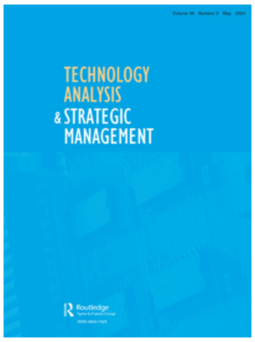

Routledge
Taylor & Francis Group

Technology Analysis & Strategic Management

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/ctas20

Blockchain technology for operational excellence and supply chain resilience: a framework based on use cases and an architecture demonstration

Khuram Shahzad, Petri Helo, Mikko Ranta & Essi Nousiainen

To cite this article: Khuram Shahzad, Petri Helo, Mikko Ranta & Essi Nousiainen (17 Jan 2024): Blockchain technology for operational excellence and supply chain resilience: a framework based on use cases and an architecture demonstration, Technology Analysis & Strategic Management, DOI: 10.1080/09537325.2024.2304698

To link to this article: https://doi.org/10.1080/09537325.2024.2304698

TECHNOLOGY ANALYSIS & STRATEGIC MANAGEMENT
https://doi.org/10.1080/09537325.2024.2304698

Blockchain technology for operational excellence and supply chain resilience: a framework based on use cases and an architecture demonstration

Khuram Shahzad[a,c], Petri Helo[a], Mikko Ranta[b] and Essi Nousiainen[b]

[a]School of Technology and Innovations, Industrial Management, University of Vaasa, Vaasa, Finland; [b]School of Accounting and Finance, Accounting, University of Vaasa, Vaasa, Finland; [c]Innovation and Entrepreneurship InnoLab, University of Vaasa, Vaasa, Finland

ABSTRACT

Increased risks and uncertainties can disrupt the whole supply chain (SC), resulting in ineffective value transition. Facilitated by digital technologies, SC resilience can be achieved which enables organisations to strengthen capabilities. Therefore, blockchain is emerging as a promising technology that promises transparency and decentralisation across multiple SC nodes and can effectively respond to any disruption and recover fast through visibility. However, prior research does not offer a clear framework for blockchain adoption to achieve operational excellence and SC resilience. This paper develops an explanatory framework for SC resilience and operational excellence by conducting a rigorous analysis of recent literature, existing industrial cases (i.e. food SC, diamond SC, electric vehicle (EV) battery SC, blood SC), and a reference architecture implementation in forest SC. We explore how blockchain has addressed the traceability challenges and developed operational excellence in selected use cases. The theoretical and use case analysis reveal the promising effect of blockchain in developing capabilities and effective response systems where transparency, traceability, real-time information sharing, process, and security are the most common value propositions. The reference model (available on GitHub) demonstrates an increase in process efficiency by offering data safety, and transparent and traceable information which cannot be altered throughout SC.

ARTICLE HISTORY
Received 27 June 2022
Revised 14 October 2023
Accepted 5 January 2024

KEYWORDS
Blockchain; Supply chain ecosystem resilience; operational excellence; reference model

1. Introduction

Scholars and business leaders are re-evaluating supply chain (SC) practices due to advancements in digital technologies, which significantly impact organisational value (Zutshi, Grilo, and Nodehi 2021). Recent supply chain disruptions over the past decade, including the challenges posed by coronavirus pandemic, have impacted the survival of various ecosystem actors (Lohmer, Bugert, and Lasch 2020; Ganguly 2022). The complex and transparent nature of SC ecosystems, involving diverse stakeholders with varying business interests (Guercini and Runfola 2015), has introduced risks and uncertainties, resulting in disruptions and ineffective value transitions (Lohmer, Bugert, and Lasch 2020). Organisations are facing pressure to revolutionise their operations and develop technological solutions to address diverse stakeholder needs, manage relationships, and enhance

CONTACT Khuram Shahzad khuram.shahzad@uwasa.fi
Supplemental data for this article can be accessed online at https://doi.org/10.1080/09537325.2024.2304698.

resilience and operational excellence (Chowdhury et al. 2023) in response to disruptions. The enriched flow of data and knowledge among ecosystem actors (Pucci et al. 2018) drives organisations to create value and resilience throughout the SC and protect against unforeseen disruptions.

SC involves sharing information and resources, collaborative communication, and aligning objectives, aided by digital technologies (Guercini and Woodside 2012) such as IoT, automation, and AI to develop fast, secure, and effective operations. However, most existing digital platforms are centralised and vulnerable, despite some decentralisation efforts (Zutshi, Grilo, and Nodehi 2021). Blockchain technology offers a solution by promising decentralisation across multiple nodes, addressing operational lags and SC delays to build resilience (Kamble et al. 2021; Chowdhury et al. 2023), enhancing efficiency, and reducing transaction costs (Shahzad 2020). With its trusted open-source verified codes, secure, transparent, and traceable transactions among untrusted actors, blockchain can transform the SC ecosystem, unlocking potential for value creation, new structures, and enhanced collaboration (Friedlmaier, Tumasjan, and Welpe 2018; Emrouznejad, Chowdhury, and Dey 2023).

Prior research on blockchain's role in operations management and SC resilience and efficiency is limited, lacking a comprehensive framework that outlines blockchain-based value propositions, underlying business models, operational excellence, and reference implementations in industrial SC cases (Zutshi, Grilo, and Nodehi 2021; Morkunas, Paschen, and Boon 2019; Cole, Stevenson, and Aitken 2019). This gap hinders a holistic understanding of how blockchain can create value, transform business models, and impact ecosystems. While some studies have focused on technical applications of blockchain, they often overlook operational efficiency challenges, including resource and expertise constraints (e.g. Lohmer, Bugert, and Lasch 2020; Ganguly 2022). Consequently, there's a growing call for further research to address complex SC operations and production networks through blockchain to enhance SC resilience (Emrouznejad, Chowdhury, and Dey 2023; Lohmer, Bugert, and Lasch 2020; Manupati et al. 2022). Fernandez-Vazquez et al. (2023) propose developing a technical blockchain architecture to evaluate real-world network implementations. He and Turner (2022) advocate for more research to uncover challenges in the forest industry and identify suitable blockchain practices for broader adoption.

Thus, this paper investigates how blockchain technology contributes to achieving SC resilience, operational excellence, and value propositions. We analyze selected industrial use cases, i.e. Food SC, Diamond SC, EV Battery SC, and Blood SC, to understand their SC challenges and how blockchain addresses these issues, enhancing their SC resilience. Additionally, we propose a blockchain-based reference case implementation in the forest industry, demonstrating how SC partners use smart contracts and transaction validation to respond resiliently to SC disruptions, promoting operational excellence and value propositions. This process helps in developing an explanatory framework offering insights into technology-related issues, implementation, and performance within SC context. This paper contributes to blockchain literature in SC resilience (Min 2019; Morkunas, Paschen, and Boon 2019; Tönnissen and Teuteberg 2020; Lohmer, Bugert, and Lasch 2020) by designing a blockchain reference implementation. It provides rationales and publicly available source codes illustrating how SC information can be securely stored in immutable blocks (He and Turner 2022). The reference implementation, available on GitHub,[1] serves for research and experimentation purposes and can be replicated for various research scenarios.

2. Theoretical background

2.1. Operational excellence and resilience in the SC

SCs are vulnerable to disruptions, natural disasters, and epidemics (such as the recent coronavirus), making SC network management difficult and forcing firms to adjust their response systems and resilience utilising digital innovation for operational excellence (Dutta et al. 2020). Operational excellence encompasses innovation, relations, cost, quality, time, and flexibility. Achieving excellence requires data visibility (Awwad et al. 2018), optimised business processes, cost minimisation, improved security and collaboration, and a reliable system. SC efficiency and effectiveness are measured by performance and how processes use resources to reduce costs and meet SC stakeholders' needs (Madhani 2021). SC resilience is the ability to anticipate, detect, and protect against risks before harm occurs (Lohmer, Bugert, and Lasch 2020). Proactive and reactive strategies such as flexibility, visibility, and agility target risks and improve SC capabilities (Kamalahmadi and Parast 2016). Research has examined SC resilience from risk effect and risk knowledge management perspective, reducing vulnerabilities, communication, collaboration, flexibility, and integration (Wieland and Wallenburg 2013), dynamic products and processes, and multi-sourcing, supplier reinforcement and emerging stocks re-positioning (Sabouhi, Pishvaee, and Jabalameli 2018). Despite the abundant literature, the impact of blockchain on SC resilience is unknown. Researchers (e.g. Min 2019; Emrouznejad, Chowdhury, and Dey 2023; Lohmer, Bugert, and Lasch 2020; Manupati et al. 2022) proposed to study how blockchain technology can improve SC resilience and operational excellence.

