_j \frac{[(x_j)_{\text{max}} - x_{ij}]}{[(x_j)_{\text{max}} - (x_j)_{\text{min}}]} \right)^p \right\} \frac{1}{p} \quad 1 \leq p \leq \infty; \quad i = 1, 2, ..., m \] (1)

\[ E_i = L_p,i = \sum_{j=1}^{n} w_j \frac{[(x_j)_{\text{max}} - x_{ij}]}{[(x_j)_{\text{max}} - (x_j)_{\text{min}}]} \] (2)

\[ F_i = L_{\infty,i} = \text{Max}^n \left\{ w_j \frac{[(x_j)_{\text{max}} - x_{ij}]}{[(x_j)_{\text{max}} - (x_j)_{\text{min}}]} \right\} \quad j = 1, 2, ..., n \] (3)

\[ E_i = L_1,i = \sum_{j=1}^{n} w_j \frac{x_{ij} - (x_j)_{\text{min}}}{[(x_j)_{\text{max}} - (x_j)_{\text{min}}]} \] (4)

\[ P_i = v \left( \frac{E_i - (E_i)_{\text{min}}}{(E_i)_{\text{max}} - (E_i)_{\text{min}}} \right) + (1 - v) \left( \frac{F_i - (F_i)_{\text{min}}}{(F_i)_{\text{max}} - (F_i)_{\text{min}}} \right) \] (5)

3.3 CoCoSo
A new MCDM ranking model known as the CoCoSo technique was proposed by Yazdani et al. in 2019. It is based on the amalgamation of three compromise score aggregation algorithms (Ecer and Pamucar, 2020; Hashemkhani Zolfani et al., 2020). CoCoSo has been used in many ways in a variety of sectors, such as sustainable development and performance evaluation, due to its high dependability in computing optimal compromise scores utilizing an integrated framework. Considering pertinent data from each of the three sustainability framework pillars. Ecer et al. (2019) proposed a CoCoSo-based methodology for the environmental
assessment of OPEC countries. Using research from the literature and the opinions of experts, Khan and Haleem (2021) established a CoCoSo-based approach to assess sustainability and circular economy practices. The full algorithm below is a presentation of the CoCoSo method, which is centered on the incorporation of the weighting method and the exponentially weighted product approach.

Step 1. The original decision matrix is built using facts or the recommendations of experts.

Step 2. Depending on the extent of the criterion, the initial choice matrix is normalized as follows.

\[
 r_{ij} = \frac{x_{ij} - \min_i x_{ij}}{\max_i x_{ij} - \min_i x_{ij}} \quad (6)
\]

\[
 r_{ij} = \frac{\max_i x_{ij} - x_{ij}}{\max_i x_{ij} - \min_i x_{ij}} \quad (7)
\]

Step 3. Based on the following equations, the weighted comparability sequence sum \( S_i \) and the power-weighted comparison sequence sum \( P_i \) for each alternative are determined:

\[
 S_i = \sum_{j=1}^{n} (w_j r_{ij}) \quad (8)
\]

\[
 P_i = \sum_{j=1}^{n} (w_j)^{e_j} \quad (9)
\]

Step 4. The relative weights of the options are determined using three aggregated appraisal ratings.

\[
 M_{ia} = \frac{P_i + S_i}{\sum_{i=1}^{m} (P_i + S_i)} \quad (10)
\]

\[
 M_{ib} = \frac{S_i}{\min_i S_i} + \frac{P_i}{\min_i P_i} \quad (11)
\]

\[
 M_{ic} = \lambda(S_i) + (1 - \lambda)(P_i); \quad 0 \leq \lambda \leq 1
\]

Equation (10) denotes the arithmetic average of the sums of the scores, whereas equation (11) denotes the total of the relative scores concerning the best option. Equation (11) finally determines a reasonable compromise score. The value of \( \lambda \) in equation (12) (typically) varies between 0 and 1 and is determined by the DM and expert.

Step 5. The output for each alternative is calculated using equation (13), and the alternatives are ranked following that value.
4. Data analysis and results

To achieve rankings for each of the five related challenges of the BT selected for effective decision-making, the study has emphasized VIKOR processes based on the suggested flowchart. These input and output criteria were chosen by the authors (Opricovic and Tzeng, 2004). The research has also worked hard to create a methodology that may be used to prioritize the problems that are chosen by VIKOR. The outcomes of the analysis and prioritization of the specified variables aid in the formulation of strategic and tactical decisions. These choices have additional significance for sectors adopting operational strategies for blockchain-based operations in supply chains.

This model’s execution, including top to lowermost ranking and blockchain implementers, has to provide greater focus, which is showcased in the present part. So, based on tactical based alternatives of 10 makers of a decision whose demographic details are presented in Table 2, the judgment is significant since they have provided the assigned weight “0.010”, “0.150”, “0.050”, “0.140”, “0.050”, “0.150”, “0.050” and “0.200” considering challenges such as privacy challenges (PC), transparency challenges (TC), OC, regulatory challenges (RC) and infrastructure challenges (IC) and criteria PC1, PC2, PC3, TC1, TC2, TC3, OC1, OC2, OC3, RC1, RC2, RC3, IC1, IC2 and IC3 respectively. Further, these challenges are categorized and relative weights are given in Table 3 considering methods equation (1) and equation (2).

