Potentials of blockchain technologies for supply chain collaboration: a conceptual framework

Abderahman Rejeb
Széchenyi István University, Győr, Hungary
John G. Keogh
University of Reading, Greenlands, Henley-on-Thames, UK
Steven J. Simske
Colorado State University, Fort Collins, Colorado, USA
Thomas Stafford
Louisiana Tech University, Ruston, Louisiana, USA, and
Horst Treiblmaier
Modul University Vienna, Vienna, Austria

Received 16 February 2020
Revised 25 July 2020
9 October 2020
9 January 2021
18 January 2021
Accepted 25 January 2021

Abstract

Purpose – The purpose of this study is to investigate the potentials of blockchain technologies (BC) for supply chain collaboration (SCC).

Design/methodology/approach – Building on a narrative literature review and analysis of seminal SCC research, BC characteristics are integrated into a conceptual framework consisting of seven key dimensions: information sharing, resource sharing, decision synchronization, goal congruence, incentive alignment, collaborative communication and joint knowledge creation. The relevance of each category is briefly assessed.

Findings – BC technologies can impact collaboration between transaction partners in modern supply chains (SCs) by streamlining information sharing processes, by supporting decision and reward models and by strengthening communicative relationships with SC partners. BC promises important future capabilities in SCs by facilitating auditability, improving accountability, enhancing data and information transparency and improving trust in B2B relationships. The technology also promises to strengthen collaboration and to overcome vulnerabilities related to moral hazard and shortcomings found in legacy technologies.

Research limitations/implications – The paper is mainly focused on the potentials of BC technologies on SCC as envisioned in the current academic literature. Hence, there is a need to validate the theoretical inferences with other approaches such as expert interviews and empirical tests. This study is of use to practitioners and decision-makers seeking to engage in BC-collaborative SC models.

Originality/value – The value of this paper lies in its call for an increased focus on the possibilities of BC technologies to support SCC. This study also contributes to the literature by filling the knowledge gap of how BC potentially impacts SC management.

Keywords Supply chain collaboration, Blockchain, Collaboration dimensions, Resource efficiency, Transparency, Auditability, Accountability

Paper type Conceptual paper

Introduction

Firms operating in globalized, multi-party supply chains (SCs) face increasing competitive pressures driven by the accelerating pace of business (Connelly *et al.*, 2013). These multi-

Steven J. Simske's work on this was partially supported by NSF EAGER grant with the abstract number 1842577, Advanced Analytics, Intelligence and Processes for Disrupting Operations of Illicit Supply Networks.

The International Journal of Logistics Management

0957-4093
DOI 10.1108/IJLM-02-2020-0098

party SCs are often labeled as "virtual organizations" or "value chains." In such virtual organizational forms, multiple parties agree to collaborate in the generation of value, to share in the risk of collaborating and to expect to receive positive outcomes in return (Ketchen and Giunipero, 2004). To balance against the inherent complexities and risks of forming and managing such complex global SCs, firms seek high levels of collaboration to leverage the knowledge and resources of their exchange partners (Cao and Zhang, 2011).

As firms explore new and innovative business models, the notion of securing and assuring value chain transaction details using blockchain technology (BC) has gained the attention of researchers (Korpela *et al.*, 2017; Kim and Laskowski, 2018), leading to perspectives that span transaction trust to security and privacy threats that firms face in digital-enabled global value chains (Dai and Vasarhelyi, 2017; Hong *et al.*, 2014). Security and privacy features require specific enhancement to ensure that business data are both safe and reliable and that services are resilient against the many different forms of attacks likely to occur (Newman *et al.*, 2016).

Managers strive for increased efficiency, reduced risk and improved responsiveness and aim to achieve these qualities through the introduction of modern technologies to enhance transparency and trust (Power *et al.*, 2001; Wamba *et al.*, 2020a, b). From this perspective, the auditability characteristic of the BC environment serves to extend transactional trust beyond the traditional understanding (which specifies that a cooperative partner will deliver on promises under unknown circumstances). The BC enhancement of SC trust trust arises from advantageous features such as automated deal execution, executional transparency and data traceability among peers (Xia and Yongjun, 2017; Kamble *et al.*, 2019).

Existing SC technologies already provide buyers with governance tools to monitor supplier actions and behaviors in real-time. However, these tools provide only a modicum of moral hazard risk reduction. Existing tools also provide transaction verification (Bergen *et al.*, 1992); but the traditional transaction management tools are from an era predating the present network-enabled automated SCs that have emerged. Network-enabled SCs can now take advantage of advantageous BC solutions for risk reduction and transaction verification.

BC represents a potent solution in the form of a new business model that can account for and assure the veracity of digital SC transactions (Schmidt and Wagner, 2019). Previous research has already demonstrated the feasibility of designing collaborative business processes based on BC. Simulation models and surveys, both, have shown that BC is quite effective in overcoming collaboration and trust issues in SCs; this can lead to beneficial effects on SC performance by providing an effective solution for balancing information asymmetries between partners (Longo *et al.*, 2019; Wamba and Guthrie, 2020).

Firms interact primarily based on shared mutual interests (Kumar and Banerjee, 2012); firms also face agency problems, which imply threats regarding opportunism and subsequent moral hazard in business relationships (Bosse and Phillips, 2016). The protection of private information in SCs is a research problem with multidisciplinary appeal for just this reason (Hong *et al.*, 2014). Trust between exchange partners remains a mission-critical requirement in business-to-business B2B information sharing networks (Arnold *et al.*, 2014) where current implementations do not provide for the technological facilitation of trust between SC partners (Lu *et al.*, 2018). For this reason, prior and existing SC solutions are seen as vulnerable to information assurance issues and security threats (Koh *et al.*, 2014).

In this context, BC has the potential to take collaboration in SCs to a new trust level by addressing SC information security problems (Treiblmaier, 2018) and subsequently gaining consumer and investor confidence in the technology at the same time (Sodhi and Tang, 2019). The functionality, pervasiveness and extent of the BC solution auger well for its application beyond archetypical cryptocurrency use cases (Risius and Spohrer, 2017; Treiblmaier and Beck, 2019), while at the same time providing much-needed information accounting, information assurance, transaction verification and auditing capabilities for business transactions (Kokina *et al.*, 2017).

In supporting industrial SCs, BC supports a growing number of supply chain management (SCM) use cases (Rejeb *et al.*, 2019; Park *et al.*, 2020). When business-to-business interparty trust is boosted in transactions, SC transparency is beneficially enhanced (Sodhi and Tang, 2019). BC accounting features providing data assurance, data provenance and data auditability are of specific value in SCs (Kokina *et al.*, 2017).

The shift toward a decentralized open-network approach embodied in the BC era also implies new business processes (Hald and Kinra, 2019) that can enhance collaboration between SC partners through the provision of data and information assurance, security and auditability in public network venues (Treiblmaier, 2018). In these new transactional business models, research issues for investigation are readily apparent (Wamba and Queiroz, 2020); such issues include the contribution of BC to enhance the relationships between social variables such as trust, power, knowledge sharing and cooperation and SC members and then the real cost savings that BC provides SCs as part of its informational/transactional disintermediation function.

Virtual organization forms, such as extended value chains, support the development of effective internal interparty trust relationships with BC which substantially improve collaboration processes. This, in turn, can beneficially impact firms' operational capabilities (Pan *et al.*, 2019). However, there is a noticeable lack of conceptualization in the literature about the ways in which BC will fit the multidimensional nature of modern technology-enabled SC collaboration (SCC). This paper bridges this knowledge gap by exploring these emergent BC-based SCC models. In structuring our perspective of BC-enabled SCM, we argue for private BCs based on ad hoc dynamic sub-networks of value; such private BCs are likely to contribute to more effective forms of collaboration. To that end, our guiding question is:

RQ. What are the potentials of blockchain for supply chain collaboration?

The remainder of this paper is structured as follows: in the following section, we briefly review BC and its key attributes. Then, we develop a collaboration framework in a step-by-step manner to incorporate the strengths of BC in supporting SCC. The paper concludes with a discussion that highlights the potential for future research.

Blockchain technology

Treiblmaier defines BC as a digital, decentralized and distributed ledger in which transactions are logged and added in chronological order to create permanent and tamperproof records (2018, p. 547). The first functional BC was described in the cryptocurrency Whitepaper, "Bitcoin: A Peer-to-Peer Electronic Cash System," which pinpointed the inefficiencies resulting from the conventional banking system in which a trusted third party (i.e. a bank) acts as the central authority for mediating business transactions and preventing double-spending (Nakamoto, 2008). This cryptocurrency rubric quickly became the popular archetype for BC implementations, demonstrating ingenious combinations of methods such as linked time stamping, verifiable logs, digital cash, proof of work, fault tolerance, public-private key authentication and smart contracts. In this instance, the problem of double-spending was solved and transactions no longer required explicit trust in intermediaries because their facilitating function was immutably and irreversibly recorded in a distributed ledger (Narayanan and Clark, 2017).

Beyond the cryptocurrency rubric, it has to be noted that more than one specific type of BC exists, and also that the term "blockchain" is frequently (and incorrectly) used to denote distributed ledger technologies ranging from open public systems to restricted access implementations limited to a defined group of users (i.e. private BC). The most promising nonfinancial BC applications include modern SC applications (Kshetri, 2018), facilitating new ways of communication and asset transfer between SC peers without the assistance of third-party intermediaries (Mougayar, 2016). The scope of BC use cases range from the exchange of

money to the transfer of information, demonstrating novel forms of disintermediated governance and the effective allocation of resources in the human and corporate levels of the economy (Treiblmaier and Clohessy, 2020).