2.2. Blockchain technology and its applications in ecosystems

Satoshi Nakamoto created blockchain to solve digital currency ownership issues. As a decentralised ledger system shared by network members (Crosby et al. 2016), it is a chain of blocks with transaction info, hashes, and nonce, secured by cryptography and immutable. Each block in the chain has its cryptographic hash and is linked to the previous block's hash. A timestamp (nonce) is added to each transaction to show the blocks are in chronological order. Blockchains are classified into three types based on access rights: permissionless, permissioned, and private (Fernandez-Vazquez et al. 2023). Permissionless blockchains are public, decentralised networks like Bitcoin and Ethereum, where any participant can create, verify, and approve transactions. Permissioned blockchains are semi-centralised, requiring permission from consortium members to join the network. Private blockchain restricts write and/or read access to authorised users or one organisation (Kim, Kim, and Kim 2020).

Numerous scholars (e.g. Dutta et al. 2020; Friedlmaier, Tumasjan, and Welpe 2018; Lohmer, Bugert, and Lasch 2020) have recognised blockchain technology as a critical innovation enabling collaboration in the SC ecosystem. While prior research on ecosystems has highlighted the significance of network structures like 'key players' or 'hubs' in promoting network health and stability within large, loosely connected networks where entities interact in complex ways (Iansiti and Levien 2002; Breslin et al. 2021). These ecosystems are considered complex adaptive systems due to the coevolutionary interactions among organisations, technologies, consumers, and products, resulting in diverse structures (Breslin et al. 2021). Recent efforts have expanded industrial marketing research beyond dyadic business relationships, aiming to provide a broader perspective on networks, ecosystems, and market systems. For example, Möller, Nenonen, and Storbacka (2020) developed a comprehensive theoretical framework that recognises business environments as multilayered, dynamic, and influenced by various forces. Continuous innovation reshapes the boundaries of business networks, influencing the roles of actors and coevolutionary relationships (Breslin et al. 2021).

Pucci et al. (2018) explored the motivations behind a focal firm's decision to collaborate with partners within or outside its innovation ecosystem, considering various dimensions such as technological, organisational, cultural, and political/social aspects. They identified fits and misfits and offered insights into the roles of actors as teachers or learners in interactions. Guercini and Woodside (2012) examined inter-firm marketing cooperation among SMEs in local systems, particularly focusing on consortium marketing among Italian leatherwear manufacturers. They found that consortium marketing organisations play a vital role in coordinating activities within SCs. Similarly, Guercini and Runfola (2015) explored the role of focal firms in local communities, emphasising that a focal firm's innovator status within a network is determined by its recognised roles in previous interactions rather than a predefined strategic role. Öberg and Alexander (2019) investigated various types of company-to-company linkages, their relevance to open innovation and ecosystems, and their impact on knowledge flow. They underscored the importance of formality and social ties in these linkages and their role in knowledge outcomes, enhancing organisations' ability to engage in open innovation.

However, the emergence of blockchain technology fuels rapid digital innovation and revolutionises such complex ecosystems by replacing traditional governance methods with its autonomous self-governing system, characterised by its protocols and code-based rules (Lumineau, Wang, and Schilke 2021; Shahzad 2020). Blockchain technology has been used in many industrial ecosystems, from tracking luxury item property rights to intellectual property rights and insurance. While blockchain-based applications in different industrial ecosystems are growing (see Appendix 1), firms should remain cautious about their central role in business ecosystems and innovation processes due to the ongoing immaturity of implementation. New blockchain applications continue to emerge rapidly as blockchain technology evolves (Zīle and Strazdiņa 2018). In 2019, blockchain start-ups secured $3 billion in funding, leading to the emergence of several blockchain-based ecosystems fostering inter-organisational collaboration (Lumineau, Wang, and Schilke 2021). Blockchain challenges traditional notions of interdependence, partner behaviour expectations, and historical judgment, enabling collaboration beyond traditional boundaries and establishing integrity through system immutability (Shahzad 2020). Scholars (e.g. Lumineau, Wang, and Schilke 2021) differentiate blockchain governance from contractual and relational governance based on various factors, making identity less crucial and fostering cooperation within ecosystems.

2.3. Blockchain technology and SC resilience

SC and practice literature is increasingly exploring blockchain for traceability, security, visibility, transparency, and smart contracts in various SCs (Cole, Stevenson, and Aitken 2019; Choi 2019; Gor et al. 2020; Saberi, Kouhizadeh, and Sarkis 2019; Tönnissen and Teuteberg 2020; Kim, Kim, and Kim 2020; Asokan et al. 2022; Badzar 2016; Dutta et al. 2020; Ganguly 2022; Choi 2019; Kamath 2018). However, these studies mainly focus on SC management, overlooking blockchain's role in enhancing SC resilience and operational excellence and providing blockchain-based value propositions. Few studies have addressed this (e.g. Awwad et al. 2018; Dutta et al. 2020) and combined industrial examples to understand SC operations. Traditional digital platforms and risk management approaches are centralised and vulnerable to hacking, security breaches, forging, communication asymmetries, and fraud. Blockchain's decentralised structure, detailed transaction history, data security, and trustworthiness can help organisations reduce invisible risks and improve SC resilience (Min 2019; Lohmer, Bugert, and Lasch 2020).

Research on blockchain adoption for SC resilience and operational excellence is scarce, with few studies exploring its potential benefits (Min 2019; Dutta et al. 2020; Ivanov, Dolgui, and Sokolov 2019). Blockchain can manage risks by speeding up information sharing, improving inventory and logistics visibility, and providing multi-level protection for the SC network, making it more responsive and resilient during disruptions (Dutta et al. 2020; Sunny, Undralla, and Pillai 2020). It creates a decentralised, immutable, and automated transactional system, enhancing SC operational efficiency, agility, and traceability (Madhani 2021; Min 2019). However, challenges like scalability, operability, and user confidentiality remain (Zīle and Strazdiņa 2018; Ganguly 2022). Blockchain can improve SC agility by facilitating the addition of new partners, sharing resources, and enabling real-time tracking and traceability (Lohmer, Bugert, and Lasch 2020; Saberi, Kouhizadeh, and Sarkis 2019). Flexibility, adaptability, and quick detection of disruptions contribute to SC resilience (Lohmer, Bugert, and Lasch 2020; Ivanov, Dolgui, and Sokolov 2019).

Analysis of prior literature shows blockchain technology can improve operations and SC resilience but lacks a comprehensive framework. There is no outline of blockchain-based value propositions, business models, and operational excellence in an industrial SC case. Blockchain technology can create an effective and resilient response system (Lohmer, Bugert, and Lasch 2020), and can achieve operational excellence, contributing to SC resilience and agility, and developing blockchain-based value propositions (Zutshi, Grilo, and Nodehi 2021; Morkunas, Paschen, and Boon 2019; Cole, Stevenson, and Aitken 2019).

3. Methods

This study has two steps: first, we studied four industrial SC use cases, then we implemented a blockchain architecture in forestry SC to create resilience and value. This exploratory research aims to conceptualise how values are changing and understand blockchain's integrated role and impact. It builds on design research thinking to create a new understanding and theoretical basis for future research (Hevner et al. 2004). We plan to construct a use cases-based framework, so concepts from operations management and SC perspectives and use case models remain high-level analysis (Peltoniemi and Ihalainen 2019). We employed an empirical-to-conceptual technique (Nickerson, Varshney, and Muntermann 2013; Tönnissen and Teuteberg 2020) to create a taxonomies approach. We gathered characteristics, dimensions, and applications of blockchain from prior research (empirical approach) and used use case analysis to build a framework for further research and practice (conceptual approach).

We conducted a literature review by searching academic databases, Google Scholar, and Google with keywords such as blockchain technology, business model, use case, SC resilience, and operational excellence. Research in these areas is limited, so we consulted commercial sources to gain different perspectives. This enabled us to find pilot use cases where blockchain has been implemented and further steps were taken based on learning. This approach aligns with design technique, as real-life cases and blueprints represent existing, accepted industry artifacts (Peltoniemi and Ihalainen 2019; Hevner et al. 2004). We encountered difficulties in locating prior research that encompassed multiple use cases, which motivated us to conduct case study analysis as a means of establishing a foundation for our research. This method provides a natural setting for studying a phenomenon and has the potential to yield robust findings or develop theories based on practical insights (Yin 2003).