The VIKOR methods are adopted in the study and shown in Tables 4–6. The normalized decision matrix and normalized relative weighted matrix minimum, are given in Table 4 and Table 5 for given indicators, considering method equation (2) and equation (3). Mostly with the value of the weighting of technique v, the highest group utility in this case, we evaluate

$$M_i = (M_{ia} M_{ib} M_{ic})^{\frac{1}{3}} + \frac{1}{3} (M_{ia} + M_{ib} + M_{ic})$$  \hspace{1cm} (13)

### Table 3. Relative weights scored by experts

<table>
<thead>
<tr>
<th>Challenges</th>
<th>0.010</th>
<th>0.150</th>
<th>0.050</th>
<th>0.150</th>
<th>0.050</th>
<th>0.140</th>
<th>0.050</th>
<th>0.150</th>
<th>0.050</th>
<th>0.200</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>TC</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>OC</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>RC</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>IC</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>BEST(max)</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>WORST(min)</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

**Source(s):** Authors’ own work

### Table 4. Normalized decision matrix

<table>
<thead>
<tr>
<th>Challenges</th>
<th>DM1</th>
<th>DM2</th>
<th>DM3</th>
<th>DM4</th>
<th>DM5</th>
<th>DM6</th>
<th>DM7</th>
<th>DM8</th>
<th>DM9</th>
<th>DM10</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>TC</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
<td>0.5</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>OC</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0.5</td>
<td>1</td>
<td>0.5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>RC</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>IC</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0.5</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

**Source(s):** Authors’ own work
the maximum and lowest magnitude values for each criterion depending on these weighting decision matrices. We determine the order of options by the values of Ei, Fi and Pi shown in Table 6 using equations (4) and (5). A significantly higher rank is represented by low values of Pi. Table 6 summarizes the rankings and selections made after taking equation (4) into account.

The final rank of the associated challenges for affecting blockchain implementation-associated challenges is given as PC > IC > TC > RC > OC. Table 6 illustrates that PC and OC have the lowest and highest Pi scores, respectively, for challenges. According to the Pi values presented in Figure 2 for each task, the charts have been drawn in order of priority. The graphs indicate the final ranking of problems for supply chain operators using blockchain technology. The important markers of their improved efficiency for BT adoption-based processes in the firm are these difficulties. The existing organizational units are advised to prioritize this challenge selection in order to choose their sequence properly and greatly improve both their competitiveness and operational performance in order to survive in the current cutthroat business environment.

The assessing progress toward ranking and prioritizing the criteria as shown in Table 1 by using CoCoSo. Consider the prioritization for criteria based on other alternatives for validation of this technique. After constructing the decision matrix for the criteria such as to ensure that risks of cyber-attacks and security issues posed by BT are contained (PC1), to balance data openness and secrecy in BT in order to maximize business benefit (PC2), to prevent hacking and restoration or rectification of data in the event of incorrect input caused by unforeseen circumstances (PC3), to reduce distrust among the supply chain network’s business partners (TC1), to exchange data on producers, suppliers and vendors that was maintained on a private account (TC2), to remove middlemen from various product supply chains to prevent fraud (TC3), to encourage collaboration among the many supply chain participants (OC1), to determine supply chain stakeholders’ behavior of BT adoption (OC2), to convince employees for the change in operations and management due to BT (OC3), to tackle the legal and regulatory uncertainties (RC1), to establish government policies that encourage and promote BT in organizations (RC2), to clearly understand the cultural differences across different geographies (RC3), to overcome scalability challenges rising with the increase in the

<table>
<thead>
<tr>
<th>Challenges</th>
<th>DM1</th>
<th>DM2</th>
<th>DM3</th>
<th>DM4</th>
<th>DM5</th>
<th>DM6</th>
<th>DM7</th>
<th>DM8</th>
<th>DM9</th>
<th>DM10</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>0.01</td>
<td>0.15</td>
<td>0.05</td>
<td>0.15</td>
<td>0.05</td>
<td>0</td>
<td>0</td>
<td>0.15</td>
<td>0.05</td>
<td>0</td>
</tr>
<tr>
<td>TC</td>
<td>0</td>
<td>0.15</td>
<td>0.05</td>
<td>0</td>
<td>0.05</td>
<td>0</td>
<td>0</td>
<td>0.025</td>
<td>0.15</td>
<td>0</td>
</tr>
<tr>
<td>OC</td>
<td>0.01</td>
<td>0</td>
<td>0.05</td>
<td>0.15</td>
<td>0.05</td>
<td>0.14</td>
<td>0.025</td>
<td>0.15</td>
<td>0.025</td>
<td>0.2</td>
</tr>
<tr>
<td>RC</td>
<td>0.01</td>
<td>0.15</td>
<td>0</td>
<td>0.15</td>
<td>0</td>
<td>0.14</td>
<td>0.05</td>
<td>0</td>
<td>0.05</td>
<td>0.2</td>
</tr>
<tr>
<td>IC</td>
<td>0.01</td>
<td>0.15</td>
<td>0.05</td>
<td>0.15</td>
<td>0.05</td>
<td>0.14</td>
<td>0</td>
<td>0.15</td>
<td>0.025</td>
<td>0</td>
</tr>
<tr>
<td><strong>Source(s):</strong> Authors’ own work</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Normalized relative weighted matrix