Key attributes of blockchain technology

In a Whitepaper for the World Economic Forum, Tapscott and Tapscott (2017, p. 4) wrote that unlike the Internet, BCs are not centralized; they are distributed and are open. They are not hidden, they are inclusive rather than exclusive, they are immutable and they are *secure*. Several key attributes of BC make it unique, innovative and visibly distinct from existing technologies:

Decentralization: BC takes the form of a distributed peer-to-peer network in which all the nodes interact and reach mutual agreement via a consensus mechanism and without the need for intermediaries (Cui and Idota, 2018).

Immutability: BCs have the potential to act as an unimpeachable record keeper. Immutability, however, can come with a price; for the information in a BC to be immutable, the set of ledger members is also immutable. This suggests that "late binding" of BC participants is recommended where the workflow is expected to add participants, and that the creation of (potentially multiple) private BCs including all potential participants in a workflow is ill-advised (or even illegal) due to privacy, security, access control and data exportation concerns.

Pseudonymity: BCs do not require the disclosure of identity when transacting and transferring data.

Equality and distribution of rights: In public and permissionless BC networks, all members have the same status and rights; there are no administrators or information custodians. By contrast, in permissioned BC networks, privileged parties can be appointed. The latter is more directly amenable to ad hoc and "late-binding" BCs.

Trust and provenance: BC provides incontestable evidence of data provenance, in that all transaction data can be retrieved at any time and from any location. Every event log creates an automatic proof of the history, position and ownership of each block on the chain.

Security: Each entity in the BC network maintains the security and integrity of the database or ledger. In effect, BC data already entered cannot be deleted or changed.

Methodology

In order to address our research question – BC's potential to foster collaboration in the SC – we conducted a narrative literature review that served as the basis for the creation of our conceptual framework. Narrative reviews are mainly used to describe and classify published articles without an explicit focus on methodological details. This approach permits us to speculate on future developments and to use the researchers' judgments while preserving an objective and critical analysis of the subject at hand. Given the novelty of the BC subject, we preferred this approach over conducting a systematic literature review that would be more appropriate for a topic with a strong literature base and selection criteria, where the methods for data extraction and synthesis can be explicitly described (Ferrari, 2015).

We started our search process in established academic databases including Scopus, Web of Science, ScienceDirect, EBSCO Business Source Premier and Google Scholar, but we did not restrict ourselves to peer-reviewed research. We also considered what we call the "grey literature" outside of academic purview on the chance of finding new insights on BC. In the selection process, we screened the abstracts of all potentially relevant papers, then extracting the main topics and selecting descriptive categories (Mayring, 2000). This extraction/categorization process led to the framework presented in this paper. Following the narrative literature review process, the final structure that we discuss in the remainder of this paper emerged as a result of the analysis and categorization process.

A blockchain-enhanced supply chain collaboration framework

Collaboration is an increasingly important aspect of the corporate environment. The philosophy of SCM extends the scope of bilateral partnerships into multi-firm networks to achieve collaborative management of SC flows and thus achieve more significant benefits (Carrus and Pinna, 2011). The success of a collaboration depends on the readiness of firms and managers to create a trusted environment and build strong relationships among their exchange partners (Panayides and Venus Lun, 2009). The trustworthiness of SC partners determines the eventual success of their collaboration efforts. To support such trust, shared information in the SC should be reliable and available to all participants involved in the collaboration scheme (Stefansson, 2002) in order to reduce ex-post opportunism, the risk of moral hazard (Stump and Heide, 1996) and the failure of working relationships (Simatupang and Sridharan, 2002).

Recently, technology-facilitated collaboration has significantly improved the way SCs operate and how they meet customer expectations, but such collaborations also make SCs more vulnerable to an array of IT-specific threats (Baker *et al.*, 2007). In this paper, the focus will be specifically on the implications of BC for collaboration. We leverage a collaborative framework from Cao *et al.* (2010) as the lens for our narrative review. The authors categorized collaboration into seven dimensions: *information sharing*, *resource sharing, decision synchronization*, *goal congruence, incentive alignment*, *collaborative communication* and *joint knowledge creation*. In the following sections, we will successively discuss the respective dimensions and how they can be potentially impacted by BC.

Information sharing

Information sharing is an essential tool for SC integration (Lotfi *et al.*, 2013). The success of multi-party SCs depends on bidirectional information exchanges between parties, conveying strategic and tactical data related to inventory levels, sales forecasts and marketing strategies (Hofstede, 2003). Information sharing has been regarded as one of the main tools for reducing costs and enhancing SC performance. To enable information sharing in SCM and logistics, advanced information technologies must be incorporated. EDI and other related technologies and standards have historically provided interoperability and integration of information flows (Schemm and Legner, 2008), at the same time that legacy information technologies have built and strengthened closer connections and coordination among SC participants regardless of their location or time zones.

Information sharing failures: The lack of information sharing between companies results in inefficiencies in coordinating actions (Lotfi *et al.*, 2013). Fragmented and non-interoperable information technologies render information sharing a strenuous, costly and inefficient process that requires individuals' commitment, time and energy (Goodman and Darr, 1998). Therefore, in order to mitigate these problems and ensure information quality and integrity, a configured BC can facilitate the sharing of structured, standards-based data aligned to SC standards.

BC has the potential to enable SC partners to exchange structured information in what is termed a "trustless" environment (Saberi *et al.*, 2019). With trust "built in" to the architecture of the BC arrangement, issues related to data assurance, data provenance, privacy, confidentiality and security are potentially resolved by BCs. The assurance of trust in such situations is contingent on the majority of the BC participants (1) being incented to ensure the security, privacy and fairness of the transactions and (2) being part of the approval process for transactions of value to them.

Information security: Regardless of implementation considerations, BC is largely perceived as "un-hackable". The likelihood of information security breaches engendered by existing communication networks – such as electronic data interchange, continuous

replenishment programs and vendor managed inventory – will be significantly reduced in a BC-enabled system. BC can overcome information sharing challenges such as the lack of common standards or incompatibility of different IT systems (Ghosh and Tan, 2018).

BC can be integrated with existing communication and information systems (e.g. EDI, ERP and VMI) and can also support the secure access and sharing of sensitive information between SC partners. Through the tamperproof recording of information, blockchain technology promises to facilitate the exchange of information by breaking data silos generated by disconnected systems, reducing paperwork, substantially removing data redundancy, supporting validation requirements and inhibiting data manipulation and product counterfeiting in SC activities (Dobrovnik *et al.*, 2018).

Benefits of ledger membership: A problem that has seen extensive discussion in the literature regards potential imbalances is the distribution of benefits resulting from information sharing between collaborative partners (Yu *et al.*, 2001). Implicitly speaking, all SC partners should benefit proportionally from the distributed benefits of sharing information. Here is yet another circumstance in which late-binding of participants in a BC provides a considerable advantage; participants who do not stand to benefit from the arrangement will not be members of the distributed ledger.

BC improves on legacy technologies by ensuring data integrity along with establishing trust relationships between SC partners, thus leading to superior capabilities and improved decision-making (Baihaqi and Sohal, 2013). An important caveat is that data entered into a BC must be truthful and accurate since its recorded transactions are immutable.

Resource sharing

Resource sharing is the process of leveraging capabilities and assets that are jointly invested with SC partners (Cao *et al.*, 2010); this is conceptually similar but also subtly different from the sharing of information. The distributed architecture of the BC allows the interconnected nodes and peers to efficiently share and exchange information between each other without using a central node of control. And, yet, BC is also highly compatible with multi-echelon SCs and can support interoperability as well as collaborative operations between partners.

BC strengthens "the sharing economy," envisioned by Lessig (2008). A sharing economy is defined as collaborative consumption made by the activities of sharing, exchanging and rental of resources without actually *owning* the goods (Choi *et al.*, 2014, p. 625). BC promises to deliver its full potential in the infrastructure and transaction trust layers of the sharing process and allows SC exchange partners to make more efficient usage of scarce resources and capabilities, enhanced by the information-sharing capabilities of the distributed ledger. Resources which can be shared might involve a broader range of physical items (e.g. goods, manufacturing equipment, facilities, empty warehouse space, trucks and vehicles) or extend to intangible elements (information sharing and consulting expertise and services). In logistics services, for example, firms can have an increased level of visibility for their freight vehicle capacity and can achieve tight control of activities as diverse as driver authentication, waste disposal and payments (Kouhizadeh and Sarkis, 2018). Hence, BC could enable a new cooperative ecosystem where firms take full advantage of their underutilized resources while reducing the strain on the environment through better resource utilization. Figure 1 shows the complex interactions triggered by resource sharing within the BC ecosystem as well as the main stakeholders in a value chain who can use BC for sharing resources.

