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Adoption of Blockchain for Sustainable Supply Chains

An Identification of Benefits, Challenges, and Risks

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Adoption of Blockchain for Sustainable Supply Chains: An Identification of Benefits, Challenges, and Risks

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ABSTRACT (MAX. 200 WORDS):
Supply chain management (SCM) has become more challenging than ever, considering the effect of globalization on organizations as operating through transnational business networks. Conventional supply chains have been facing struggles such as lack of advanced technologies and traceability in operation, which then leads to operational inefficiencies. Blockchain (BC) technology offers a set of features that supply chains can leverage, including transparency, data reliability, security, auditability, and automation. Existing pressures from governments, communities, and consumers as drivers of reaching sustainability goals direct us to further evaluate the use of BC as a facilitator for sustainable supply chain management (SSCM). However, there are also caveats associated with the adoption of BC technology. This thesis aims to evaluate the capabilities of BC technology in the context of SSCM. The authors construct a framework consisting of mainstream BC features, the three pillars of SSCM, together with challenges and risks. The findings of this study reflect that BC is promising to benefit the sustainability aspect of SCM through increasing transparency, security and integrity of data, and automation capability by smart executions. Nonetheless, there are also issues to reckon with, such as the increasing need for awareness and technical competence, organizational collaboration, and effective change management.

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Abdulazeem Adesanya

Abbreviations

AI	Artificial Intelligence
BC	Blockchain
DLT	Distributed Ledger Technology
ERP	Enterprise Resource Planning
IS	Information Systems
IoT	Internet of Things
ML	Machine Learning
PoC	PoC
PoS	PoS
PoW	PoW
RFID	Radio-Frequency Identification
SCM	Supply Chain Management
SSC	Sustainable Supply Chains
SSCM	Sustainable Supply Chain Management
P2P	Peer-to-Peer
ROI	Return on Investment
TBL	Triple-Bottom Line

Content

Definitions

Artificial Intelligence	A technology that supports human intelligence such as visual perception, speech recognition, decision making and translation between languages (Habeeb, 2017).
Counterfeit	Cheating or defrauding people with an illegal copy of something (Cambridge dictionary, 2020).
ERP	Information systems to administer business activities such as sales, finance, supply chain processes, risk management and compliance (Ramadhan, Koutaini, W. Aridah, & Ahmed, 2019).
Fraud	Illegal act of falsifying things or cheating someone to gain monetary values or goods (i.e., identity fraud) (Oxford dictionary, 2020).
IoT	A form of network that connects anything to the Internet according to specific protocols via information sensing devices to carry out exchange of information and communications (Patel, Patel, & Scholar, 2016).
Ledger	A digital document that finance establishments use to record the fund they have received or paid out. (Oxford dictionary, 2020).
P2P Network	A network that is established when two or more computers are interconnected without any need for a separate computer server (Parameswaran, Susarla, & Whinston, 2001).
PoC	"A phrase frequently used in descriptions of research sought in program announcements, in experimental studies, and in the marketing of new technologies" (Kendig, 2016, p.1).
PoS	Protocols in BC that allows entities holding stakes in the system to make decisions (Bentov et al., 2014).
PoW	Protocols in BC that give the entities carrying out computation tasks the authority to make decisions (Bentov et al., 2014).
ROI	A performance measure used to evaluate the profits made from a business activity for a specific period compared with the amount invested in the business (Cambridge dictionary, 2020).