Using a multiple case study approach, we evaluated pilot cases that implemented blockchain technology to understand its uses. Blockchain research is still emerging, and themes like transparency, visibility, traceability, security, and integrity have been identified (Seawright and Gerring 2008; Yin 2003). Repeating themes emerged during the empirical case study analysis as companies considered blockchain technology (Rose, Spinks, and Canhoto 2014). We anticipate future research to explore additional aspects. Our approach included four use cases at the implementation maturity level to optimise operations and justify empirical inquiry (Seawright and Gerring 2008). Focusing on the SC industry, we examined various actors in food, diamond, EV battery, and blood SCs, considering their sensitive information (Yin 2003). We also studied blockchain applications in other fields (see Appendix 1) to understand expectations and limitations across industries and create a reference model for the forestry industry's SC.

4. Analysis and results

We analyzed these typical cases by evaluating their solution reports, case study reports, news sections, white papers, blogs, commentary, and websites to demonstrate the scope of their solutions, value propositions for customers, classifications of blockchain applications, and underlying business models.

4.1. Food SC and blockchain

The food SC's complexity increases fraud risks as false claims at any node can undermine the entire chain. For example, network participants from consumers to farmers rely on the label claims and any false claim at any node within this network makes the whole chain dubious. Blockchain's potential lies in providing shared product information access for all actors, addressing traceability challenges in the complex network. *Walmart's challenges in the food supply ecosystem*: Senior Director at Walmart Technology expressed in a published case study of Hyperledger that tracing origin without any broken supplies has been a challenge in the food supply ecosystem and it remained difficult to figure it out. The existing traceability system (a more centralised system), due to the fragmented, complex, and analog global food system, did not support Walmart enough to cut the required time down to recall unsafe food items, and ensuring food safety was not possible in a short period, as it can take days to find the source (Hoffman 2021; Kamath 2018). Table 1 captures the problem of Walmart's food SC and presents the blockchain-based solution.

Walmart implemented blockchain into the food SC ecosystem to bring unique transparency. This move allowed them to trace back foodborne diseases swiftly, potentially saving lives. In 2018, the US reported almost 18 outbreaks of foodborne illness, making it crucial for firms to address such issues promptly and protect the livelihoods of farmers by investigating affected farms. In collaboration with IBM and based on Hyperledger Fabric (Hyperledger, 2020), Walmart developed a food traceability system for tracing mangos in US stores and tracking pork in China stores. Through this system, Walmart can trace the origin of about 25 products from 5 different suppliers (Hyperledger, 2020; Hoffman 2021; Kamath 2018). The use of blockchain technology drastically reduced tracking time for their mangoes, from 7 days to 2.2 s (Figure 1).

4.2. Diamond SC and blockchain

4.2.1. Challenges in the diamond SC business

The consumers of high-value items such as diamonds are creating a high demand for transparency, traceability, and sustainability information in diamond SC. The diamond business is sophisticated and contains several threats of fraudulent behaviours and unlawful activities which has burdened the insurance industry with billions of dollars as provenance remains paper-based. The provenance of diamonds usually is based on paper certificates that can get lost or can be tampered with. Since paper reports are vulnerable to fraud and tempering, consumers demand digital solutions based on a user-friendly platform. The risk of counterfeit products can destroy the original brand since these products account for a huge percentage of global trade and are rising. It has become difficult to detect double financing, fraud, and document tampering for diamonds, and therefore, blood diamonds get their way to the market (Gordon 2018). To address such issues of provenance and sustainability in SC, blockchain in the diamond industry has worked to bring transparency and trust as well as complete information from mine to finger. For example, for diamond and gemstone certification, Everledger has created a closed network of the blockchain-enabled permanent ledger as well as a transaction history that includes digital thumbprint identity (e.g. height, width, weight, depth, colour, etc. are hashed and registered in a ledger) for each diamond (Crosby et al. 2016), which prevents the 'blood diamonds' to enter in the market.

4.2.2. Use cases

Table 2 highlights some use cases of diamond SC, the problems in traditional SCs, and how these use cases have addressed several issues faced in diamond SC, through collaboration with technology partners (e.g. Everledger), and implemented blockchain.

Table 1. Walmart's food SC use case.

Use case	Problem	Solution
Walmart's food SC (Hyperledger, 2020)	Foodborne illness due to the lack of traceability of ecosystem, farmers' livelihood	Food traceability system based on permissioned Hyperledger Fabric Two projects: tracing mangoes and pork

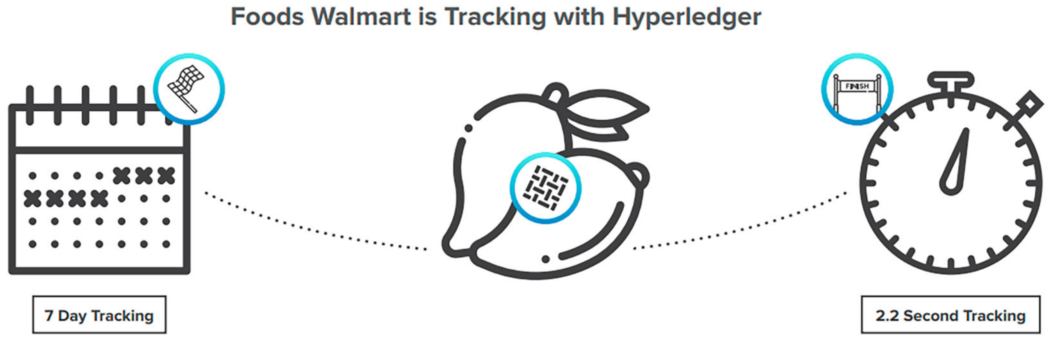

Figure 1. Reduced time needed to trace mangoes' provenance.
Source: Hyperledger 2020.

4.3. Electric vehicle (EV) batteries and blockchain

4.3.1. Challenges in EV batteries SC

Car makers face pressure to demonstrate responsible sourcing of raw materials like cobalt for lithium-ion batteries. Traceability of cobalt, involving extraction, processing, trade, and transportation, poses sustainability challenges due to unethical practices like child labour and minerals from conflict-affected areas. Volvo Cars' existing monitoring system lacked cobalt origin information due to complex upstream networks.

Volvo Cars is committed to achieving complete traceability by leading the initiative. The head of procurement emphasised blockchain's role in providing full traceability for raw materials used in batteries, minimising risks, and maximising supplier and customer values. Volvo Cars' blockchain solution ensures transparent cobalt origin, size, weight, and chain of custody, fostering trust between SC partners (Volvo Cars 2019; Banks-Louie 2020). By authenticating each person in the network, blockchain offers information about cobalt extraction, mining, and transportation, ensuring trust in the SC. See Table 3 for Volvo Cars' use case and blockchain solution for tracing cobalt.

Figure 2 explains the process and framework of blockchain implementation in Volvo Cars.

4.4. Blood SC and blockchain

4.4.1. Challenges in blood SC

Blood SC faces numerous issues related to reliability, lack of information on blood bags, poor management, and trust among network actors (Gor et al. 2020; Kim, Kim, and Kim 2020). The current centralised information system limits real-time data on blood bag transportation and hospital/blood

Table 2. The use cases of diamonds' certification and blockchain implementation.

Use case	Problem	Solution
Network of the blockchain-based permanent ledger (Crosby et al. 2016; Badzar 2016)	Blood diamonds and unethical sourcing	Everledger – digital thumb-print identity (e.g. height, width, weight, depth, colour, etc. are hashed and registered in a ledger)
Kimberly Process (KP) – Diamond certification scheme (Chair 2016)	Fraudulent activity and security issues	Offers a system of warranties of the stones' origins
Rare Carat and Rock Solid Diamonds (Everledger 2021a; Dotson 2021; Choi 2019)	The provenance of diamonds – origin tracing	Offering transparency with detailed information and capturing consumers' interest
Chow Tai Fook and GIA (Everledger 2021b)	Security, privacy, and traceability issues	Everledger-based digital solution providing grading information on diamonds' quality and offering traceable, truthful, thoughtful, and transparent footprints, delivering consumer values upfront

Table 3. EV batteries use case.