Decision synchronization

Decision synchronization, which considers the interests of the entire SC, rather than those of individual can be difficult since SC partners have varying decision rights and expertise

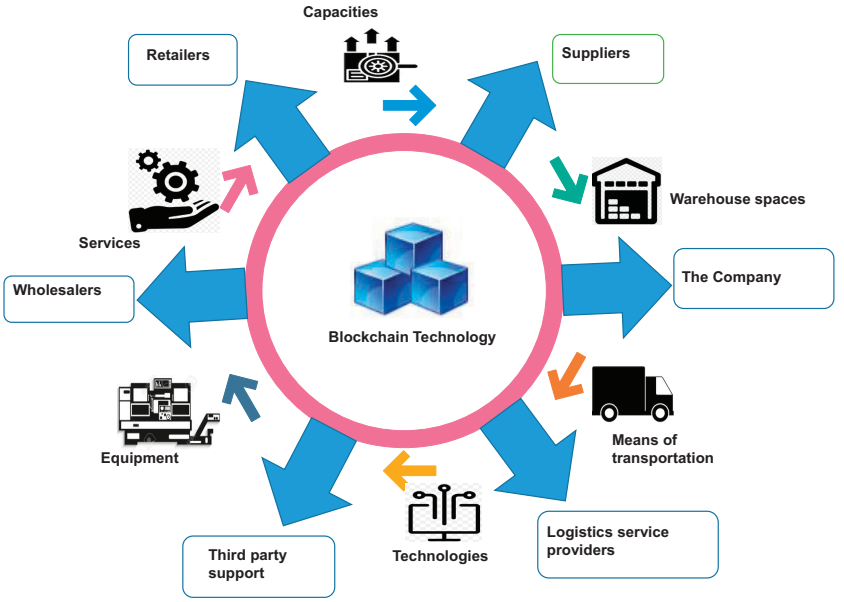

Figure 1.
Resource sharing in the blockchain ecosystem

regarding SC planning and operations (Simatupang and Sridharan, 2005). BC is well suited for coordinating critical decisions in SCs, and the result is improved performance. BC integrates and synchronizes data between the different nodes in a SC ecosystem, providing an alternative to basing collaboration on the arm's length principle where the principal (i.e. buyer) is the dominant, self-interested party and where negotiating power is asymmetric. It ensures a high level of decision synchronization, drives unity of action and helps SC partners maintain visibility and control over their own operations. Practical applications of such implementations have proven valuable for tracking inventory, monitoring product components and tracing the global footprint of collaborating firms (Omran *et al.*, 2017).

BC assists in optimizing business operations by simplifying tasks and improving product-related information flows from raw material suppliers up to the point of sale. To illustrate this point, suppliers can access and analyze accumulated data related to customer buying patterns, order placement trends and product delivery to better profile their customers in order to improve the forecasting of the downstream SC (van Engelenburg *et al.*, 2018). In this way, the technology can bring about a precise match between supply and demand through enhancing practices like VMI and just-in-time replenishment; this serves to improve profits for each SC actor.

SC transparency is also enhanced (Bai and Sarkis, 2020) through smart contract features which allow trading partners to swiftly agree upon precise conditions while reducing the risk of disagreements or inter-party conflicts. Previous research has shown the design of smart contracts can be presented as an instance of flexible flow shop scheduling in an event-driven dynamic approach (Dolgui *et al.*, 2020). Therefore, BC optimizes SC decisions and creates new capabilities and value-generating activities, such as the rich possibilities of "just-in-time" creation of BCs for adaptive SC workflows.

Goal congruence

The goal congruence aspect of collaboration is defined as a state in which the goals of diverse groups coincide (Cao *et al.*, 2010). Within this context, BC is founded on the premise of goal

congruence, given that collaborating nodes need to verify the validity of new information and the overall veracity of existing records (Mougayar, 2016). Because there is no single entity that can cause or exercise opportunistic control over the distributed ledger at any time (Rechtman, 2017), BC advances and reinforces the cause of goal congruence.

Operating within a BC-enabled SC, congruence of purpose facilitates behavior-based outcomes, constrains opportunism and reduces the risk of moral hazard or "hidden actions" on the part of suppliers (Bergen *et al.*, 1992). Although unethical conduct such as quality cheating, collusion or fraud can take place outside of the BC environment, the technology provides important data provenance and auditability functions, which may help to reduce occurrence and impact of participants with conflicting self-interests (Hong *et al.*, 2014). To the extent that self-dealing is reduced by auditability, BC scales up to the best type of contractual agreements through achieving a high level of goal symmetry (Cole *et al.*, 2019).

BC-enabled smart contracts, which serve to control asymmetry, can assist in the formation and maintenance of stronger alliances; such strong alliances hold promise for more disintermediation over the prior dominance of well-resourced actors within the SC (Treiblmaier, 2018). In such contractually structured "smart partnerships," SC partners are able to transact business with full accountability and secure data stewardship. This buttresses the process by which SC participants organize and orchestrate decisions in their planning and operations, thus yielding SC efficiencies that allow robust responsiveness to market variability (Nakasumi, 2017).

Incentive alignment

Incentive alignment necessitates the sharing of costs, risks and benefits between SC partners (Simatupang and Sridharan, 2002). It is here that BC potentially aligns incentives among SC partners through the formulation and enforcement of incentive schemes. This incentive alignment also addresses trust issues between partners and gives confidence to the participants in the network that all parties are abiding by the rules (Cole *et al.*, 2019). In this manner, BC integrates SC partners into specific consortiums where they can mobilize resources, co-create value and collaboratively reach common goals.

The use of BC-enabled smart contracts aligns the interests of the different parties in the SC, as an example (Eenmaa-Dimitrieva and Schmidt-Kessen, 2019). We demonstrate this alignment process in Figure 2.

Capitalizing on the functionalities of smart contracts, suppliers can significantly increase the velocity of transactions, benefit from disintermediation, achieve shortened payment cycles and obtain a better understanding of customers' needs. Customers, in turn, might also be better served and incentivized by better targeting and more timely deployment of discount offers and service improvements. The costless and rapid verification capabilities offered by BCs can serve

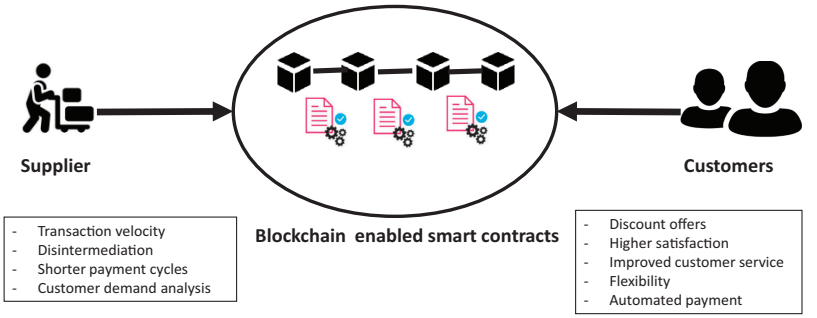

Figure 2.
Incentive alignment under blockchain-enabled smart contracts

as a motive for key SC actors (e.g. certification authorities) to rely on these technologies in their accreditation and auditing. One of the simplest ways of showing these benefits is through transparency of the BC ledger membership.

The firms involved in the BC ecosystem are subject to increased levels of controls for ensuring the authenticity of their products and validation of claims; this is especially the case for credence claims, which are unobservable and unverifiable by consumers at the point of purchase (such as Organic, Non-GMO, Halal and Kosher) (Rejeb *et al.*, 2019). In support of such claims, BC aggregates and optimizes the efforts of all actors in the chain and helps to reduce the risk of fraudulent practices. AdChain is one BC protocol that typifies what network partners are doing to align their incentives to maintain a universally decentralized whitelist for nonfraudulent publishers (Ismail and El-Yagoubi, 2018). In AdChain's transactional scheme, network participants are offered more ad value and better campaign outcomes through cryptographically secure impression tracking processes provided by the network (Epstein, 2017).

Collaborative communication

Communication between SC exchange partners is considered to be the backbone of organizational continuity (Galaskiewicz, 2011). Nevertheless, the communication gap between businesses is widening due to SC fragmentation, increased cross-border activities and suboptimal coordination.

Communication between SC stakeholders is often plagued by inefficiencies, disparate data, misunderstandings and siloed business processes (Muzzy, 2018). Advocates of BC assert it will expand opportunities for information exchange among SC exchange partners by reducing the reliance on intermediaries and, consequently, reducing the distortions and noise associated with intermediary conduits of information (Pisa and Juden, 2017).

When the extended SC exchange partners share B2B data and information, beyond just one level up and one level down, it enhances SC transparency and facilitates improved traceability and the ability to track, trace and recall unsafe products rapidly (Sodhi and Tang, 2019; Hastig and Sodhi, 2020). BC fosters direct interactions between businesses and avoids the necessity of routing communications or sharing files through centralized digital platforms (Di Gregorio *et al.*, 2017). Moreover, achieving a shared understanding of the data first (e.g. structured to comply with GS1 standards) entails the cleaning, validating and structuring of the data to be shared, which is an unintended but significant benefit of implementing BC.

Permissioned BCs (i.e. private and consortium-based) are considered the most suitable for SC applications since access and permissions are restricted to the network members only. Despite being closed and centralized (contrary to the original intentions of decentralized BCs), permissioned BCs imply a controlled and effective collaborative environment. Permissioned BC also provides just-in-time infrastructure for customized networks. In addition to enabling the interaction of humans in SC data curation; BC commands an unprecedented capability for machine-to-machine communication from interconnected devices, interacting securely and autonomously in modern SCs.

BC simplifies business relations and removes friction in communication between business partners, thus allowing them to communicate directly without the need for a trusted third-party (Kharlamov and Parry, 2018). The high speed of communication and agility encountered with BC technologies improves operational efficiencies and sets the scene for the widespread emergence of flattened organizational hierarchies, where responsiveness and flexibility are the most prized outcomes for SC exchange partners.