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1 Introduction

1.1 Background

Globalization of supply chains which imposes the establishment of multifarious regulations and immense diversification of cultural and human behavior makes it grueling to process information and handle risks within involute networks (Sarpong, 2014; Ivanov, Dolgui & Sokolov, 2019). Growing issues such as transaction inefficiency, transaction fraud, and inaccurate supply chain operations make inroads into lower trustworthiness, and hence, an exigency of better information sharing, and verification capability (Saberi, Kouhizadeh, Sarkis & Shen, 2019). In this context, BC technology looks promising, as a distributed ledger technology that incorporates a decentralized network where each transaction is immutably recorded, verified, and stored as encrypted information (Fraga-Lamas & Fernández-Caramés, 2019; Rejeb, Keogh & Treiblmaier, 2019). This potential makes BC the new era of the internet-based technology that possesses the capability to offer enhanced transparency, traceability and security throughout a supply chain network (Francisco & Swanson, 2018; Westerkamp, Victor & Küpper, 2018; Kouhizadeh & Sarkis, 2018; Saberi et al., 2019; Kamble, Gunasekaran & Sharma, 2020). Furthermore, BC is an ever-expanding technology for supply chain use cases, which is estimated to grow at an annual growth rate of 87%, and hereby proposing an increase from $45 million in 2018 to $3,314.6 million by 2023 (Kamilaris, Fonts & Prenafeta-Boldύ, 2019).

BC technology gained popularity with the emergence of cryptocurrency and Bitcoin to be focally incorporated into financial applications (Nakamoto, 2008). However, the authentic features of BC technology paved the way for more extensive use of this technology for non-financial business areas, where supply chains are at the forefront of these fields (Kouhizadeh & Sarkis, 2018). BC is essentially different from most of the prevailing IS architectures by consisting of four distinguished characteristics: decentralization, visibility, auditability, and smart execution (Steiner & Baker, 2015). The execution of BC technology through supply chains are growing larger by the day in cooperation with the IoT and machines delivering automated operational data, and hence increasing efficiency (Helo & Hao, 2019). This comprises smart devices (e.g., sensors, RFID tags, other electronics) interconnected to each other to allow data mining and data access over a communication network (Dorsemaine, Gaulier, Wary, Kheir, & Urien, 2015). Furthermore, considering the distributed, resilient and immutable composition of BC technology, all branches of a global supply chain (i.e., procurement, manufacturing, distribution, service) are potentially convenient to be exposed to a top-down disruption (Aich, Chakraborty, Sain, Lee & Kim, 2019).

On the other hand, there are also a handful of studies dealing with the vulnerable aspects of BC in terms of security, rigor, and compatibility (Lin & Liao, 2017; Khan & Salah, 2018; Reyna, Martin, Chen, Soler, & Diaz, 2018; Zheng, Xie, Dai, Chen, & Wang, 2018). Furthermore, there is a limited number of studies in the literature that examine whether BC technology can be an initiator for the aspects of sustainability (Kouhizadeh & Sarkis, 2018; Saberi et al., 2019), recalling the TBL framework adopted by companies to achieve sustainability goals (Elkington,

2013). In this connection, the concerns of green and SSC encompass many different aspects (e.g., environmental, economic, technological, organizational), where each of these needs to be inquired if they have intersections with the boundaries of BC use cases. Starting from this point, an in-depth analysis can be made towards effectiveness, performance, and capabilities acquired by the use of BC technology through the supply chain networks (Saberi et al., 2019). Besides that, company, industry, product, service, market characteristics prevailing in competition may each impact the embracement of BC technology for SSC (Kouhizadeh & Sarkis, 2018). In the literature, scientific studies on the BC and its affinity with sustainable practices seem to be rather immature for reaping ideas and theories about the future use cases of this technology for the sake of SSCM. In practical terms, the global research and advisory firms continuously conduct case studies regarding how BC technology can be effectively used for supply chain networks. According to a recent report from Gartner, nearly 90% of BC-based supply chain initiatives are in danger of ineffectively adopted due to a lack of feasible use cases (Gartner, 2019a). On the other hand, these companies also address the game-changer role of BC technology, specifically pointing out its transformational impact on supply chains (Gartner, 2019b; Frost & Sullivan, 2019). In any case, BC technology seems to be much of a growing issue by the day that is expected to disrupt supply chains in many aspects.