<table>
<thead>
<tr>
<th>Challenges</th>
<th>Ei</th>
<th>Fi</th>
<th>Pi</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>0.61</td>
<td>0.15</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>TC</td>
<td>0.625</td>
<td>0.2</td>
<td>0.539474</td>
<td>3</td>
</tr>
<tr>
<td>OC</td>
<td>0.8</td>
<td>0.2</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>RC</td>
<td>0.75</td>
<td>0.2</td>
<td>0.868421</td>
<td>4</td>
</tr>
<tr>
<td>IC</td>
<td>0.725</td>
<td>0.15</td>
<td>0.302632</td>
<td>2</td>
</tr>
<tr>
<td><strong>Source(s):</strong> Author’s own work</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6. Summary of scores for final selection and ranking
number of nodes in BT (IC1), to integrate BT with sustainable practices (IC2) and to illustrate the legitimacy of socially conscious production techniques (IC3) respectively. We evaluated the normalized value with the help of equation (6) and used equation (7) for each criterion from Table 1. Table 7 displays the normalized decision matrix importance with indicators generated by evaluating equation (6) and equation (7), with the improved optimizing values for “Max” and “Min” illustrating the value of all criterion weights.

Equation (8) was used to determine the weighted sum value ($S_i$), and equation (9) was used to obtain the exponentially weighted product value ($P_i$). Table 8 also includes the values of the three consolidated evaluation scores, $M_{ia}$, $M_{ib}$, and $M_{ic}$, which were derived using equations (10) to equation (13). The evaluation for these values data is taken from Table 7, and evaluated values are displayed in Table 8. Figure 3 displays the effects of performance evaluations on the parameter based on the three scores $M_{ia}$, $M_{ib}$, and $M_{ic}$ on $M_i$. Figure 3 depicts the effects of various parameter values. The performance score $M_i$ of all 15 criteria is provided in Table 9, which summarizes the study’s real findings. It shows that option PC3 has the best performing score, trailed by criteria TC2 and OC2, while criteria RC3, IC3 and PC1 have the lowest performance scores. Consequently, depending on the performance rating displayed in Table 9.
5. Discussion and analysis

PC3 ("To prevent hacking and restoration or rectification of data in the event of incorrect input caused by unforeseen circumstances") is ranked as the most serious challenge in the implementation of BT in supply chains. Even if a blockchain record is secure, contaminated or fake commodities might still be identified and added to the supply chain mistakenly or by a dishonest actor. Inaccurate inventory data brought on by errors in the scanning, tagging and data input is another risk. Nothing on the BT prevents inaccurate data from being included in a transaction, whether by fraud or mistake. Let’s take the case of a supply chain that is tracked by a BT. There will be a record of the delivery and acceptance of certain products, and a smart contract will then automatically execute the payment. The party receiving the
products, however, discovers that the package contains errors. There is an unexpected business dispute, and if the transaction took place on a true BT (a decentralized system with the transaction taking place simultaneously on different nodes throughout the world), then concerns about determining which country’s laws apply and where to seek redress arise. Potentially, the jurisdiction and laws of any nation where a node is situated might apply to the

![Histogram](image)

**Figure 3.** Illustration of criteria with impacting value for parameter $\lambda = 0.5$

<table>
<thead>
<tr>
<th>Criteria</th>
<th>$M_i$</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC1</td>
<td>1.141413</td>
<td>15</td>
</tr>
<tr>
<td>PC2</td>
<td>2.48802</td>
<td>4</td>
</tr>
<tr>
<td>PC3</td>
<td>2.891019</td>
<td>1</td>
</tr>
<tr>
<td>TC1</td>
<td>2.033077</td>
<td>12</td>
</tr>
<tr>
<td>TC2</td>
<td>2.881262</td>
<td>2</td>
</tr>
<tr>
<td>TC3</td>
<td>2.192753</td>
<td>8</td>
</tr>
<tr>
<td>OC1</td>
<td>2.134828</td>
<td>9</td>
</tr>
<tr>
<td>OC2</td>
<td>2.737408</td>
<td>3</td>
</tr>
<tr>
<td>OC3</td>
<td>2.226779</td>
<td>7</td>
</tr>
<tr>
<td>RC1</td>
<td>2.227845</td>
<td>6</td>
</tr>
<tr>
<td>RC2</td>
<td>2.281727</td>
<td>5</td>
</tr>
<tr>
<td>RC3</td>
<td>1.789645</td>
<td>13</td>
</tr>
<tr>
<td>IC1</td>
<td>2.041594</td>
<td>11</td>
</tr>
<tr>
<td>IC2</td>
<td>2.130653</td>
<td>10</td>
</tr>
<tr>
<td>IC3</td>
<td>1.528683</td>
<td>14</td>
</tr>
</tbody>
</table>