Joint knowledge creation

Joint knowledge creation refers to the degree to which SC exchange partners collaborate in the production and sharing of process and market knowledge in order to develop a better

understanding of the competitive environment (Malhotra *et al.*, 2005). In creating and sharing knowledge, SC partners commonly rely on online platforms that facilitate the creation and dissemination of knowledge.

Some of these online platforms promote a centralized approach (Wu *et al.*, 2015); cloud platforms are also a problematic medium for sharing knowledge because they require organizations to trust third-parties with the management of their IT resources and data (Shimba, 2010). They also pose an increased risk related to the exposure via an intermediary of business-critical information or trade secrets and an increased likelihood of breaches of privacy policies (Li *et al.*, 2018).

To address these issues, the use of the decentralized and distributed technology of BCs holds promise for secure and high-level knowledge co-creation and sharing throughout the SC. Knowledge in BC networks can be presented in the form of data blocks, broadcasted to the involved nodes of the distributed network for approval and validation, and shared among peers (Li *et al.*, 2018). This knowledge might involve the competencies necessary for the design and co-creation of products and solutions across the value chain or tools to spur innovations (e.g. mutual usage of skills and expertise).

BC implementations are built upon the premise of promoting a corporate culture that encourages continuous learning and fosters innovation (Chowdhury and Lishman, 2018). Collaboration in a decentralized organizational system is enabled, permitting participating parties to understand the dynamics of the business environment and implement best working practices and richest knowledge sharing within and across partnered organizations. Lastly, BC supports firms in the creation of value through harnessing data to improve decision-making within SCs (Baryannis *et al.*, 2019).

Figure 3 summarizes the seven collaboration dimensions from Cao *et al.* (2010), as discussed above, and demonstrates the potential impact of BC technologies on each collaborative dimension.

Discussion and implications

In this paper, we derive a conceptual framework based on the existing literature which highlights the potential benefits provided by BC-based SCC. Such collaborations feature critical accounting qualities of information assurance, data and information provenance and auditability. This framework fills existing research gaps and advances the understanding of BC implications on the various dimensions of SCC, and we have discussed numerous collaborative practices and applications facilitated by BC solutions in SC contexts. We argue for customization and the inclusion of just-in-time attributes in BC networks, affording a wider, more adaptable range of private, ad hoc and task-specific BC solutions to be derived and deployed in SC contexts.

Managerial implications

The architecture of BC supports secure and decentralized information sharing by removing intermediaries, reducing information asymmetries and enhancing information integrity. A considerable body of the literature has emphasized the benefits of BC for ensuring seamless coordination of information flows within the SC (Pan *et al.*, 2019; Zelbst *et al.*, 2019). Due to the dynamically changing business environment and increasingly fierce market competition (Garg and Goyal, 2012), collaboration in SC partnerships is challenging. By using BC, the ability of firms to integrate and manage information can be significantly strengthened, resulting in more effective collaboration among SC partners. Managerial practitioners can call on the sophisticated applications and capabilities of BC to create an effective platform for information sharing as well as for data analysis in support of logistics coordination, and even to plan for emerging market trends.

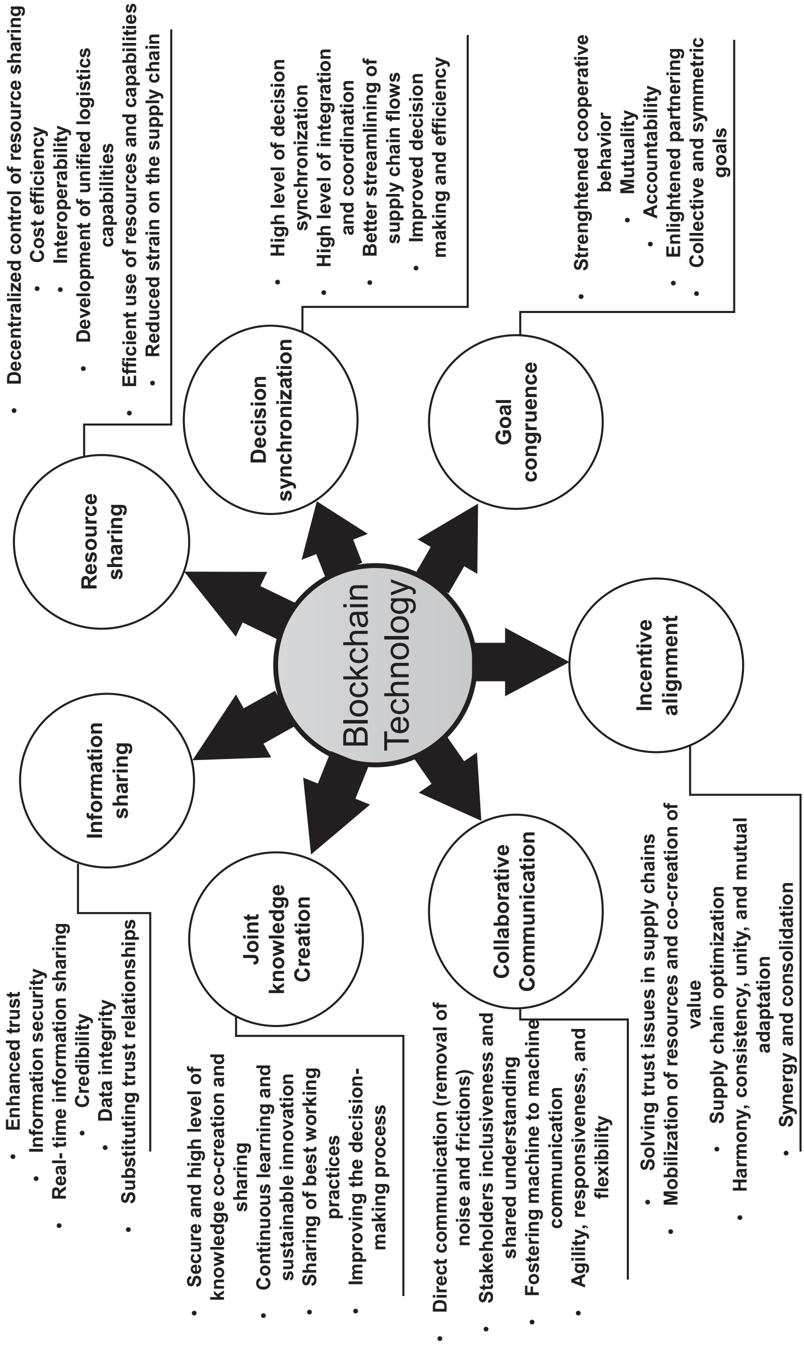

Figure 3.
Framework for blockchain potentials for supply chain collaboration

Securing data in the knowledge economy: In the knowledge economy, firms rely on data exchanges and information sharing; BC facilitates such exchanges through the mechanism of trusted networked collaboration. The decentralization and security of BC contribute to the coherency and consistency of information, increased cooperation and diffusion of quality information across organizational boundaries. BC protects organizations against specific threats to confidential information leakage by facilitating fully interactive SC operations without risking disclosure of proprietary and sensitive business information beyond the parties necessary to a given transaction (Ying *et al.*, 2018). To that end, BC redefines trust in B2B relationships (Xia and Yongjun, 2017) by altering the fundamental building blocks of SCC – a process we graphically illustrate in Figure 3.

By sharing a broad range of resources such as equipment, energy and warehouse space via BC, collaborating firms can reduce the costly reliance on their internal resources and enhance their capabilities to cope quickly with increasing SC uncertainties and to expand their capacity to meet customer demands. A peer-to-peer (P2P) resource sharing structure enabled by BC can generate benefits such as SC cost reduction, economies of scale and the development of well-established means of improving operational efficiencies.

Enhancing collaborative models: This study suggests that BC-based collaborative models can provide firms with the necessary tools to optimize their SC decisions across a variety of business interactions and make well-informed decisions regarding the allocation of SC resources and the control of production, distribution and inventory processes in a multi-tier SC (Manupati *et al.*, 2020). The increased visibility of BC transactions is critical for improving the management of inter-firm cooperation, organizational processes and the adaptability of SCs to new market conditions (Hald and Kinra, 2019). For decision synchronization, firms can use BC as a useful decision-making tool which can consolidate information among SC partners, integrate their business units, streamline their operational processes and, subsequently, contribute to better decisions, SC adaptability, flexibility and responsiveness.

Enhancing relational exchange in the SC: The literature has provided valuable insights into the possibilities of BC for the promotion of goal congruence and the reduction of relational risks such as opportunistic behavior (Schmidt and Wagner, 2019) as well as cheating and information distortion (Kshetri, 2018). In view of BC's ability to enhance trust in collaborative relationships (Fawcett and Magnan, 2002), protection is provided against the exploitation of transaction-specific assets. With BC, the management of SC opportunism is an easy task because of the high visibility for forecasting, planning, product development and production scheduling information supplied by the network. These serve to reduce SC opacity and lower the incentives of trading partners to behave opportunistically in the absence of full and complete information (Dyer, 1997).

When firms engage in collaborative relationships, they are more likely to face uncertainties due to their dependence on trading partners and the inevitable sharing of costs and risks. To alleviate these concerns, managers can use BC to restructure their collaborative arrangements through the development of incentive schemes, wherein potential power imbalances in the SC are minimized (Pan *et al.*, 2019).