1.2 Problem Area

After reviewing the existing literature, we identified certain studies dealing with the application of BC technology on various use cases (Tian, 2016; Glaser, 2017; Bocek, Rodrigues, Strasser & Stiller, 2017; Karamitsos, Papadaki & Al Barghuthi, 2018). One very good example here is the agriculture and food industry where food safety, food integrity, and food security have been among the challenges faced in the industry (Tian, 2016). According to Gupta (2018), Chinese food companies incorporate BC integrated RFID technology in the supply chain for a list of purposes, such as data acquisition through production processes, maintaining sales links of the agri-food supply chain, warehousing and dispatching operations. At this point, product traceability is key as is the case with any given supply chain network. To demonstrate the importance of traceability provided by BC technology, Gupta (2018) exemplifies the spinach outbreak in the USA which ended up with deaths and hospitalized patients, which then resulted in all the spinach to be pulled out and banned from grocery stores. The author further mentions that it took two weeks to locate the farmer with the contagious spinach due to not being able to track and trace the item flow in the supply chain (Gupta, 2018). Considering the magnitude of such outcomes, BC has the potential to aid in the enhancement of traceability throughout the supply chain networks.

Further to the agri-food industry, in broad strokes, conventional supply chains have been facing a list of challenges: lack of advanced technologies to benefit from; insufficient traceability; lack of flexibility; distrust on the information flow; and inaccurate supply chain risk management (Aich et al. 2019), in which the first two can be seen as the initiators of the subsequent challenges. There are also pressures from governments, communities, and consumers as drivers of reaching sustainability goals, regarding which the corporate world plays a pivotal role (Saeed & Kersten, 2019). To overcome these concerns, BC technology potentially offers a list of features and benefits including transparency, data reliability, security, auditability, and automation (Kouhizadeh & Sarkis, 2018; Zheng et al., 2018). On the other hand, BC technology comes with challenges and risks, including technical issues such as scalability, privacy leakage and selfish mining (Zheng, Xie, Dai, Chen & Wang, 2017); as well as considerations around

business process management such as fund of BC knowledge, change management and organizational adaptability (Kshetri, 2018; Helo & Hao, 2019). Accordingly, there seems to be a distinct perspective shared by some academia and business world that this disruptive technology can fall short of the mark for certain non-financial areas (Lin & Liao, 2017; Notheisen, Hawlitschek & Weinhardt, 2017; Risius & Spohrer, 2017; Khan & Salah, 2018; Reyna et al. 2018), which may then raise concerns about supply chain use cases, considering the highly complex built-in structure of traditional supply chains.

After going through the literature to scrutinize the promising use of BC along with the supply chain networks, we start questioning whether BC is sui generis, groundbreaking and transformative in this respect, or just another novelty that is not much differentiated from the existing systems. Having said that, does the BC universe rely upon adaptable rules as other supply chain technologies? How can the use of BC transform supply chains as compared to the prevalent ERP systems? Moreover, how can BC technology be deployed into the current foundation of the supply chain IS networks? To obtain SSC, is it worth it to invest in such a highly precious advanced technology? These are all questions originated from the fact that the adaptability of the current supply chain dynamics and practices to the BC universe is still an unstable matter of discussion. Furthermore, the field of IS seems to be rather immature when it comes to the evaluation of BC technology in the context of SSCM. Only a handful of mainstream articles shed light on this aspect and there is almost no paper in the literature that makes a bilateral assessment regarding the pros and cons of BC technology adoption in the context of SSC. Therefore, it seems to require further efforts to alleviate ambiguity in this field and identify the perks of this technology for SSCM. This thesis hereby focuses on carrying out a qualitative study and explore the advantages of BC technology for supply chains within the context of sustainability, together with the challenges and risks involved in BC adoption in supply chain networks.