**Table 9.** Final performance score $M_i$ for the criteria

**Source(s):** Authors’ own work
transactions. Logistically, this results in a jumble of laws and regulations that might contradict and apply to blockchain transactions. As a result, this is a matter that will need to be resolved in court as well as via the use of a contract clause addressing the appropriate laws and venues. Moreover, the issue of culpability comes up concerning blockchain problems that are suffering faults. The possibility of incorrect data entry into a blockchain inadvertently causing a slew of unexpected erroneous results in supply chains is also highlighted in Stoldt et al. (2021).

TC2 (“To exchange data on producers, suppliers, and vendors that were maintained on a private account.”) is ranked second in the list of major challenges in the implementation of BT in SCM. To maintain smooth functioning in supply chains it is paramount to make important information about very stakeholder in the supply chain organization available to everyone. This poses one of the major hurdles as making private and confidential data public can cause serious privacy issues threatening to lose trust in blockchain networks. The participants might not be willing or be skeptical about disclosing information that is perceived as sensitive and confidential. This lack of information can deteriorate the quality of supply chains thereby leading to a loss in productivity and efficient outcomes. This finding is consistent with Calvão and Archer (2021), Etemadi et al. (2021).

OC2 (“To determine SC stakeholders’ behavior of BT adoption”) is the next major challenge plaguing the adoption of BT in SC. It is a well-established fact from the literature on consumer behavior that positive intention toward an object goal indicates favorable action towards the attainment of the object goal (Salim and Rajput, 2021; Garg et al., 2023). Thus understanding the intentions and perspectives of stakeholders from diverse backgrounds and operational abilities in a supply chain can be a challenge for organizations to put BT into practice. The variety of perceptions in the adoption of BT and related technology are directly correlated to the users’ experience, perceived risks and values, and external factors in the form of external validation from peers. BT is a new concept with theoretical underpinnings in information technology. Experienced personnel and participants in a typical supply chain have become accustomed to working with traditional methods making them skeptical to consider new disruptive technologies. The challenge in adopting BT in supply chains posed by the behavioral intention of stakeholders is confirmed by Kramer et al. (2021), Liu and Ye (2021), Sciarelli et al. (2021).

PC2 (“To balance data openness and secrecy in BT in order to maximize business benefit”) and RC2 (“To establish government policies that encourage and promote BT in organizations”) are the next entries in the list of challenges in the adoption of BT in SC. People’s perceptions of the complexity and practical use of future technology will be influenced by government policies, standards and guidelines. The results reveal that a vital factor influencing the adoption of BT in SC is backing from government policy. According to Balasubramanian et al. (2021), one significant environmental element influencing the adoption of blockchain is the backing of governmental laws and regulations. Implementing effective government policies and laws for the smooth adoption of BT in SC is a challenge for the government as well as organizations. PC2 is mostly a consequence of TC2. The issue of data and information sharing among the participants in supply chains boils down to a tradeoff between data openness and secrecy. Exactly how much information has to be revealed to efficiently manage blockchains is a challenge for the authorities which calls for effective decision-making in blockchain management. BT involves creating blocks of data with important information regarding the transactions made in the supply chains coupled with the personal information of suppliers, contractors and other stakeholders in the supply chains. In this situation, many stakeholders might not be comfortable with disclosing personal details and making them public. Thus it becomes a challenge for the organizations to convince every participant in supply chains to agree with the personal information disclosure which was also revealed in de Boissieu et al. (2021), Friedman and Ormiston (2022), Mathivathanan et al. (2021).
RC1 (“To tackle the legal and regulatory uncertainties”) and OC3 (“To convince employees of the change in operations and management due to BT”) are the challenges that organizations confront while conceiving the idea of implementing BT in supply chains. BT adoption by entrepreneurs in some areas will be met with a deluge of opposition from their colleagues and other gatekeepers. Forget about the supposed advantages of the technology; some businesspeople will simply not be interested in the concept and will be much less interested in the idea of regulation. Regulation is the main critical challenge to the most widespread adoption of BT. The regulatory landscape has not kept up with innovation and frequently impedes or delays adoption. Although many customers won’t be aware of the shift, as the regulatory environment matures, more items and services used by mainstream consumers will include the technology. Many supply chain companies are still working exclusively on paper at the moment. Therefore, it is a tough ask to convince them to switch from paper records to electronic databases utilizing BT. The technology itself isn’t that challenging; it’s been created. However, change management is a significant task. For any sector, changing people’s behavior is not a simple feat (Balci and Surucu-Balci, 2021).