In practice, many firms fail to recognize the importance of incentive alignment and make decisions considering only local rewards and penalties (Simatupang and Sridharan, 2002). To align incentives among SC partners, firms can use BC to reduce incentive misalignment through the design of contractual mechanisms which protect the company while assuring partners of performance through facilitating transparency, traceability and authenticity of information within global SC networks (Helo and Shamsuzzoha, 2020). The alignment of partnership incentives changes over time (Narayanan and Raman, 2004), but BC can help trading partners to mitigate misalignment through the implementation of smart contracts. Companies can integrate these contracts in BC to support continuous process improvement

and automation, organize various financial arrangements (Saberi *et al.*, 2019), increase transparency and allow SC partners to balance their rewards and penalties.

Enhancing communications between partners: Our study suggests that BC can foster fruitful communication among SC entities, sparking more effective approaches to developing workable SC solutions and strategies. There is an increasing realization in the literature that BC is a driving force for enhanced collaborative communication and the attainment of better decisions (Zelbst *et al.*, 2019).

Companies striving to make their communication systems compatible with their SC partners often find that BC can serve as a common platform for all stakeholders, enabling interactive, real-time and optimal communication between SC parties. A further point of consideration is that BC offers the potential for frictionless machine-to-machine (M2M) interaction without any human intervention, such that much of the transactional minutiae in SC interactions can be automated. In this way, firms can transact dynamically, initiate business processes with other systems, trigger automatic events across collaborative platforms and gain increased control over their industrial processes.

For managers, BC can be an innovative approach to expand knowledge lacking in-house, ameliorate their joint knowledge creation and sharing routines, invigorate innovative practices, promote the sharing of new ideas and encourage improvement initiatives. Therefore, the generation of collective knowledge among SC partners can be a powerful tool to disseminate new ideas, motivate the joint development of products and drive new improvement initiatives.

In summary, our proposed framework provides specific guidance and insights into how firms can use BC to enhance their collaborative practices and maintain competitiveness in globally interconnected SCs. Thus, we believe that this framework can better inform operations and SC managers on the benefits of BC implementation for SCC. The more managerial power associated with BC the higher is the ability of managers to profit from information richness, improve the quality of their decisions, align the goals of the different parties within the SC, reduce incentive misalignment, streamline collaborative communication and improve the firms' capacity to create knowledge and facilitate joint innovation. Thus, managers can leverage BC to devise much-needed strategies for sustainable and successful relationships with their SC exchange partners.

Theoretical implications

Recent studies on BC have either focused on business process modeling or the technology design process of BC-based solutions (Pan *et al.*, 2019), or they have investigated enablers of BC for achieving sustainable SC performance (Hald and Kinra, 2019). A thorough analysis of the theoretical implications of BC on SCC has been missing from the literature, so far. This study begins that process.

Drawing on a seminal study by Cao *et al.* (2010), we proposed a framework for BC potentials for SCC. This framework is an initial attempt to advance the understanding of BC from a relational perspective by creatively synthesizing ideas, developing relationships between the foundational dimensions of SCC and the technology and by closing a previously unaddressed research gap.

An integrative framework: In our work, we respond to the issue of the lack of a comprehensive and integrative framework to understand BC characteristics and their impact on transaction partners in modern SCs facing operations and SCM scholars. In future research, the relative magnitude of BC's impact on collaborative practices among firms should be empirically investigated. From a theoretical standpoint, the proposed framework is vital to advancing a theory of virtual collaboration in the SC (Narayanan *et al.*, 2009).

There is general consensus that the lack of information sharing is a fundamental cause for the failure of business relationships (Elmuti, 2002). To mitigate this issue, BC permits firms to

cultivate improvements in SC transparency, secure information sharing and establish confidence (Wang *et al.*, 2019). The security and transparency generated by BC is attractive to adopters in industry because the technology is expected to improve SC efficiencies for all parties to the network. However, privacy issues such as leakage of business and trade secrets remain of some concern and form the basis for fruitful further investigation (Feng *et al.*, 2019). BC provides data security and privacy through encryption, but concerns over the information policies which identify how much and what type of information is shared are still largely unexamined in inter-organizational collaboration research (Kouhizadeh *et al.*, 2021).

A thorough understanding of the factors influencing organizational predispositions to share information via BC is also a crucial area for future research. Our framework stipulates that trust is a primary driver for BC adoption within SCM (Longo *et al.*, 2019; Wang *et al.*, 2018; Queiroz *et al.*, 2020), and we know that trust can be established in BC-based collaborations because systems are decentralized, eliminating the need for assessing the trustworthiness of intermediaries and other participants involved in the network (Kumar *et al.*, 2021). Therefore, our framework can be used to guide investigations of SCC from the lens of socio-political theory, which insists that trust and power are the key factors influencing collaboration between organizations (Reve and Stern, 1986).

Resource sharing: BC unlocks the potential of the sharing economy and presents new opportunities for coordinating the exchange of resources among collaborators. From a resource-based view (RBV) perspective, these resources may comprise a wide range of physical assets such as manufacturing equipment and facilities, as well as the more intangible elements of services and technology (Harland *et al.*, 2004). We believe that BC can increase the availability of these resources between virtual partners beyond organizational boundaries. Consistent with the RBV and transaction cost theories (Grant, 1991; Williamson, 1993), it is anticipated that the adoption and diffusion of BC can optimize a firm's internal resources and integrate its business operations with exchange partners at higher efficiency and lower transaction costs. Thus, there is a chance for researchers to extend the focus of these theories in the BC context, from the organizational resource use perspective to the inter-organizational cooperation and resource sharing view.

Besides securing data storage and sharing, BC can assist in synchronizing data, coordinating processes and integrating functions. A wide array of SC use cases are documented underscoring the value of BC in driving better operational and competitive performance. This poses another important step in the development of a digital SC, which itself can be seen as a constituent of the "Industry 4.0" phenomenon (Queiroz *et al.*, 2019).

Traceability: BC facilitates SC traceability, which can lead to the elimination of the paperwork that is often utilized for such verification purposes. Such digitization can increase consumers' and investors' trust in firms, while also serving to provide for better monitoring of suppliers and the facilitation of documentation for regulatory compliance (Sodhi and Tang, 2019). In attaining these objectives, BC lays the foundation for sound collaborative relationships and helps to align the incentives of SC exchange partners and create synergy among them while reducing agency risks through real-time monitoring of the supplier's operational data. This, in turn, can support better usage of underutilized network resources, sharing of scarce skills and competencies, fostering communication and co-creating knowledge.

Avenues for future theorization: Diverse theories can be encapsulated in the variables of the proffered framework in order to further explicate the impact of BC on the various dimensions of SCC. Some of the obvious applications for the framework include consideration of stakeholder theory, resource dependence theory, signaling theory, collaboration theory and learning and knowledge theory. The framework, then, can invoke new insights and advance the conceptual base of BC research within the SCC literature.

The use of BC can potentially strengthen the power of users vis-à-vis institutions; meanwhile, it shifts the risk to the users (Lenz, 2019). Collaborating partners have diverse and

often conflicting interests and goals; therefore, researchers should attempt to identify the relative importance of stakeholders in relation to each other and their roles in different BC-enabled SC settings.

Consideration of the BC alternative will also stimulate changes in current trust-based theories in SCM (Saberi *et al.*, 2019). While empirical academic research in this field is scarce, some data are already available that confirm the relevance of BC for the SC, and our framework encapsulates key perspectives for consideration in leveraging the study of the phenomena going forward. Using data from international nongovernmental organizations, Dubey *et al.* (2020) illustrate that BC positively impacts collaboration and SC resilience via swift trust as a mediating factor; the electronic and immutable aspects of BC networks lead to situations in which trust is "built in," as an aspect of the easy auditability embedded in the associated general ledger. Table 1 summarizes the implications of our study both from a managerial and theoretical perspective.

Conclusion, limitations and further research

One potential limitation of this paper is that we exclusively focus on the potentials of BC, as envisioned by the authors of the papers that we analyzed. Depending on the characteristics of future implementations, adverse side effects may arise, which also deserve further attention. For example, apart from potential technical problems, implementing new collaboration technologies may introduce shifts in interorganizational power structures, as was evidenced in the slow initial adoption of TradeLens, a BC joint venture created by shipping giant Maersk and IBM. This lack of adoption was allegedly caused by Maersk being an owner of the joint venture and therefore self-interestedly benefitting from its growth (Tinianow, 2018).

	Main implications	
Managerial	(1)	BC provides a more secure, efficient and flexible information flow among exchange partners
	(2)	BC can help managers to structure their SC exchange relationships, promoting more trust, reciprocation and efficient resource exchanges among organizations
	(3)	SC partners can use BC to improve cooperation, make well-informed decisions and to seamlessly integrate operational processes
	(4)	BC has the potential to enhance relational exchanges, instigating trust, commitment, accountability and alignment among SC partners
	(5)	Organizations can use BC to develop an environment that encourages open communication and fosters coordination capabilities, synchronous operations, knowledge sharing and innovativeness
Theoretical	(1)	BC can substantially transform SCC
	(2)	This study provides a better understanding regarding the role of BC to reconfigure SCC and to ensure more direct, smooth and timely communication between exchange partners
	(3)	The findings of the study extend the rapidly growing body of knowledge regarding BC, enriching the literature with an integrative framework for identifying the potentials of the technology for SCC
	(4)	This study contributes to the prevailing theories of SCC and suggests moving beyond the firm-supplier dyad to involve all potential stakeholders in the BC ecosystem
	(5)	BC can extend firm capabilities to improve integration, synchronization, resource sharing, traceability and overall digitization strategies
	(6)	From a theoretical view, this study makes a substantial contribution to the BC literature, suggesting a move beyond the narrow focus of some well-established theories (e.g. transaction cost theory) to theories better explaining collaborative relationships between SC partners using BCs (e.g. relational view theory, learning and knowledge theory and signaling theory)

Table 1.
Summary of study implications

Potential risks for new fraud opportunities arising from the unique nature of the implementation and consideration of crucial aspects such as algorithms need further consideration from a forensic accounting and auditing perspective. Furthermore, it should be noted that there is a growing concern in the literature on food SCs that further research is required on "mutable" BCs to match system functionality with the business reality of food chain "shrinkage" where damaged, spoiled or stolen food might require transactional adjustments to match the reality of the business model.