Use case	Problem	Solution
Electric vehicle (EV) batteries – Volvo Cars (Volvo Cars 2019; Banks-Louie 2020)	Traceability of cobalt's extraction, mining, and transportation	Blockchain, along with mine site inspection, GPS tracking, verified logistics providers, facial recognition, ID checks, and time tracking, offers a full package of information on material responsible sourcing, avoiding conflicted minerals or child labour

bank management, leading to uncertainty, delays, and security risks (Asokan et al. 2022; Gor et al. 2020). Transparency and security challenges persist, including uncertain demand, transportation delays, resource adequacy, mis-transfusion risks, and security threats in blood SCs.

Blockchain-based tokenization can improve blood SC efficiency by providing monitoring and traceability from donor to hospital. An example of this solution is BloodChain, a cost-effective blood donation promotion system led by Blodon, which integrates blood cryptocurrency (Zaremba et al. 2017). BloodChain aims to cooperate with public healthcare and blood banks to gather potential donors, supporters, and recipients (Zaremba et al. 2017). Table 4 highlights the use cases of blood SC and blockchain solutions addressing these challenges.

Figure 3 presents the blockchain-based blood SC and how transparency can be achieved to make the whole SC ethical.

5. Cross-case synthesis and discussion

This section synthesises findings from use cases and aligns them with literature, generating propositions for future work. The discussion focuses on blockchain's role in enhancing SC resilience, including operational excellence, value propositions, and business models. Our cases demonstrate blockchain's impact on effectiveness and efficiency through data sharing, smart contracts, cost reduction, and security. Blockchain streamlines transactions and response management, replacing intermediaries. Cases lack existing traceability and transparency technologies, emphasising blockchain's importance. Individual analyses derive customer-centric values (Tönnissen and Teuteberg 2020).

Among our cases, the food SC achieves operational excellence by reducing false claims and retailers' costs, consistent with Kamath's findings (2018). In diamond SC, blockchain addresses challenges

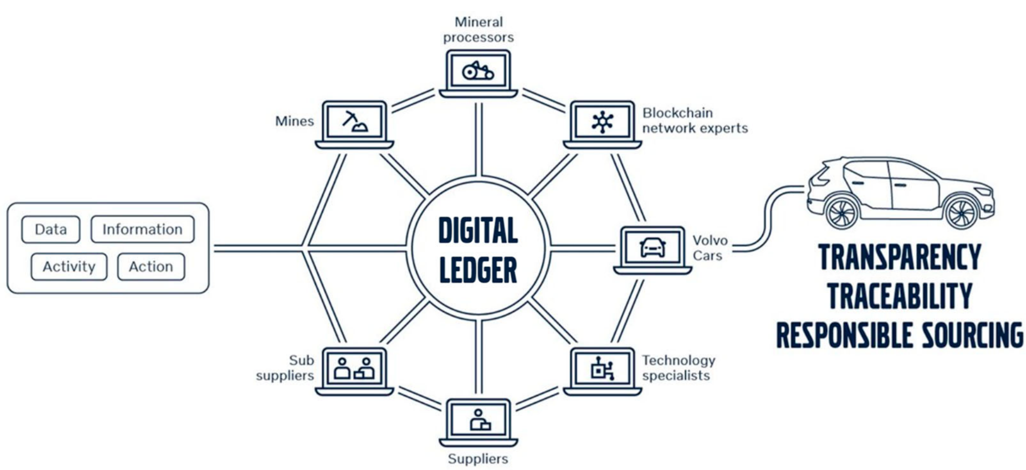

Figure 2. Volvo Cars framework to implement blockchain.
Source: Volvo Cars.

Table 4. Use cases of blood SC.

Use case	Problem	Solution
Blood donation – BloodChain by Blodon (Zaremba et al. 2017)	Reliability, broken or lack of information on bags, failure to reflect detailed updates, poor management in handling blood bags, and trust among network actors throughout the SC	Monitoring and maintaining data, avoiding waste, and leveraging smart contract security on Ethereum to control transactions and build conflict-free relationships Private solution – an extensive solution of blood donation integrating blood cryptocurrency
SmartBag – LifeBank (Giwa 2018)	Blood shortage and transparency within the process involved in transfusions	Helps discover safety records and track information from donor to hospital while preserving integrity and immutability

of counterfeiting and traceability by enhancing operational efficiency through transparent information flow and minimised risks (Crosby et al. 2016; Badzar 2016; Chair 2016; Dotson 2021; Choi 2019). For EV batteries, blockchain ensures transparency throughout the chain to prevent unethical practices, optimising operations through traceability capture (Banks-Louie 2020). Blood SC faces issues of reliability, lack of information on blood bags, and trust in the network. Blockchain enhances transparency and integrity, monitoring data to prevent blood waste, providing security, and tracking all processes from donor to hospital (Zaremba et al. 2017; Giwa 2018).

We discovered twelve dynamic value propositions across cases that blockchain develops, including transparency, traceability, real-time information sharing, operational efficiency, and security (see Table 5). These value propositions contribute to SC resilience and are seen as added benefits to customers. They are closely tied to blockchain's characteristics of data immutability, real-time data processing, data availability, peer-to-peer networking, and open-source nature (Tönnissen and Teuteberg 2020). Blockchain technology actively responds to uncertainties and challenges, disrupting traditional value systems and fostering transparency and efficiency for consumers. It builds a resilient and transparent system, creating trust and reducing risks in valuable item businesses like diamond SC and offering cost reduction by enhancing transparency in industries like food SC (Zutshi, Grilo, and Nodehi 2021). In EV battery SC, it helps eradicate child labour and conflicted material usage, while in blood SC, it provides visibility and real-time data for traceability, instilling decentralised trust and value for customers in related product SCs (Zutshi, Grilo, and Nodehi 2021; Tönnissen and Teuteberg 2020).

This study examines various aspects of the business model, including target customers, offerings, value propositions, revenue streams, and cost drivers (Morkunas, Paschen, and Boon 2019; Iansiti and

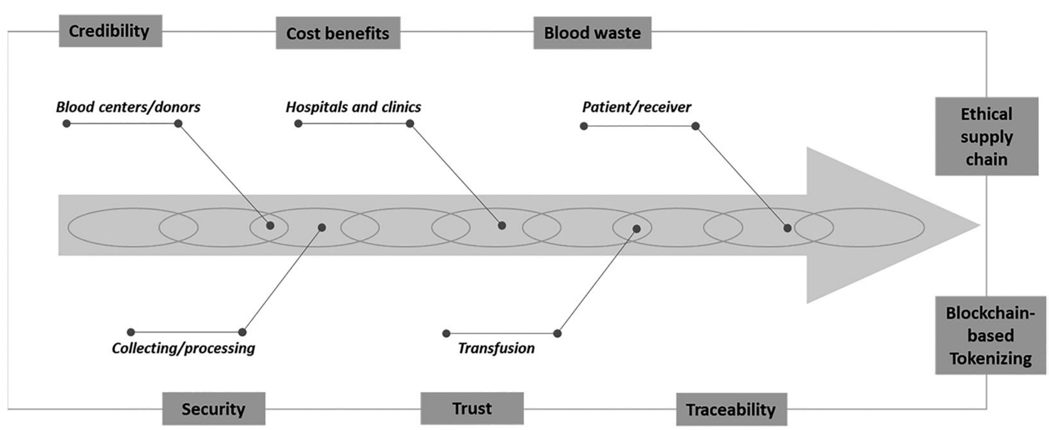

Figure 3. Blood SC and blockchain-based concept.

Table 5. Blockchain-based applications from the perspective of operational excellence, value propositions, and underlying business models.