The next ranked challenges in the adoption of BT in SC are TC3 (“To remove middlemen from various product supply chains to prevent fraud”), OC1 (“To encourage collaboration among the many supply chain participants”) and IC2 (“To integrate BT with sustainable practices”). The supply chain is a collaborative platform that requires the interaction of several participants for decision-making to improve the quality of supply chain activities. These participants, sometimes referred to as the middlemen act as mediators between organizations and nurture relationships. With the inclusion of BT in supply chains, the role of these intermediaries will be minuscule to the point where they might opt out of the supply chains altogether. This poses a big challenge for organizations that want to retain healthy relationships with the middlemen organizations that help foster holistic growth (Rosca et al., 2022). The challenge just discussed has a strong correlation with the next ranked challenge OC1 which states the importance of increase collaboration with supply chain partners. When using BT to register and monitor supply chain activities in blocks there is a possibility of losing internal interaction with many supply chain partners thereby rendering the loss of significant information pivotal for a better outcome. This finding is strongly confirmed by Lim et al. (2021b). We are all well aware of the devastating effects that climate change is having on the planet. The ice caps have been destroyed by global warming, deforestation has decreased the natural creation of CO₂ and oxygen, and energy-hungry businesses have ravaged whatever opportunity we have to reduce our carbon footprint. A challenging mathematical challenge called mining must be solved to add a block to the block chain. A blockchain’s operation is unaffected by machines participating in mining; they just raise the energy consumption of the network. This inhibits many organizations from adopting BT in industries particularly the ones where the energy consumption is already surpassing the thresholds. The issue of heavy power consumption by BT networks in supply chains has also been highlighted by Li et al. (2021b).

TC1 (“To reduce distrust among the supply chain network’s business partners”), RC3 (“To clearly understand the cultural differences across different geographies”), IC3 (“To illustrate the legitimacy of socially conscious production techniques”) and PC1 (“To ensure that risks of cyber-attacks and security issues posed by BT are contained”) are the least ranked challenges in the context of the adoption of BT in SC. However, these difficulties must nevertheless be viewed as obstacles to the acceptance of new technologies. The absence of governmental oversight is the one contributing factor that makes the blockchain business an unsteady environment and a top candidate for market manipulation. For instance, after several investors lost money hoping that the infamous one coin scam would be the next ground-breaking digital currency, it was later discovered to be a Ponzi scheme fraud. There is always a chance that the online wallet one is using might be compromised or prohibited by the
authorities as a consequence of some shady actions, regardless of how informed you are about cryptocurrencies. The same logic transpired in the block chains as well. BT involves a cryptographic method of sharing and storing important confidential information which makes it a vulnerable technical platform for cyber-attacks. Though block chains are created with utmost security and care yet it is not invincible to cyber-security attacks. The propensity to the adoption of new technologies in organizations varies significantly with the cultural factors specific to geographies. In developing nations where the awareness and skills of understanding sophisticated technologies are significantly low, it becomes a challenge to categorically understand the cultural differences across countries and act on bringing new technologies to various facets of organizations.

6. Implications

6.1 Theoretical implications
The potential of BT is currently receiving commendable attention. Practitioners are now creating actual SC applications. The SC is the intricate framework that connects the production and distribution of commodities from raw materials to completed items and final customers. Some SC systems are now unable to track the product’s real-time changes while it is being processed. Therefore, BT offers a range of applications near SC because of its immutability and transparency in transaction features (Yaqoob et al., 2022). Researchers may uncover some murky areas in the adoption of BT in SC by using the priority of the identified difficulties to guide their decision-making. Since SC is a multi-party system, challenges with information exchange and mistrust between the parties with various jurisdictions exist. Additionally, since governing power is centralized and single, there is only one place where the system may collapse. By distributing trust across SC stakeholders and enhancing information-sharing capabilities among all participants, BT can solve these issues. The system becomes more effective and of higher quality as a result of the interaction and transaction visibility of all SC participants (Agarwal et al., 2022).

6.2 Managerial implications
The study postulated multiple implications for managers at organizations to effectively manage supply chains by incorporating new technologies such as BT. The framework hypothesized in the study can be used as a reference to create a customized challenge assessment framework for observing the reasons for the non-adoption of new technologies such as BT in organizations. In general, the implications drawn from this study specifically are discussed next:

(1) Managers should hire a skilled team of professionals in the domain of Artificial Intelligence/Machine Learning/BT to ensure the correct coding of algorithms needed to deploy blockchain platforms in the SC. The codes of software to deploy block chain framework need to be thoroughly verified and checked for authenticity and veracity. The loopholes and vulnerabilities existing in the software should be patched as soon as possible to avoid cyber-attacks and infringement by malicious hackers. A team of specialists should be employed to validate and check the data entry by every participant in the SC. The data should be allowed to be entered in the blocks once a thorough check up of the data is done.

(2) Periodical interactions with the supply chain partners are required to increase awareness of the benefits that new technologies such as BT can bring in the improvement of the quality of supply chains. Workshops and seminars can prove to be immensely useful techniques to impart knowledge regarding the new
sophisticated technologies to the stakeholders repeatedly. Meetings with the partners to understand their sentiments towards using the new technological framework in various operational activities should be given due importance.