Common issues such as industry collusion (e.g. price-fixing or dual-quality products) and supplier agency issues (e.g. bribery, corruption, deforestation and slave labor) cannot be detected by use of a BC alone. Further research is needed to understand where vulnerabilities exist in SCs and when human interaction can result in false data being "locked in as an immutable lie" in a BC. Further research is also needed to explore where evolving technologies such as artificial intelligence, machine learning, big data and predictive analytics can complement BCs and add value in exchange party relationships.

In conclusion, BC has the potential to influence how businesses collaborate in SC exchange relationships, thus impacting how they execute transactions, and permitting them to create shared value across global SCs. More research is needed to refine the perspective of BC-enabled SCCs and to investigate how it interacts with other drivers of SC and organizational performance, such as big data and predictive analytics (Dubey *et al.*, 2018; Gunasekaran *et al.*, 2017). In recognition of vast potential benefits, the first step is taken here in suggesting BC as a collaboration-supporting framework for SC accountability and the enhancing of trust and transparency between SC exchange partners. In particular, customized, just-in-time BCs can extend the range of applications that can be supported with security, privacy, access control and transparency. The role of BC in impacting SCC and operational performance raises intriguing questions for future logistics implementations in the channels and for critical aspects of accounting support for such ventures.

References

Arnold, V., Benford, T.S., Hampton, C. and Sutton, S.G. (2014), "Enterprise risk management: Re-conceptualizing the role of risk and trust on information sharing in transnational alliances", *Journal of Information Systems*, Vol. 28 No. 2, pp. 257-285.

Bai, C. and Sarkis, J. (2020), "A supply chain transparency and sustainability technology appraisal model for blockchain technology", *International Journal of Production Research*, Vol. 58 No. 7, pp. 2142-2162.

Baihaqi, I. and Sohal, A.S. (2013), "The impact of information sharing in supply chains on organisational performance: an empirical study", *Production Planning and Control*, Vol. 24 Nos 8–9, pp. 743-758.

Baker, W., Smith, G. and Watson, K. (2007), "Information security risk in the e-supply chain", in Qingyu, Z. (Ed.), *E-Supply Chain Technologies and Management*, Hershey, London, pp. 142-161.

Baryannis, G., Validi, S., Dani, S. and Antoniou, G. (2019), "Supply chain risk management and artificial intelligence: state of the art and future research directions", *International Journal of Production Research*, Vol. 57 No. 7, pp. 2179-2202.

Bergen, M., Dutta, S. and Walker, O.C. Jr (1992), "Agency relationships in marketing: a review of the implications and applications of agency and related theories", *Journal of Marketing*, Vol. 56 No. 3, pp. 1-24.

Bosse, D.A. and Phillips, R.A. (2016), "Agency theory and bounded self-interest", *Academy of Management Review*, Vol. 41 No. 2, pp. 276-297.

Cao, M. and Zhang, Q. (2011), "Supply chain collaboration: impact on collaborative advantage and firm performance", *Journal of Operations Management*, Vol. 29 No. 3, pp. 163-180.

Cao, M., Vonderembse, M.A., Zhang, Q. and Ragu-Nathan, T.S. (2010), "Supply chain collaboration: conceptualisation and instrument development", *International Journal of Production Research*, Vol. 48 No. 22, pp. 6613-6635.

Carrus, P.P. and Pinna, R. (2011), "Information technology and supply chain management coordination: the role of third party logistics providers", *International Journal of E-Services and Mobile Applications*, Vol. 3, pp. 21-36.

Choi, H.R., Cho, M.J., Lee, K., Hong, S.G. and Woo, C.R. (2014), "The business model for the sharing economy between SMEs", *WSEAS Transactions on Business and Economics*, Vol. 11 No. 1, pp. 625-634.

Chowdhury, M. and Lishman, R. (2018), "The blockchain high of cannabis supply chains", *Pi Lab Research Brief, Productivity and Innovation Lab*, Niagara College Canada, pp. 1-14.

Cole, R., Stevenson, M. and Aitken, J. (2019), "Blockchain technology: implications for operations and supply chain management", *Supply Chain Management: An International Journal*, Vol. 24 No. 4, pp. 469-483.

Connelly, B.L., Ketchen, D.J. and Hult, G.T.M. (2013), "Global supply chain management: toward a theoretically driven research agenda", *Global Strategy Journal*, Vol. 3 No. 3, pp. 227-243.

Cui, Y. and Idota, H. (2018), "Improving supply chain resilience with establishing a decentralized information sharing mechanism", *ACM International Conference Proceeding Series*, pp. 1-7.

Dai, J. and Vasarhelyi, M.A. (2017), "Toward Blockchain-based accounting and assurance", *Journal of Information Systems*, Vol. 31 No. 3, pp. 5-21.

Di Gregorio, R., Nustad, S.S. and Constantiou, I. (2017), *Blockchain Adoption in the Shipping Industry*, Copenhagen Business School, Copenhagen.

Dobrovnik, M., Herold, D., Fürst, E. and Kummer, S. (2018), "Blockchain for and in logistics: what to adopt and where to start", *Logistics*, Vol. 2 No. 3, p. 18.

Dolgui, A., Ivanov, D., Potryasaev, S., Sokolov, B., Ivanova, M. and Werner, F. (2020), "Blockchain-oriented dynamic modelling of smart contract design and execution in the supply chain", *International Journal of Production Research*, Taylor & Francis, Vol. 58 No. 7, pp. 2184-2199.

Dubey, R., Luo, Z., Gunasekaran, A., Akter, S., Hazen, B.T. and Douglas, M.A. (2018), "Big data and predictive analytics in humanitarian supply chains", *International Journal of Logistics Management*, Vol. 29 No. 2, pp. 485-512.

Dubey, R., Gunasekaran, A., Bryde, D.J., Dwivedi, Y.K. and Papadopoulos, T. (2020), "Blockchain technology for enhancing swift-trust, collaboration and resilience within a humanitarian supply chain setting", *International Journal of Production Research*, Vol. 58 No. 11, pp. 3381-3398.

Dyer, J.H. (1997), "Effective interim collaboration: how firms minimize transaction costs and maximise transaction value", *Strategic Management Journal*, Vol. 18 No. 7, pp. 535-556.

Eenmaa-Dimitrieva, H. and Schmidt-Kessen, M.J. (2019), "Creating markets in no-trust environments: the law and economics of smart contracts", *Computer Law and Security Review*, Vol. 35 No. 1, pp. 69-88.

Elmuti, D. (2002), "The perceived impact of supply chain management on organizational effectiveness", *Journal of Supply Chain Management*, Vol. 38 No. 2, pp. 49-57.

Epstein, J. (2017), *Blockchain and the CMO: The Next Era of Marketing*, White Paper, Blockchain Research Institute, Toronto, pp. 1-50.

Fawcett, S.E. and Magnan, G.M. (2002), "The rhetoric and reality of supply chain integration", *International Journal of Physical Distribution and Logistics Management*, Vol. 32 No. 5, pp. 339-361.

Feng, Q., He, D., Zeadally, S., Khan, M.K. and Kumar, N. (2019), "A survey on privacy protection in blockchain system", *Journal of Network and Computer Applications*, Vol. 126, pp. 45-58.

Ferrari, R. (2015), "Writing narrative style literature reviews", *Medical Writing*, Vol. 24 No. 4, pp. 230-235.

Galaskiewicz, J. (2011), "Studying supply chains from a social network perspective", *Journal of Supply Chain Management*, Vol. 47 No. 1, pp. 4-8.

Garg, A. and Goyal, D.P. (2012), "Striving towards strategic alignment in SMEs: an empirical analysis", *Journal of Advances in Management Research*, Emerald Group Publishing, Vol. 9 No. 1, pp. 77-95.

Ghosh, D. and Tan, W.K. (2018), *A Framework for Implementing Blockchain Technologies to Improve Supply Chain Performance*, Working Paper Series, SCALE, pp. 1-24.

Goodman, P.S. and Darr, E.D. (1998), "Computer-aided systems and communities: mechanisms for organizational learning in distributed environments", *MIS Quarterly*, Vol. 22 No. 4, pp. 417-440.

Grant, R.M. (1991), "The resource-based theory of competitive advantage: implications for strategy formulation", *California Management Review*, SAGE Publications, Vol. 33 No. 3, pp. 114-135.

Gunasekaran, A., Papadopoulos, T., Dubey, R., Wamba, S.F., Childe, S.J., Hazen, B. and Akter, S. (2017), "Big data and predictive analytics for supply chain and organizational performance", *Journal of Business Research*, Vol. 70, pp. 308-317.

Hald, K.S. and Kinra, A. (2019), "How the blockchain enables and constrains supply chain performance", *International Journal of Physical Distribution and Logistics Management*, Vol. 49 No. 4, pp. 376-397.