Blockchain-based value for SC resilience	Food SC	Diamonds SC	EV battery SC	Blood SC
Operational excellence	Minimising false claims in the system Reduced retailer's costs	Product quality Minimised risks Transparent information flow	Process and operational optimization Traceability from mine to the car factory	Transparent SC
Value propositions	Transparency in the entire journey: farming and food processing Cost reduction	No risk of counterfeit Quality and trust Traceability and transparency Digital records of features and ownership	Responsible material sourcing No child labour or conflicted minerals Trust in network and traceability and sustainability	Trust among network actors Visibility, traceability, and transparency Real-time data availability
Underlying business model	Technological integration to design the best suitable peer-to-peer application to trace the food-borne disease and speed up the process	Aggregation of distributed data and immutable transactions create a trusted network, verifying business relationships	Focuses on responsible sourcing and sustainability	Token-based business models Cost-effective blood donation promotion

Levien 2002). Redesigning the business model within a blockchain ecosystem requires considering the impact of blockchain to better understand internal and external coordination and market plans of organisations (Tönnissen and Teuteberg 2020), creating opportunities for new value generation (Morkunas, Paschen, and Boon 2019). The cases analyzed demonstrate diverse underlying business models in conjunction with blockchain technology. For instance, the food SC case adopts a peer-to-peer interface for traceability and speed, while the diamond SC case emphasises distributed data aggregation, document security, and transparency to establish trusted business networks. The EV battery case focuses on responsible sourcing and sustainability, while the blood SC implements token-based business models to promote cost-effective blood donation. Transparency and traceability play pivotal roles in the business model, reshaping the current business logic of organisations (Morkunas, Paschen, and Boon 2019; Tönnissen and Teuteberg 2020).

5.1. Strategic-tactical-operational analysis

Based on within-case and cross-case analyses, we utilised a multi-level framework (strategic-tactical-operational or STO level) (Vidal and Goetschalckx 1997). This framework allows to identify involved parties and their roles in an ecosystem (Pucci et al. 2018) in determining, approving, and implementing blockchain technology. At the strategic level, we consider collaboration planning and compliance, while assessing the organisation's capacity for blockchain implementation. The tactical-level analysis focuses on actual blockchain implementation, addressing organisational structure and readiness. Operational-level analysis deals with daily operational aspects like innovation, technology, time frame, and processes, that contribute to strategy implementation. This multi-level framework provides valuable insights into necessary steps and actions at different organisational levels when adopting blockchain technology (see Figure 4).

Table 6 gives an overview of the analyzed use cases with the STO framework. Food, diamonds, EV battery, and blood SCs exhibit distinct operational priorities based on their value propositions and business models, contributing to their operational excellence. The STO framework proves beneficial in addressing specific challenges faced by each industry, helping to develop a resilient and responsive management system that aligns with customer needs and operational excellence.

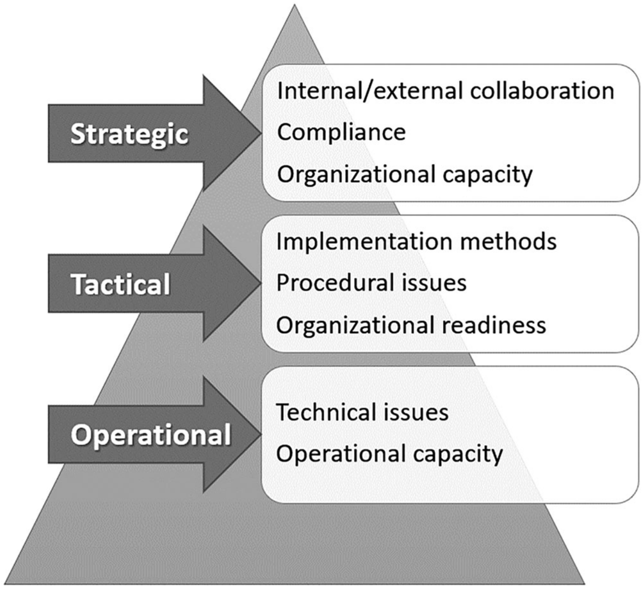

Figure 4. Strategic-tactical-operational framework.

6. Blockchain-based solution for forest industry – a reference implementation

This section showcases a proof-of-concept implementation of a blockchain system for a forest industry SC. The example illustrates the application of the blockchain-based reference framework to trace transactions and gather crucial information on sustainability and certification, thus enhancing SC resilience. Despite the forest industry's efforts to ensure sustainability through certifications and compliance with sustainable forest management principles via logging site audits, it remains vulnerable to tampering with certification records and facing challenges like deforestation and illegal logging throughout the SC. Given the lack of prior literature on blockchain implications in the forest industry (He and Turner 2022), our paper addresses this gap and demonstrates blockchain's implementation to strengthen SC resilience and tackle the aforementioned issues in the forest SC. The reference codes of this implementation for research and experimentation purposes are available in the GitHub[2] repository.

6.1. Reference case explanation

Our purpose is to utilise blockchain and smart contracts to record crucial sustainability information throughout the supply chain (SC). Figure 5 illustrates the reference case example of wood trading,

Table 6. Factors affecting blockchain implementation at STO levels.

	Food SC	Diamonds SC	EV battery SC	Blood SC
Strategic	Transparency and visibility to the source	Guarantee of authenticity	Social responsibility	Safety – proven trust in the ecosystem
Tactical	Linking SC to consumers by offering trusted visibility	Known responsible sources Linking ecosystem actors	Responsible sourcing	Real-time and reliable decisions
Operational	Cost reduction initiatives Traceability	Product quality Transparency toward upstream Signing process	Traceability Evidence on performance	Visibility Traceability/tracking

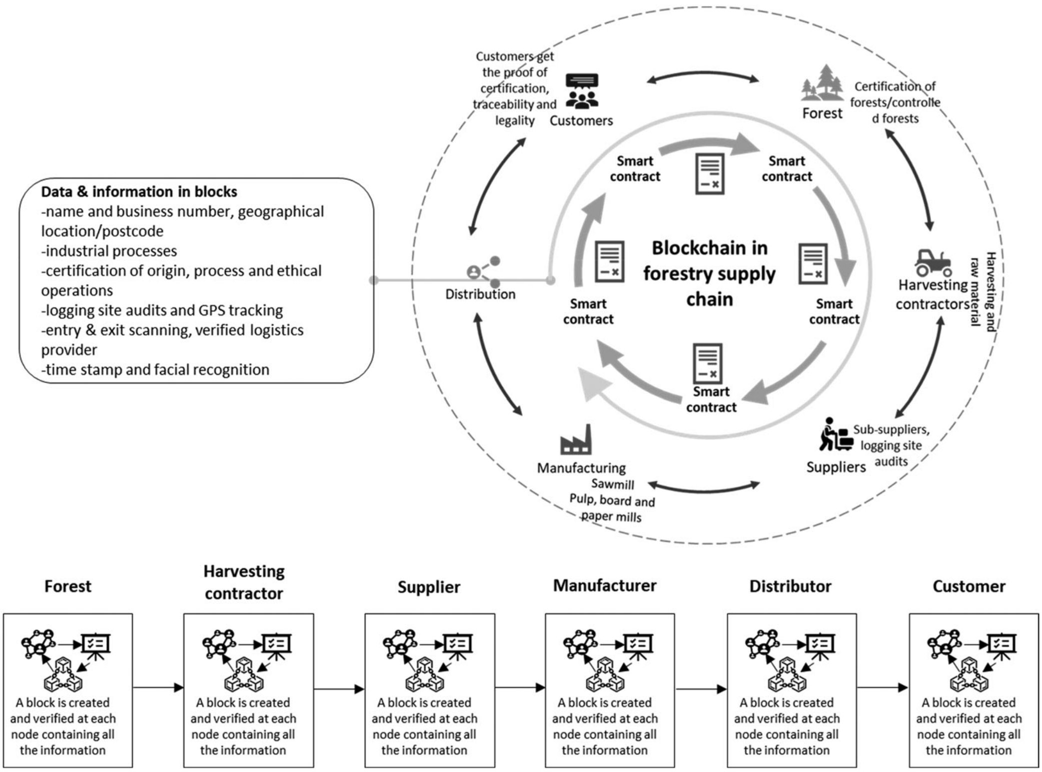

Figure 5. Reference case example of wood trading.

depicting blockchain information and involved parties throughout the SC. Manufacturers source wood from forest owners and certify its origin, ensuring forest biodiversity, safeguarding endangered species, and promoting good working conditions. All data is stored in the genesis block. As the wood moves to sawmills, new information on their environmental and quality management systems is added. Wood harvesting data is also included to trace the transportation chain from stump to mill. Downstream supplies benefit from efficient logistics, with information on delivery volumes, optimised models, return load utilisation, and minimised empty kilometres added to the block. Customers receive comprehensive information and certifications on wood usage and its sustainable origin from managed forests.

6.2. Design implementation and discussion

This blockchain-based traceability and sustainability of wood have three main data objects – blockchain, block, and transaction details as shown in Figure 6.