1.3 Research Question

As we spot a gap in the adoption of BC as a means of SSC, this thesis aims to contribute to the IS field of study by delving into the evaluation of whether the use of BC technology is a worthy endeavor for SSCM. We plan to analyze the capabilities of BC technology that can be leveraged to attain SSC. By doing that, our aim is to identify the benefits of BC technology, together with the challenges and risks associated with the adoption of this technology into supply chains. Hence, we develop a framework around BC technology characteristics, the major aspects of SSCM, and the challenges and risks involved in the adoption. Therefore, our thesis will seek an answer to the following research question:

“How does BC technology impact the sustainability aspect of SCM?”

1.4 Purpose

To comprehend whether the adoption of BC technology is a worthy disruption for SSC, the purpose of this thesis is to identify the potential benefits that may lead to attaining sustainability in SCM, together with the challenges and risks involved in the use of BC technology. We aim to contribute to the IS field of study by developing a framework around our research question,

by which we are in the hope of delivering a basis for future studies that can further deliver a grounded approach associated with the use of BC technology for the sake of SSC. Last but not least, this thesis may contribute to shared knowledge in the business world if companies from different industries look upon our study as a foundation to scrutinize the impact of BC technology on SSC.

1.5 Delimitation

This study is planned to tackle the impact of BC technology on SCM, by specifically focusing on the sustainability aspect of supply chain networks. Regarding this, some of the conclusive findings and implications may not be generalizable to every supply chain mechanism since each industry is likely to have distinct features and dynamics that may require a particular investigation. Furthermore, the technical implementation of BC technology or any aspects associated with the infrastructural deployment of this technology within supply chains is wide off the mark in the suggested research. Instead, based on empirical findings, this study aims at making a profound evaluation of the influence of BC technology on SSC. Considering the viewpoint of methodology selection, the study is limited to the inferences and results obtained from interviews that have been performed in collaboration with company professionals from different sectors.

2 Theoretical Background

2.1 Blockchain

BC is a state-of-the-art technology that was first developed to process the cryptocurrency Bitcoin, which was proposed by Satoshi Nakamoto in 2008 and later put in use by him for the first time in 2009 (Farah, 2018). In the BC literature, a handful of scholarly publications have used the terms 'BC' and 'Bitcoin' interchangeably for describing BC technology, which is a misattribution since BC is terminologically the rightful notion to entitle the protocol and client by which not only digital currency but transactions are handled (Swan, 2015). Bitcoin, on the other hand, registers and verifies the order of transactions and secures the process record through a digital mechanism, which is delivered by BC technology (Sultan, Ruhi, & Lakhani, 2018). Furthermore, BC technology has been drawing greater interest across different sectors, thanks to its applicability to many other use cases apart from the digital currency (Aich et al., 2019). Lacity (2018) propounds that BC technology seems to be the new era of information flow paradigm through which enterprises in competitive markets are looking to extract substantial business value. The rise of Bitcoin along with BC in financial practices has given it a penetration force through a wide range of non-financial sectors (Farah, 2018), where SCM and logistics are included in as spearheading functions (Abeyratne & Monfared, 2016; Maurer, 2017). This is because BC is capable of enhancing data collection, storage, and processing through a decentralized and trustless database that enables global-scale transactions across different parties with minimum or no involvement of intermediaries based on the setting (Crosby, Pattanayak, Verma & Kalyanaraman, 2016).

This section is divided into five parts by which the authors aim to reflect the description of BC, the technical aspects of BC technology, the forms of BC, the fundamental characteristics of BC, as well as challenges and risks with the adoption of BC technology. Having said that, the authors elucidate the capabilities of BC technology that may be beneficial for the sake of SSC, together with the possible constraints and risks that may adversely affect the performance of SCM. The aim is to represent the existing theoretical standing of this artifact bi-directionally so that the authors can build up a solid framework to extract deeper insights through the subsequent parts.

2.1.1 Description of BC

As going through the most up-to-date research, the definition of BC shows a certain variety depending on the context of use and the interpretation of functional aspects. Oxford dictionary proposes the following description for a BC:

"A system in which a record of transactions made in bitcoin or another cryptocurrency are maintained across several computers that are linked in a peer-to-peer network" (Oxford Dictionaries, 2018).