Harland, C., Zheng, J., Johnsen, T. and Lamming, R. (2004), "A conceptual model for researching the creation and operation of supply networks", *British Journal of Management*, Vol. 15 No. 1, pp. 1-21.

Hastig, G.M. and Sodhi, M.S. (2020), "Blockchain for supply chain traceability: business requirements and critical success factors", *Production and Operations Management*, Vol. 29 No. 4, pp. 935-954.

Helo, P. and Shamsuzzoha, A.H.M. (2020), "Real-time supply chain—a blockchain architecture for project deliveries", *Robotics and Computer-Integrated Manufacturing*, Vol. 63, p. 101909.

Hofstede, G.J. (2003), "Transparency in netchains", in Harnos, Z., Herdon, M. and Wiwczaroski, T.B. (Eds), *Information Technology for a Better Agri-Food Sector, Environment and Rural Living*, Debrecen University, Debrecen, pp. 17-29.

Hong, Y., Jaideep, V. and Wang, S. (2014), "A survey of privacy-aware supply chain collaboration: from theory to applications", *Journal of Information Systems*, Vol. 28 No. 1, pp. 243-268.

Ismail, A. and El-Yagoubi, F. (2018), "The verified ad protocol", White Paper, available at: https://www.varanida.com/wp-content/uploads/2018/04/varanida.pdf (accessed 15 March 2019).

Kamble, S., Gunasekaran, A. and Arha, H. (2019), "Understanding the Blockchain technology adoption in supply chains-Indian context", *International Journal of Production Research*, Taylor & Francis, Vol. 57 No. 7, pp. 2009-2033.

Ketchen, D.J. and Giunipero, L.C. (2004), "The intersection of strategic management and supply chain management", *Industrial Marketing Management*, Vol. 33, pp. 51-56.

Kharlamov, A. and Parry, G. (2018), "Advanced supply chains: visibility, blockchain and human behaviour", in Moreira, A., Ferreira, L. and Zimmerman, R. (Eds), *Innovation and Supply Chain Management: Relationship, Collaboration and Strategies*, Springer, Cham, pp. 321-343.

Kim, H.M. and Laskowski, M. (2018), "Toward an ontology-driven Blockchain design for supply chain provenance", *Intelligent Systems in Accounting, Finance and Management*, Vol. 25 No. 1, pp. 18-27.

Koh, E.B., Oh, J. and Im, C. (2014), "A study on security threats and dynamic access control technology for BYOD, smart-work environment", *Proceedings of the International MultiConference of Engineers and Computer Scientists*, Vol. 2, pp. 1-6.

Kokina, J., Mancha, R. and Pachamanova, D. (2017), "Blockchain: emergent industry adoption and implications for accounting", *Journal of Emerging Technologies in Accounting*, Vol. 14 No. 2, pp. 91-100.

Korpela, K., Hallikas, J. and Dahlberg, T. (2017). "Digital supply chain transformation toward Blockchain integration", *Proceedings of the 50th Hawaii International Conference on System Sciences,* pp. 4182-4191.

Kouhizadeh, M. and Sarkis, J. (2018), "Blockchain practices, potentials, and perspectives in greening supply chains", *Sustainability*, Vol. 10 No. 10, p. 3652.

Kouhizadeh, M., Saberi, S. and Sarkis, J. (2021), "Blockchain technology and the sustainable supply chain: theoretically exploring adoption barriers", *International Journal of Production Economics*, Vol. 231, 107831.

Kshetri, N. (2018), "Blockchain's roles in meeting key supply chain management objectives", *International Journal of Information Management*, Vol. 39, pp. 80-89.

Kumar, G. and Banerjee, R.N. (2012), "An implementation strategy for collaboration in supply chain: an investigation and suggestions", *International Journal of Services and Operations Management*, Vol. 11 No. 4, pp. 407-427.

Kumar, V., Ramachandran, D. and Kumar, B. (2021), "Influence of new-age technologies on marketing: a research agenda", *Journal of Business Research*, Vol. 125, pp. 864-877, doi: 10.1016/j.jbusres.2020.01.007.

Lenz, R. (2019), *Managing Distributed Ledgers: Blockchain and beyond*, SSRN Scholarly Paper No. ID 3360655, Social Science Research Network, Rochester, NY, doi: 10.2139/ssrn.3360655.

Lessig, L. (2008), *Remix: Making Art and Commerce Thrive in the Hybrid Economy*, Bloomsbury Publishing plc, London.

Li, Z., Wang, W.M., Liu, G., Liu, L., He, J. and Huang, G.Q. (2018), "Toward open manufacturing: a cross-enterprises knowledge and services exchange framework based on blockchain and edge computing", *Industrial Management and Data Systems*, Vol. 118 No. 1, pp. 303-320.

Longo, F., Nicoletti, L., Padovano, A., d'Atri, G. and Forte, M. (2019), "Blockchain-enabled supply chain: an experimental study", *Computers and Industrial Engineering*, Vol. 136, pp. 57-69.

Lotfi, Z., Sahran, S., Mukhtar, M. and Zadeh, A.T. (2013), "The relationships between supply chain integration and product quality", *Procedia Technology*, Vol. 11, pp. 471-478.

Lu, Q., Goh, M. and De Souza, R. (2018), "An empirical investigation of swift trust in humanitarian logistics operations", *Journal of Humanitarian Logistics and Supply Chain Management*, Vol. 8 No. 1, pp. 70-86.

Malhotra, A., Gosain, S. and El Sawy, O.A. (2005), "Absorptive capacity configurations in supply chains: gearing for partner-enabled market knowledge creation", *MIS Quarterly*, Vol. 29 No. 1, pp. 145-187.

Manupati, V.K., Schoenherr, T., Ramkumar, M., Wagner, S.M., Pabba, S.K. and Singh, R.I.R. (2020), "A blockchain-based approach for a multi-echelon sustainable supply chain", *International Journal of Production Research*, Taylor & Francis, Vol. 58 No. 7, pp. 2222-2241.

Mayring, P. (2000), "Qualitative content analysis", *Forum: Qualitative Social Research*, Vol. 1 No. 2, doi: 10.17169/fqs-1.2.1089 (accessed 17 July 2020).

Mougayar, W. (2016), *The Business Blockchain*, Wiley, Hoboken, New Jersey, NJ.

Muzzy, E. (2018), "Ondiflo: 'blockchain for oil and gas'", available at: https://media.consensys.net/ondiflo-blockchain-for-oil-and-gas-9de5e01cd680 (accessed 3 January 2020).

Nakamoto, S. (2008), "Bitcoin: a peer-to-peer electronic cash system, white paper", available at: https://bitcoin.org/bitcoin.pdf (accessed 17 June 2017).

Nakasumi, M. (2017), "Information sharing for supply chain management based on block chain technology", *Proceedings of the 19th Conference on Business Informatics, CBI 2017*, Vol. 1, pp. 140-149.

Narayanan, A. and Clark, J. (2017), "Bitcoin's academic pedigree", *ACM Queue*, Vol. 15 No. 4, pp. 1-30.

Narayanan, V.G. and Raman, A. (2004), "Aligning incentives in supply chains", *Harvard Business Review*, Vol. 82 No. 11, pp. 94-103.

Narayanan, S., Marucheck, A.S. and Handfield, R.B. (2009), "Electronic data Interchange: research review and future directions", *Decision Sciences*, Vol. 40 No. 1, pp. 121-163.

Newman, R., Chang, V., Walters, R.J. and Wills, G.B. (2016), "Model and experimental development for business data science", *International Journal of Information Management*, Vol. 36 No. 4, pp. 607-617.

Omran, Y., Henke, M., Heines, R. and Hofmann, E. (2017), "Blockchain-driven supply chain finance: towards a conceptual framework from a buyer perspective", *Proceedings of the IPSERA 2017*, Budapest, pp. 1-15.

Pan, X., Pan, X., Song, M., Ai, B. and Ming, Y. (2019), "Blockchain technology and enterprise operational capabilities: an empirical test", *International Journal of Information Management*, Vol. 52 June, 101946.

Panayides, P.M. and Venus Lun, Y.H. (2009), "The impact of trust on innovativeness and supply chain performance", *International Journal of Production Economics*, Vol. 122 No. 1, pp. 35-46.

Park, G., Shin, S.R. and Choy, M. (2020), "Early mover (dis)advantages and knowledge spillover effects on blockchain startups' funding and innovation performance", *Journal of Business Research*, Vol. 109, pp. 64-75.

Pisa, M. and Juden, M. (2017), *Blockchain and Economic Development : Hype vs. Reality*, Policy Paper, Center for Global Development, Vol. 107, pp. 1-49.

Power, D.J., Sohal, A.S. and Rahman, S. (2001), "Critical success factors in agile supply chain management - an empirical study", *International Journal of Physical Distribution and Logistics Management*, Vol. 31 No. 4, pp. 247-265.

Queiroz, M.M., Pereira, S.C.F., Telles, R. and Machado, M.C. (2019), "Industry 4.0 and digital supply chain capabilities: a framework for understanding digitalisation challenges and opportunities", *Benchmarking: An International Journal*. doi: 10.1108/BIJ-12-2018-0435.

Queiroz, M.M., Wamba, S.F., De Bourmont, M. and Telles, R. (2020), "Blockchain adoption in operations and supply chain management: empirical evidence from an emerging economy", *International Journal of Production Research*. doi: 10.1080/00207543.2020.1803511.