The implementation framework (GitHub) (also see Appendix 2 for source codes snippets with explanation) offers an easy-to-implement demonstration of a fully functioning blockchain for storing information in a distributed ledger. It serves as an illustrative example, showcasing how immutable information-based blocks are constructed using Python dictionaries, containing detailed data from actions and SC actors. This framework provides audit information, geo-location, important dates, certificates, management systems used, and other vital details to verify sustainable practices for all SC participants (see Appendix 2).

We propose a unique distributed ledger-based blockchain to address the lack of complete monitoring information records in the forest industry's processes. This approach not only

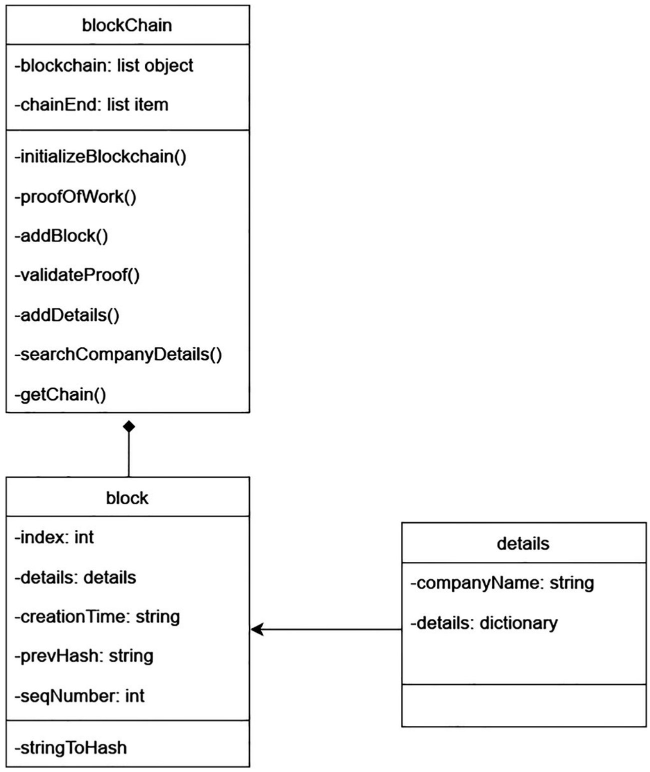

Figure 6. Domain framework of blockchain.

traces practices throughout the SC but also records crucial immutable sustainability information, linked with smart contracts. It addresses the problem of a 'broken information chain on sustainability' with two objective functions: ensuring forest sustainability and enhancing traceability and transparency in the forest ecosystem (Tönnissen and Teuteberg 2020). The blockchain-based approach enhances SC reliance, identifies risk sources, and minimises disruptions through shared information in blocks (Min 2019). Overall, it has great potential to assure customers of products made from sustainably managed forests while preserving forest well-being and biodiversity, aligning with the underlying business model (Morkunas, Paschen, and Boon 2019; He and Turner 2022).

7. Conclusions and the explanatory framework

Blockchain's implementation in the SC ecosystem and the logistics sector has been widespread due to its distributed nature and lack of single-actor control, offering benefits of trust and transparency in transactions for organisations seeking to enhance operational excellence and performance (Tönnissen and Teuteberg 2020; He and Turner 2022). However, prior research on blockchain's impact on operations and SC has been unclear and scattered, lacking comprehensive frameworks for understanding its role in developing new values and business models within the ecosystem. Our study examines four use cases to shed light on the role of blockchain technology in emerging operations and SC ecosystems, showcasing a demonstration of SC network configuration and actor interaction using blockchain-based traceability and sustainability in the forest industry. This demonstration illustrates data safety, information flow among partners, transaction tracing, and technology-based trust enabled by smart contracts on a blockchain network.

Table 7. SC ecosystem needs and blockchain potential.

	Product	Process	Organisation
Immutability	Material identification as the basis of product life-cycle (lot numbers, serial numbers)	Process routing data, acceptance tests, quality documentation Legally binding transactions and contracts	Product and process data-related evidence connected to organisations, individuals, and locations
Distributed actors and data storage	Standardized identifications codes Real-time visibility to all	Enabling interoperability between SC steps Automated trusted transactions	Ownership of product and process data is distributed; new use cases can be developed at various organisations
Trust	Product safety Warranty information Certificates of authenticity Ownership of asset Service history	Process security Sustainable sourcing Environmental impacts verified	Connecting the actors from organisations to trusted operations

We summarise our findings based on the proposed framework, incorporating current literature, within-case and cross-case analysis of selected use cases, and a technical reference implementation. The explanatory framework outlines blockchain technology's roles and functions, enabling immutability, trust, distributed control, and smart contracts that uphold governance rules and compliance. These features contribute to operational excellence and value propositions, fostering SC resilience. Implementing blockchain effectively reduces procedural complexity by minimising intermediaries, and enhancing SC effectiveness and efficiency (Kamble et al. 2021; Friedlmaier, Tumasjan, and Welpe 2018). Resilient SC practices and user-friendly implementation enable blockchain adoption in complex and uncertain SC operations (Chowdhury et al. 2023; Emrouznejad, Chowdhury, and Dey 2023). Table 7 highlights blockchain's potential contributions to building SC resilience and Figure 7 represents the explanatory framework of the study.

Such a research setting strengthens basic research to understand future adoption of blockchain as well as a framework explaining new values and trends in SC ecosystem.

This paper contributes to the literature on blockchain in SC resilience by designing a blockchain reference implementation (Min 2019; Morkunas, Paschen, and Boon 2019; Tönnissen and Teuteberg 2020) and providing publicly available source codes for secure storage of SC information in unalterable blocks. The implementation, available on GitHub, serves research and experimentation purposes and can be replicated for other settings, providing an easy-to-implement demonstration of

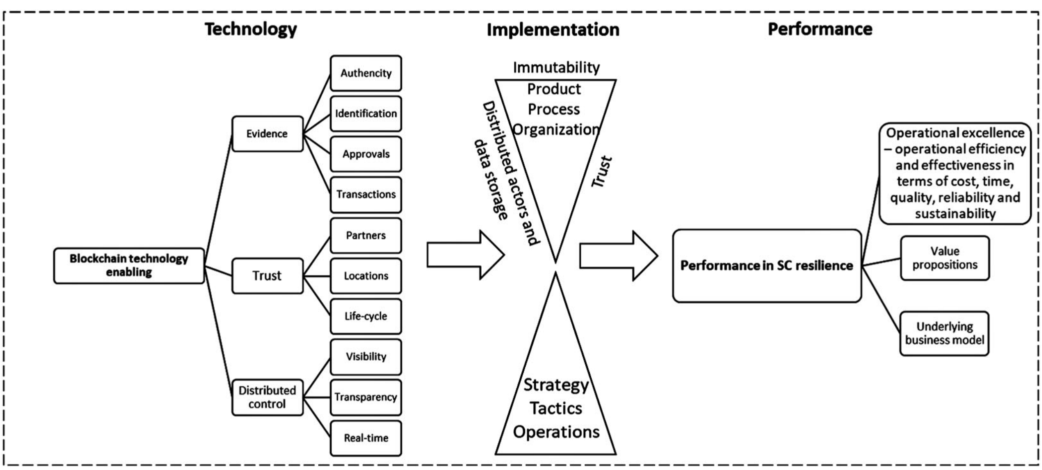

Figure 7. Explanatory model of technology, implementation, and performance in SCs.

the proposed framework's functionalities. The study presents an explanatory framework based on publicly available use cases and a forest industry example, aiding managers in understanding how technology affects the SC ecosystem and achieving operational objectives. Analyzing the blockchain on different levels ensures SC resilience, comparing its characteristics of immutability, distributed control, and trust concerning product, process, and organisation. This analysis empowers managers to address uncertainties and risks in the SC, developing value propositions for customers by offering transparency, traceability, and other product-related information (Morkunas, Paschen, and Boon 2019; Tönnissen and Teuteberg 2020; He and Turner 2022).

7.1. Future research avenues

Several research avenues warrant exploration. The implementation of blockchain in public and private sectors necessitates addressing legal compliance, with the potential for research on creating a global framework for legal implications in diverse countries. While our study focuses on four use cases, generalisation remains challenging. Nevertheless, the shared value propositions centre on business model evolution for operational excellence and bolstering SC resilience. The reference model lacks a concrete efficacy evaluation, emphasising the need for future research, including simulations covering qualitative and quantitative aspects. Further investigations can expand insights by analyzing real blockchain applications, considering factors like industry types and organisational readiness encompassing culture, structure, and technology.