(3) The sensitive information of the suppliers and other stakeholders such as the one related to logistics, business strategy, tactical and financial can be stored confidentially which should be cryptographically coded using the private keys of the partners in the BT-enabled supply chain network. This will ensure that only the validated supply chain partners can enter and retrieve data from the network. The identities of each user in the supply chain network should be validated thoroughly using the established protocol and be provided with a token of validation such as a personal digital signature authenticated by the concerned authorities.

(4) A good policy should specify the objectives it seeks to accomplish, its realm of application, the procedures to be followed to comply with it and the individuals who have authority over it. A policy must also develop in a cycle of continuous improvement that takes into account lessons gained and a world and technology environment that is changing quickly. Government agencies should assist businesses in adopting a technology-neutral strategy when attempting to integrate BTs. The fundamental capabilities of interoperability are identities and data formats. Governmental authorities must establish adaptable blockchain rules that are prepared for a fast-moving and constantly changing technological environment. Rigid rules run the risk of swiftly becoming obsolete. Organizations should take a more inventive approach to blockchain than a risk-averse one since the latter will make it difficult to establish successful ventures.

(5) Regulators are unlikely to limit the use of blockchain applications as legislators and governments become more aware of the potential advantages of the technology. Instead, they frequently concentrate on developing guidelines for smart contracts or data storage. Leaders must make sure that technology conforms to all applicable rules and avoid seeing the absence of regulation as a ban on employing the technology. Where there are no regulations specifically governing blockchain, they can investigate, develop and trial blockchain implementation to find the most useful applications. Additionally, the regulators will not penalize businesses that employ BT carefully and sincerely. When there is minimal dependability data available, the best course of action is to conduct a small-scale pilot of the program. Additionally, some states have implemented blockchain-related legislation rather than the US government. For instance, Vermont passed a statute establishing a brand-new kind of corporate organization. Similarly, Delaware approved legislation allowing the administration of corporate stock records using BT.

(6) Recycling is one aspect of environmental sustainability where blockchain can make a big difference. Organizations can offer financial incentives to people in the form of cryptographic tokens by putting in place a recycling scheme on the blockchain. This could be offered in exchange for the deposit of recyclable items such as plastic bottles, cans and other containers. This assists in keeping track of crucial information like cost, volume and profit as well as in assessing the program’s participants’ environmental effects. Even if using BT to address the environmental situation has numerous advantages, there are also many drawbacks. Certain transactions on the bitcoin and Ethereum blockchains take a considerable amount of electricity and computational resources to process. In many nations where energy costs can be excessively high, this is a major problem. Additionally, regulatory frameworks are
necessary since they will be crucial in tackling the high cost of processing power. Energy customers are quite likely to take part in surplus energy trading using blockchain platforms as electricity pricing would have to alter.

(7) Blockchain scalability issues should be addressed by modifying the network’s fundamental properties and qualities, such as extending the maximum block size or speeding up block verification. Three popular methods of scaling a blockchain include sharding, segregated witness (SEGWIT) and hard forking.

- A popular blockchain scalability method is sharding. It focuses on shattering the blockchain network into more controllable, smaller units known as shards. The shards would then be executed concurrently by the network. Each shard processing a fraction of the group’s transaction processing would boost the network’s processing output. The network can function as the total of its components by being divided into smaller bits. To provide a faster and more effective transaction throughput, sharding effectively removes the need to rely on the performance of individual nodes.

- Another significant contribution to first-layer choices for blockchain scalability is Segregated Witness or SEGWIT. The SEGWIT protocol upgrade for the Bitcoin blockchain network aims to transform the organization and structure of data storage. It assists in removing the signature data associated with each transaction, increasing transaction capacity and storage space.

- A hard fork is a process that concentrates on making structural or fundamental changes to the characteristics of a blockchain network. For instance, hard forking can entail reducing the time required to build blocks or increasing the block size. The problematic hard fork effectively implies a division in the bigger blockchain network, with a certain group of people disagreeing with the core group on particular issues. In certain situations, a portion of a blockchain community may decide to fundamentally alter the underlying source.

6.3 Societal implications
In today’s rapidly evolving technological landscape, emerging innovations like blockchain technology and artificial intelligence are leaving an indelible mark on society. These transformative forces are not only revolutionizing industries and business practices but also permeating into the social fabric. In this section, we delve into the societal implications of these advancements, exploring how they affect cybersecurity, education, data privacy, regulation, environmental sustainability and more. These implications not only influence specific industries but also have a ripple effect on how society as a whole perceives and adapts to the digital era.

(1) The emphasis on hiring skilled professionals and ensuring code authenticity highlights the importance of cybersecurity. This has societal implications as it underscores the need for a workforce well-versed in AI, ML and blockchain, not only in the supply chain industry but across various sectors. This demand for expertise can influence education and training programs.