Rechtman, Y. (2017), "Blockchain: the making of a simple, secure recording concept", *CPA Journal*, June 2017 issue, available at: https://www.cpajournal.com/2017/07/14/blockchain-making-simple-secure-recording-concept/ (accessed 15 March 2019).

Rejeb, A., Keogh, J.G. and Treiblmaier, H. (2019), "Leveraging the Internet of Things and blockchain technology in supply chain management", *Future Internet*, Vol. 11 No. 7, 161.

Reve, T. and Stern, L.W. (1986), "The relationship between interorganizational form, transaction climate, and economic performance in vertical interfirm dyads", in Pellegrini, L. and Reddy, S.K. (Eds), *Marketing Channels*, Lexington Books, Lexington, MA, pp. 75-102.

Risius, M. and Spohrer, K. (2017), "A blockchain research framework: what we (don't) know, where we go from here, and how we will get there", *Business and Information Systems Engineering*, Vol. 59 No. 6, pp. 385-409.

Saberi, S., Kouhizadeh, M., Sarkis, J. and Shen, L. (2019), "Blockchain technology and its relationships to sustainable supply chain management", *International Journal of Production Research*, Vol. 57 No. 7, pp. 2117-2135.

Schemm, J. and Legner, C. (2008), "Toward the inter-organizational product information supply chain–evidence from the retail and consumer goods industries", *Journal of the Association for Information Systems*, Vol. 9 No. 4, pp. 120-152.

Schmidt, C.G. and Wagner, S.M. (2019), "Blockchain and supply chain relations: a transaction cost theory perspective", *Journal of Purchasing and Supply Management*, Vol. 25 No. 4, pp. 1-13.

Shimba, F. (2010), *Cloud Computing: Strategies for Cloud Computing Adoption*, Masters Dissertation, Dublin Institute of Technology, Dublin, pp. 1-133.

Simatupang, T.M. and Sridharan, R. (2002), "The collaborative supply chain", *The International Journal of Logistics Management*, Vol. 13 No. 1, pp. 15-30.

Simatupang, T.M. and Sridharan, R. (2005), "An integrative framework for supply chain collaboration", *The International Journal of Logistics Management*, Vol. 16 No. 2, pp. 257-274.

Sodhi, M.S. and Tang, C.S. (2019), "Research opportunities in supply chain transparency", *Production and Operations Management*, Vol. 28 No. 12, pp. 2946-2959.

Stefansson, G. (2002), "Business-to-business data sharing: a source for integration of supply chains", *International Journal of Production Economics*, Vol. 75 Nos 1-2, pp. 135-146.

Stump, R.L. and Heide, J.B. (1996), "Controlling supplier opportunism in industrial relationships", *Journal of Marketing Research*, Vol. 33 No. 4, pp. 431-441.

Tapscott, D. and Tapscott, A. (2017), *Realizing the Potential of the Blockchain*, White Paper, World Economic Forum, Cologny/Geneva.

Tinianow, A. (2018), *How Maersk's Bad Business Model Is Breaking its Blockchain*, Forbes, available at: https://www.forbes.com/sites/andreatinianow/2018/10/30/how-maersks-bad-business-model-is-breaking-its-blockchain/ (accessed 28 June 2020).

Treiblmaier, H. (2018), "The impact of the blockchain on the supply chain: a theory-based research framework and a call for action", *Supply Chain Management: An International Journal*, Vol. 23 No. 6, pp. 545-559.

Treiblmaier, H. and Beck, R. (2019), *Business Transformation through Blockchain - Volume I*, Palgrave Macmillan, Cham.

Treiblmaier, H. and Clohessy, T. (2020), *Blockchain and Distributed Ledger Technology Use Cases: Applications and Lessons Learned*, Springer International Publishing, Cham.

van Engelenburg, S., Janssen, M. and Klievink, B. (2018), "A blockchain architecture for reducing the bullwhip effect", *Lecture Notes in Business Information Processing*, Vol. 319, pp. 69-82.

Wamba, S.F. and Guthrie, C. (2020), "The impact of blockchain adoption on competitive performance: the mediating role of process and relational innovation", *Logistique and Management*, Vol. 28 No. 1, pp. 88-96.

Wamba, S.F. and Queiroz, M.M. (2020), "Blockchain in the operations and supply chain management: benefits, challenges and future research opportunities", *International Journal of Information Management*, Vol. 52, 102064.

Wamba, S.F., Kamdjoug, K., Robert, J., Bawack, R. and Keogh, G.J. (2020a), "Bitcoin, Blockchain, and FinTech: a systematic review and case studies in the supply chain", *Production Planning and Control*, Vol. 31 Nos 2-3, pp. 115-142.

Wamba, S.F., Queiroz, M.M. and Trinchera, L. (2020b), "Dynamics between blockchain adoption determinants and supply chain performance: an empirical investigation", *International Journal of Production Economics*, Vol. 229, 107791.

Wang, Y., Hungh, H.J. and Paul, B.-D. (2018), "Understanding Blockchain technology for future supply chains a systematic literature Review and Research Agenda", *Supply Chain Management: An International Journal*, Vol. 24 No. 1, pp. 62-84.

Wang, Y., Singgih, M., Wang, J. and Rit, M. (2019), "Making sense of blockchain technology: how will it transform supply chains?", *International Journal of Production Economics*, Vol. 211, pp. 221-236.

Williamson, O.E. (1993), "Transaction cost economics and organization theory", *Industrial and Corporate Change*, Oxford Academic, Vol. 2 No. 2, pp. 107-156.

Wu, D., Rosen, D.W., Wang, L. and Schaefer, D. (2015), "Cloud-based design and manufacturing: a new paradigm in digital manufacturing and design innovation", *CAD Computer Aided Design*, Vol. 59, pp. 1-14.

Xia, J. and Yongjun, L. (2017), "Trust evaluation model for supply chain enterprises under blockchain environment", *7th International Conference on Social Network, Communication and Education (SNCE 2017)*, Atlantis Press, pp. 634-638.

Ying, W., Jia, S. and Du, W. (2018), "Digital enablement of blockchain: evidence from HNA group", *International Journal of Information Management*, Vol. 39, pp. 1-4.

Yu, Z., Yan, H. and Cheng, T.C.E. (2001), "Benefits of information sharing with supply chain partnerships", *Industrial Management and Data Systems*, Vol. 101 No. 3, pp. 114-121.

Zelbst, P.J., Green, K.W., Sower, V.E. and Bond, P.L. (2019), "The impact of RFID, IIoT, and Blockchain technologies on supply chain transparency", *Journal of Manufacturing Technology Management*, Emerald Publishing, Vol. 31 No. 3, pp. 441-457.

Further reading

Barratt, M. (2004), "Understanding the meaning of collaboration in the supply chain", *Supply Chain Management: An International Journal*, Vol. 9 No. 1, pp. 30-42.

Chang, S.E., Chen, Y.-C. and Wu, T.-C. (2019), "Exploring blockchain technology in international trade: business process re-engineering for letter of credit", *Industrial Management and Data Systems*, Emerald Publishing, Vol. 119 No. 8, pp. 1712-1733.

Fisher, M. (1997), "What is the right supply chain for your product?", *Harvard Business Review*, Vol. 75, pp. 105-116.

Freeman, R.E., Wicks, A.C. and Parmar, B. (2004), "Stakeholder Theory and 'The corporate objective revisited'", *Organization Science*, INFORMS, Vol. 15 No. 3, pp. 364-369.

Fu, Z., Dong, P. and Ju, Y. (2020), "An intelligent electric vehicle charging system for new energy companies based on consortium blockchain", *Journal of Cleaner Production*, Vol. 261, 121219.

GS1 (2017), *EPCIS and CBV Implementation Guideline*, GS1, available at: https://www.gs1.org/docs/epc/EPCIS_Guideline.pdf (accessed 12 July 2019).

Kampstra, R.P., Ashayeri, J. and Gattorna, J.L. (2006), "Realities of supply chain collaboration", *The International Journal of Logistics Management*, Vol. 17 No. 3, pp. 312-330.

Treiblmaier, H. (2019), "Combining blockchain technology and the Physical Internet to achieve triple bottom line sustainability: a comprehensive research agenda for modern logistics and supply chain management", *Logistics*, Vol. 3 No. 1, pp. 1-13.

van Hoek, R. (2019), "Exploring blockchain implementation in the supply chain: learning from pioneers and RFID research", *International Journal of Operations and Production Management*, Emerald Publishing, Vol. 39 Nos 6/7/8, pp. 829-859.

Yu, C., Jiang, X., Yu, S. and Yang, C. (2020), "Blockchain-based shared manufacturing in support of cyber physical systems: concept, framework, and operation", *Robotics and Computer-Integrated Manufacturing*, Vol. 64, 101931.

Zhang, C., Bai, J. and Wahl, T.I. (2012), "Consumers' willingness to pay for traceable pork, milk, and cooking oil in Nanjing, China", *Food Control*, Vol. 27 No. 1, pp. 21-28.

Zhang, F., Masna, N.V.R., Bhunia, S., Chen, C. and Mandal, S. (2018), "Authentication and traceability of food products through the supply chain using NQR spectroscopy", *Proceedings of the 2017 IEEE Biomedical Circuits and Systems Conference*, available at: https://ieeexplore.ieee.org/xpl/conhome/8303622/proceeding.

Zmud, R.W. (1978), "An empirical investigation of the dimensionality of the concept of information", *Decision Sciences*, Vol. 9 No. 2, pp. 187-195.

Corresponding author
Horst Treiblmaier can be contacted at: horst.treiblmaier@modul.ac.at