Notes

1. https://github.com/BCforSC/Blockchain-technology-in-operations-and-supply-chain-ecosystem.git
2. https://github.com/BCforSC/Blockchain-technology-in-operations-and-supply-chain-ecosystem.git

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the Foundation of Economic Education – Liikesivistysrahasto [grant numbers 200264 and 210257].

Notes on contributors

Khuram Shahzad is an Assistant Professor of Digital Innovation Management at the School of Technology and Innovations/InnoLab, University of Vaasa Finland. His current research interests concern digital technologies and innovations, open innovation, R&D and innovation/entrepreneurial ecosystem, blockchain, digital transformation and supply chain management. His research work has been published in several journals of international repute, e.g. Industrial Marketing Management, International Business Review, Journal of Change Management, Journal of Business & Industrial Marketing and International Journal of Logistics Systems and Management.

Petri Helo is a Professor of Industrial Management, Logistics Systems and the head of Networked Value Systems research group, at School of Technology and Innovations, University of Vaasa, Finland. His research addresses the management of logistics systems in supply demand networks and use of IT in operations. He is also partner at Wapice Ltd, a software solution provider of industrial IT – sales configurator systems and IoT solutions. He has published papers in International Journal of Production Economics, Computers in Industry, Computers and Industrial Engineering, International Journal of Production Research, Industrial Management and Data Systems, Expert Systems with Applications, Decision Support Systems.

Mikko Ranta works as Associate Professor at School of Accounting and Finance, University of Vaasa Finland. His research focuses on data analytics in accounting, machine learning methods such as deep learning and accounting and finance. His research work has been published in several journals of international repute in the field of economics and finance.

Essi Nousiainen is a doctoral student in accounting at University of Vaasa. She holds a M.Sc. degree in economics from University of Vaasa. Her research interests focus on data analytics and machine learning applications in accounting and business.

References

Asokan, D., J. Sunny, V. M. Pillai, and H. V. Nath. 2022. "Blockchain Technology: A Troubleshooter for Blood Cold Chains." *Journal of Global Operations and Strategic Sourcing* 15 (3): 316–344. doi:10.1108/JGOSS-02-2022-0010.

Awwad, M., S. R. Kalluru, V. K. Airpulli, M. S. Zambre, A. Marathe, and P. Jain. 2018, September. "Blockchain Technology for Efficient Management of Supply Chain." In *Proceedings of the International Conference on Industrial Engineering and Operations Management*, 440–449.

Badzar, A. 2016. *Blockchain for Securing Sustainable Transport Contracts and Supply Chain Transparency-An Explorative Study of Blockchain Technology in Logistics*. Lund: Lund University.

Banks-Louie, S. 2020. *Volvo Mines Blockchain to Keep Ethical Sourcing Promise*. Accessed January 10, 2021. https://www.forbes.com/sites/oracle/2020/01/27/volvo-mines-blockchain-to-keep-ethical-sourcing-promise/?sh=47d2d4cf7eb6.

Breslin, D., J. Kask, M. Schlaile, and G. Abatecola. 2021. "Developing a Coevolutionary Account of Innovation Ecosystems." *Industrial Marketing Management* 98:59–68. doi:10.1016/j.indmarman.2021.07.016.

Chair, K. P. 2016. *Kimberly Process – Mid-term Report*. Accessed December 21, 2020. https://www.kimberleyprocess.com/en/system/files/documents/kimberley_process_mid-term_report.pdf.

Choi, T. M. 2019. "Blockchain-technology-supported Platforms for Diamond Authentication and Certification in Luxury Supply Chains." *Transportation Research Part E: Logistics and Transportation Review* 128:17–29. doi:10.1016/j.tre.2019.05.011.

Chowdhury, S., O. Rodriguez-Espindola, P. Dey, and P. Budhwar. 2023. "Blockchain Technology Adoption for Managing Risks in Operations and Supply Chain Management: Evidence from the UK." *Annals of Operations Research* 327 (1): 539–574.

Cole, R., M. Stevenson, and J. Aitken. 2019. "Blockchain Technology: Implications for Operations and Supply Chain Management." *Supply Chain Management: An International Journal* 24 (4): 469–483. doi:10.1108/SCM-09-2018-0309.

Crosby, M., P. Pattanayak, S. Verma, and V. Kalyanaraman. 2016. "Blockchain Technology: Beyond Bitcoin." *Applied Innovation* 2 (6–10): 71.

Dotson, K. 2021. *Everledger and Rare Carat Use Blockchain to Boost Transparency in Diamond Sales*. Accessed March 21, 2021. https://siliconangle.com/2021/01/12/everledger-rare-carat-use-blockchain-boost-transparency-diamond-sales/.

Dutta, P., T. M. Choi, S. Somani, and R. Butala. 2020. "Blockchain Technology in Supply Chain Operations: Applications, Challenges and Research Opportunities." *Transportation Research Part E: Logistics and Transportation Review* 142:102067. doi:10.1016/j.tre.2020.102067.

Emrouznejad, A., S. Chowdhury, and P. K. Dey. 2023. "Blockchain in Operations and Supply Chain Management." *Annals of Operations Research* 327:1–6. doi:10.1007/s10479-023-05451-x.

Everledger. 2021a. *Everledger Release Notes*. Accessed March 19, 2021. https://everledger.io/release-notes-blockchain-more/?builder=true&builder_id=4029037d0994f9393bc929adbfb735cb#boarding.

Everledger. 2021b. *Everledger with GIA and Chow Tai Fook*. Accessed March 10, 2021. https://www.everledger.io/wp-content/uploads/2020/04/case-study_Everledger-with-GIA-and-Chow-Tai-Fook.pdf.

Fernandez-Vazquez, S., R. Rosillo, L. Meijueiro, R. Alonso Alvarez, and D. De La Fuente. 2023. "A Comparative Study of Blockchain's Largest Permissionless Networks." *Technology Analysis & Strategic Management* 35 (4): 409–423.

Friedlmaier, M., A. Tumasjan, and I. M. Welpe. 2018. "Disrupting Industries with Blockchain: The Industry, Venture Capital Funding, and Regional Distribution of Blockchain Ventures." In *Venture Capital Funding, and Regional Distribution of Blockchain Ventures (September 22, 2017). Proceedings of the 51st Annual Hawaii International Conference on System Sciences (HICSS)*.

Ganguly, K. K. 2022. "Understanding the Challenges of the Adoption of Blockchain Technology in the Logistics Sector: The TOE Framework." *Technology Analysis & Strategic Management*, 1–15. doi:10.1080/09537325.2022.2036333

Giwa, T. 2018. *The Blood Chain – Introducing SmartBag*. Accessed April 2, 2021. https://lifebanknigeria.medium.com/lifebank-launches-smartbag-24cc7ca4b3b0.

Gor, P., D. Gosalia, R. Jhaveri, and M. A. Gawade. 2020. "Validity and Integrity Check in Supply Chain Management Using Blockchain." *International Journal of Engineering Research and Technology* 9 (2): 697–701.

Gordon, S. 2018. *Diamonds and the Blockchain*. Accessed April 4, 2021. https://www.babson.edu/academics/executive-education/babson-insight/technology-and-operations/diamonds-and-the-blockchain/.

Guercini, S., and A. Runfola. 2015. "Actors' Roles in Interaction and Innovation in Local Systems: A Conceptual Taxonomy." *Journal of Business & Industrial Marketing* 30 (3/4): 269–278. doi:10.1108/JBIM-12-2012-0256.

Guercini, S., and A. G. Woodside. 2012. "A Strategic Supply Chain Approach: Consortium Marketing in the Italian Leatherwear Industry." *Marketing Intelligence & Planning* 30 (7): 700–716. doi:10.1108/02634501211273814.

He, Z., and P. Turner. 2022. "Blockchain Applications in Forestry: A Systematic Literature Review." *Applied Sciences* 12 (8): 3723. doi:10.3390/app12083723.

Hevner, A. R., S. T. March, J. Park, and S. Ram. 2004. "Design Science in Information Systems Research." *MIS Quarterly*, 75–105. doi:10.2307/25148625.

Hoffman, A. J. 2021. "Walmart's Blockchain Quest: Integrating New Technology into a Complex Supply Chain." William Davidson Institute Case 4-290-769.