(2) Periodical interactions, workshops and seminars to disseminate knowledge on emerging technologies like blockchain can contribute to increased awareness and knowledge dissemination. This not only benefits supply chain stakeholders but also fosters a culture of continuous learning and knowledge sharing.
The use of blockchain to securely store sensitive information highlights the societal importance of data privacy. It emphasizes the need for robust cryptographic measures and identity verification protocols. This can set a precedent for data security practices in other domains.

The discussion on government agencies assisting businesses in adopting technology-neutral strategies and flexible blockchain rules underscores the need for adaptable regulations in a rapidly changing technological landscape. It suggests a shift towards more agile and adaptable regulatory approaches.

The discussion on regulators not limiting the use of blockchain while focusing on guidelines for smart contracts and data storage emphasizes the importance of regulatory innovation. This has societal implications as it encourages a dynamic and forward-thinking approach to governance.

Blockchain’s potential in recycling and environmental sustainability showcases the potential for technology to address societal challenges. It introduces the concept of incentivizing eco-friendly behavior through blockchain tokens. This can drive positive environmental change and influence how society addresses sustainability concerns.

7. Conclusion, limitation and future scope

The fourth industrial revolution, often known as Industry 4.0, has ushered in the fast industrial expansion that has required enterprises to be more agile, adaptable, inventive and responsive to survive. BT has a huge promise for helping businesses improve supply chain efficiency and transparency. However, several insurmountable obstacles come with BT adoption in corporate supply chains. The goal of this article is to comprehensively identify and organize the most significant obstacles to the adoption of BT in SC.

In order to identify and classify the main challenges utilizing the VIKOR technique, this study turns to a thorough literature analysis and interviews with experts in supply chain management, information technology and academia. According to the findings, the top three categories of issues include privacy challenges (PC), infrastructure challenges (IC) and transparency challenges (TC). The top two challenges in the PC category are maintaining a balance between data openness and secrecy and correcting erroneous input; in the IC category, the top two challenges are integrating BT with sustainable practices and ensuring legitimacy; and in the TC category, the top challenge is ensuring proper and accurate information sharing in organizations. The challenges in this study, including privacy concerns, infrastructure integration and transparency issues, are deeply interconnected within the complex landscape of supply chains. They often intertwine and influence one another. For instance, addressing privacy issues may necessitate changes in infrastructure and technology to ensure data security and compliance, while achieving transparency could require adjustments in the existing infrastructure for accurate information sharing. This interconnectedness highlights the need for a comprehensive approach, as resolving one challenge can have ripple effects on others. Supply chains, being intricate systems involving multiple stakeholders, processes and technologies, add a layer of complexity to the adoption of disruptive technologies like BT. Challenges do not exist in isolation; they emerge from the intricate web of supply chain interactions. Ensuring transparency, for example, directly impacts trust among partners, which, in turn, affects privacy and legitimacy concerns. To effectively address these multifaceted challenges, a multifaceted approach is essential, encompassing technological, regulatory, organizational and operational aspects. This approach requires collaboration between various stakeholders, combining academic
research and professional expertise to develop tailored strategies that account for the unique characteristics of each supply chain.

Blockchain is an emerging technology that both academics and professionals are attempting to understand. The use of BT in SC is still in its early stages. As a result, it is highly challenging to obtain inputs regarding facts that may be influential in the BT-enabled supply chain systems. Because of this, this work is constrained to use no more than 10 expert opinions as input to the VIKOR technique to list the main obstacles to BT adoption in supply chains. This study may also be expanded to include empirical research, and a large sample size can help it become more broadly applicable. As broad obstacles to BT adoption in supply chains are taken into consideration, this work is not context-dependent. By utilizing the outlined problems, it will be possible to establish blockchain in the SC for personalized goods and services in the future. The bullwhip effect can be reduced by using BT in supply chains. To resolve problems encountered while adopting BT in supply chains and improve supply chain performance, it may be necessary to identify the interdependencies between the obstacles that have been discovered. The criteria taken into account in this job might be adjusted depending on the products and services. Future practitioners have a significant issue with the growth of BT in supply chains.

References


Challenges in adopting blockchain technology


**Further reading**


**About the authors**

Rohit Raj is a research scholar at Department of Business Administration, National Taiwan University of Science and Technology, Taipei City, Taiwan. He completed MS in Information Management in College of informatics at Chaoyang University of Technology, Taichung, Taiwan. He has vast experience in research and has published and presented many papers in reputed national and international journals and conferences. His research areas include text mining, technological innovation and patent analysis, total quality management, manufacturing strategy and supply chain management. He has published in top-ranked international journals and conferences, for example, *Benchmarking: An International Journal, International Journal of Productivity and Performance Management, Operations Management Research, The TQM Journal* and numerous papers in conferences.