Hyperledger. 2020. *Case Study: How Walmart Brought Unprecedented Transparency to the Food Supply Chain with Hyperledger Fabric*. Accessed April 20, 2021. https://www.hyperledger.org/learn/publications/walmart-case-study.

Iansiti, M., and R. Levien. 2002. *The New Operational Dynamics of Business Ecosystems: Implications for Policy, Operations and Technology Strategy*, Vol. 3. Boston, MA: Division of Research, Harvard Business School, 113.

Ivanov, D., A. Dolgui, and B. Sokolov. 2019. "The Impact of Digital Technology and Industry 4.0 on the Ripple Effect and Supply Chain Risk Analytics." *International Journal of Production Research* 57 (3): 829–846. doi:10.1080/00207543.2018.1488086.

Kamalahmadi, M., and M. M. Parast. 2016. "A Review of the Literature on the Principles of Enterprise and Supply Chain Resilience: Major Findings and Directions for Future Research." *International Journal of Production Economics* 171:116–133. doi:10.1016/j.ijpe.2015.10.023.

Kamath, R. 2018. "Food Traceability on Blockchain: Walmart's Pork and Mango Pilots with IBM." *The Journal of the British Blockchain Association* 1 (1): 1–12. doi:10.31585/jbba-1-1-(10)2018

Kamble, S. S., A. Gunasekaran, V. Kumar, A. Belhadi, and C. Foropon. 2021. "A Machine Learning Based Approach for Predicting Blockchain Adoption in Supply Chain." *Technological Forecasting and Social Change* 163:120465. doi:10.1016/j.techfore.2020.120465.

Kim, S., J. Kim, and D. Kim. 2020. "Implementation of a Blood Cold Chain System Using Blockchain Technology." *Applied Sciences* 10 (9): 3330. doi:10.3390/app10093330.

Lohmer, J., N. Bugert, and R. Lasch. 2020. "Analysis of Resilience Strategies and Ripple Effect in Blockchain-coordinated Supply Chains: An Agent-based Simulation Study." *International Journal of Production Economics* 228:107882. doi:10.1016/j.ijpe.2020.107882.

Lumineau, F., W. Wang, and O. Schilke. 2021. "Blockchain Governance—A New Way of Organizing Collaborations?" *Organization Science* 32 (2): 500–521.

Madhani, P. M. 2021. "Supply Chain Transformation with Blockchain Deployment: Enhancing Efficiency and Effectiveness." *IUP Journal of Supply Chain Management* 18 (4): 7–32.

Manupati, V. K., T. Schoenherr, M. Ramkumar, S. Panigrahi, Y. Sharma, and P. Mishra. 2022. "Recovery Strategies for a Disrupted Supply Chain Network: Leveraging Blockchain Technology in Pre-and Post-disruption Scenarios." *International Journal of Production Economics* 245:108389. doi:10.1016/j.ijpe.2021.108389.

Min, H. 2019. "Blockchain Technology for Enhancing Supply Chain Resilience." *Business Horizons* 62 (1): 35–45. doi:10.1016/j.bushor.2018.08.012.

Möller, K., S. Nenonen, and K. Storbacka. 2020. "Networks, Ecosystems, Fields, Market Systems? Making Sense of the Business Environment." *Industrial Marketing Management* 90:380–399. doi:10.1016/j.indmarman.2020.07.013.

Morkunas, V. J., J. Paschen, and E. Boon. 2019. "How Blockchain Technologies Impact Your Business Model." *Business Horizons* 62 (3): 295–306. doi:10.1016/j.bushor.2019.01.009.

Nickerson, R. C., U. Varshney, and J. Muntermann. 2013. "A Method for Taxonomy Development and its Application in Information Systems." *European Journal of Information Systems* 22 (3): 336–359. doi:10.1057/ejis.2012.26.

Öberg, C., and A. T. Alexander. 2019. "The Openness of Open Innovation in Ecosystems–Integrating Innovation and Management Literature on Knowledge Linkages." *Journal of Innovation & Knowledge* 4 (4): 211–218. doi:10.1016/j.jik.2017.10.005.

Peltoniemi, T., and J. Ihalainen. 2019. "Evaluating Blockchain for the Governance of the Plasma Derivatives Supply Chain: How Distributed Ledger Technology can Mitigate Plasma Supply Chain Risks." *Blockchain in Healthcare Today* 2 (10): 1–13. doi:10.30953/bhty.v2.107.

Pucci, T., A. Runfola, S. Guercini, and L. Zanni. 2018. "The Role of Actors in Interactions between 'Innovation Ecosystems': Drivers and Implications." *IMP Journal* 12 (2): 333–345. doi:10.1108/IMP-05-2017-0022.

Rose, S., N. Spinks, and A. Canhoto. 2014. *Management Research: Applying the Principles*. New York, NY: Routledge.

Saberi, S., M. Kouhizadeh, and J. Sarkis. 2019. "Blockchains and the Supply Chain: Findings from a Broad Study of Practitioners." *IEEE Engineering Management Review* 47 (3): 95–103. doi:10.1109/EMR.2019.2928264.

Sabouhi, F., M. S. Pishvaee, and M. S. Jabalameli. 2018. "Resilient Supply Chain Design under Operational and Disruption Risks Considering Quantity Discount: A Case Study of Pharmaceutical Supply Chain." *Computers & Industrial Engineering* 126:657–672. doi:10.1016/j.cie.2018.10.001.

Seawright, J., and J. Gerring. 2008. "Case Selection Techniques in Case Study Research: A Menu of Qualitative and Quantitative Options." *Political Research Quarterly* 61 (2): 294–308. doi:10.1177/1065912907313077.

Shahzad, K. 2020. "Blockchain and Organizational Characteristics: Towards Business Model Innovation." In *Advances in Creativity, Innovation, Entrepreneurship and Communication of Design: Proceedings of the AHFE 2020 Virtual Conferences on Creativity, Innovation and Entrepreneurship, and Human Factors in Communication of Design*, edited by E. Markopoulos, R. S. Goonetilleke, A. G. Ho, and Y. Luximon, 80–86. Cham: Springer.

Sunny, J., N. Undralla, and V. M. Pillai. 2020. "Supply Chain Transparency Through Blockchain-based Traceability: An Overview with Demonstration." *Computers & Industrial Engineering* 150:106895. doi:10.1016/j.cie.2020.106895.

Tönnissen, S., and F. Teuteberg. 2020. "Analysing the Impact of Blockchain-technology for Operations and Supply Chain Management: An Explanatory Model Drawn from Multiple Case Studies." *International Journal of Information Management* 52:101953. doi:10.1016/j.ijinfomgt.2019.05.009.

Vidal, C. J., and M. Goetschalckx. 1997. "Strategic Production-distribution Models: A Critical Review with Emphasis on Global Supply Chain Models." *European Journal of Operational Research* 98 (1): 1–18. doi:10.1016/S0377-2217(97)80080-X.

Volvo Cars. 2019. *Volvo Cars to Implement Blockchain Traceability of Cobalt Used in Electric Car Batteries*. Accessed March 4, 2021. https://www.media.volvocars.com/global/en-gb/media/pressreleases/260242/volvo-cars-to-implement-blockchain-traceability-of-cobalt-used-in-electric-car-batteries.

Wieland, A., and C. M. Wallenburg. 2013. "The Influence of Relational Competencies on Supply Chain Resilience: A Relational View." *International Journal of Physical Distribution & Logistics Management* 43 (4): 300–320. doi:10.1108/IJPDLM-08-2012-0243.

Yin, R. K. 2003. *Case Study Research, Design and Methods*. 3rd ed. Beverly Hills, CA: Sage Publications.

Zaremba, S., A. Bubiel, A. Tkacz, R. Lugowicz, and A. Sosnowski. 2017. *White Paper, Bloodchain*. Accessed April 21, 2021. https://blodon.com/blodon_bloodchain_white_paper.pdf.

Zīle, K., and R. Strazdiņa. 2018. "Blockchain Use Cases and their Feasibility." *Applied Computer Systems* 23 (1): 12–20. doi:10.2478/acss-2018-0002.

Zutshi, A., A. Grilo, and T. Nodehi. 2021. "The Value Proposition of Blockchain Technologies and its Impact on Digital Platforms." *Computers & Industrial Engineering* 155:107187. doi:10.1016/j.cie.2021.107187.