Arpit Singh is currently working as an assistant professor in the department of Information Systems and Analytics at Jindal Global Business School (JGBS), O. P. Jindal Global University (Institute of Eminence), India. He has rich industrial experience in the Investment banking and Private Equity Research sectors. He holds a PhD in Industrial and Management Engineering from the Indian Institute of Technology (IIT) Kanpur Uttar Pradesh and an M.Tech in Operations Research (Gold Medalist) from National Institute of Technology (NIT) Durgapur, West Bengal, and a B.Tech in Electrical and Electronics Engineering (First Class) from Dr K.N. Modi Foundation, Ghaziabad, Uttar Pradesh, India. Arpit’s research interest is in the areas of Decision making under uncertainty, Big data Analytics, Statistical applications in business problems, and adoption of new technologies in the business domain. His work on these research areas has been published in multiple international peer reviewed (ABDC/ABS ranked) journals and top international conferences on advanced computing and intelligent engineering including *Safety Science* (Elsevier), *International Journal of Quality and Reliability Management* (Emerald) and *Behaviour and Information Technology* (Taylor & Francis).

Vimal Kumar is an assistant professor at Chaoyang University of Technology, Taichung, Taiwan (R.O.C.) in the Department of Information Management. He completed his postdoctoral research at Chaoyang University of Technology, Taichung, Taiwan (R.O.C.) in the Department of Business Administration in the domain of Technological Innovation and Patent Analysis. He has served as an assistant professor under TEQIP III, an initiative of MHRD, Govt. of India at AEC Guwahati in the Department of Industrial and Production Engineering. Prior to joining AEC, he served as Assistant Professor at MANIT, Bhopal in the Department of Management Studies and also served as visiting faculty at IMT Nagpur. He obtained his PhD in the domain of TQM and Manufacturing Strategy in the year 2017 and Masters in Supply Chain Management from the Department of Industrial & Management Engineering, IIT Kanpur in the year 2012. He graduated (B.Tech) in Manufacturing Technology from JSS Academy of Technical Education Noida, in the year 2010. He has published 81 articles in reputable...
international journals, nine book chapters and presented 25 papers at international conferences. His research paper entitled “Time Table Scheduling for Educational Sector on an E-Governance Platform: A Solution from an Analytics Company” has been selected for best paper award at the International Conference on Industrial Engineering and Operations Management (IEOM) held in Bandung, Indonesia, March 6–8, 2018. He was also invited to serve as session chair of session on “Energy Related Awareness” held on September 19, 2018 at iCAST 2018, IEEE International Conference on Awareness Science and Technology and “Lean Six Sigma” at the International Conference on Industrial Engineering & Operations Management (IEOM-2018) at Bandung, Indonesia and “Quality Control & Management” at the International Conference on Industrial Engineering & Operations Management (IEOM-2016) at Kuala Lumpur, Malaysia. He has been appointed as an editorial board member in the IEEE-TEMS Journal from 1 January 2022 to 31 December 2024. He is a contributing author in international journals including Journal of Cleaner Production, Journal of Informetrics, Technology in Society, CLSCN, Supply Chain Management: An International Journal, IJOA, IEEE, BSE, TFSC, JKM, CSREM, IJPPM, IQQRM, IPPMB, IPQPM, IJBIS, AJOR, The TQM Journal, and Benchmarking: An International Journal and also a guest reviewer of a reputable journal like IEEE-TEMS, JOI, IJPPM, IQQRM, TQM & Business Excellence, The TQM Journal, Benchmarking: An International Journal, Journal of Asia Business Studies and JSIT. Vimal Kumar is the corresponding author and can be contacted at: vimaljss91@gmail.com

Pratima Verma is currently working as an assistant professor in the Department of Strategic Management at Indian Institute of Management Kozhikode, India and associated with Chaoyang University of Technology, Taichung, Taiwan. She has worked as an Assistant Professor in Strategic Management area at Indian Institute of Management (IIM) Bodh Gaya, India. Prior to joining IIM, she was Postdoctoral Fellow in the Department of Management Studies at IIT Madras, India. She obtained her PhD from IIT Kanpur where she worked in the domain of Strategic Management and Horizontal Strategy in the Department of Industrial & Management Engineering, in the year 2017. She received her MBA in Finance and Human Resource Management from BBDNITM, Uttar Pradesh Technical University–Lucknow, India, in the year 2011. She completed her graduation (B.Tech) in Information Technology in the year 2009 from BBNITM, Lucknow. She has one year of experience in teaching. She also awarded JRF/SRF in the area of human resource management. She has published 48 articles in reputable international journals, nine book chapters and presented 18 papers at international conferences. Her research paper entitled “Time Table Scheduling for Educational Sector on an E-Governance Platform: A Solution from an Analytics Company” has been selected for best paper award in the International Conference on Industrial Engineering and Operations Management (IEOM) held in Bandung, Indonesia, March 6–8, 2018. She was invited to serve as session chair for Human Factors and Ergonomics Track at the International Conference on Industrial Engineering & Operations Management at Kuala Lumpur, Malaysia. She is a contributing author in International journals including Journal of Cleaner Production, Supply Chain Management: An International Journal, CLSCN, IJOA, IEEE, IJPPM, IQQRM, The TQM Journal, IPPMB, IJISE, IJBIS, and Benchmarking: An International Journal.

For instructions on how to order reprints of this article, please visit our website: www.emergaldgrouppublishing.com/licensing/reprints.htm
Or contact us for further details: permissions@emeraldinsight.com