The extent of this definition is confined to the use of cryptocurrency, however, as it is expressed before, the scope of BC technology can be further incorporated in a wide range of use cases. Viriyasitavat and Hoonsopon (2019) broaden this description to provide a more inclusive context as:

"A technology that enables immutability, and integrity of data in which a record of transactions made in a system are maintained across several distributed nodes that are linked in a peer-to-peer network" (Viriyasitavat & Hoonsopon, 2019, p. 33).

Sultan et al. (2018) propose a slightly different description by addressing the consensus model:

"A decentralized database containing sequential, cryptographically linked blocks of digitally signed asset transactions, governed by a consensus model" (Sultan et al. 2018, p. 54).

Seebacher and Schüritz (2017) set forth a congruent description to this as follows:

"A BC is a distributed database, which is shared among and agreed upon a peer-to-peer network. It consists of a linked sequence of blocks, holding time stamped transactions that are secured by public-key cryptography and verified by the network community. Once an element is appended to the BC, it cannot be altered, turning a BC into an immutable record of past activity" (Seebacher & Schüritz, 2017).

Yaga, Mell, Roby, and Scarfone (2018) emphasize the same criteria (i.e., data immutability) by the following description, addressing digital ledger technology as well.

"BCs are distributed digital ledgers of cryptographically signed transactions that are grouped into blocks. Each block is cryptographically linked to the previous one (making it tamper evident) after validation and undergoing a consensus decision. As new blocks are added, older blocks become more difficult to modify (creating tamper resistance). New blocks are replicated across copies of the ledger within the network, and any conflicts are resolved automatically using established rules" (Yaga et al., 2018, p. 1).

BC technology can be scrutinized by taking into account a great number of criteria supported by its characteristics since fundamental principles of different BC types may tally up with one another and be listed differently within certain scientific papers. Saberi et al. (2019) base upon four key characteristics of the BC to address its differentiation from the majority of prevailing IS designs: decentralization, security, auditability, and smart execution. Sultan et al. (2018) point out an outline of four core characteristics as follows: data and information immutability, decentralization, consensus mechanism (i.e., trust verification), and information transparency (i.e., auditability). Kouhizadeh and Sarkis (2018) summarize five essential principles underpinning the operating mechanism of BC platforms: (i) decentralized databases, (ii) data security, (iii) information transparency, (iv) immutability, and (v) smart contracts (i.e., computational logic). Zheng et al. (2018) collect the basic principles of BC under the following headings: decentralization, persistency, anonymity, and auditability. This thesis grounds on the characteristics and the associated elements introduced by Kouhizadeh and Sarkis (2018), Zheng et al. (2018), and Seebacher and Schüritz (2017) and further links up with additional information obtained from various sources to structure the theoretical framework regarding the potential impact of BC on SSCM.

2.1.2 Technical Aspects

The BC technology records data transactions through a secure, traceable, and transparent P2P network (Swan, 2015). BC differs from other IS designs with the use of an authentic data structure that forms a chain of blocks for data storage into which all committed transactions are recorded (Farah, 2018; Kouhizadeh & Sarkis, 2018). In this respect, whenever a new record is

introduced into the system, it creates a new block that is tied to the recent one, which is hereby constructing a chain called "BC" (Nakamoto, 2008). Every node represents a stakeholder within a P2P network through which information sharing and data recording are handled over verified copies of the distributed ledger so that information consistency can be provided (Peck, 2017; Chen, Xu, Lu & Chen, 2018; Efanov & Roschin, 2018). Since this cryptographical linkage among blocks is established by virtue of a hash digest and published in an unrestrictedly distributable file for all parties, no master copy is issued (Sultan et al., 2018), which differs from centralized systems. Figure 2-1 depicts the difference between centralized systems (i.e., conventional systems) and the BC system.

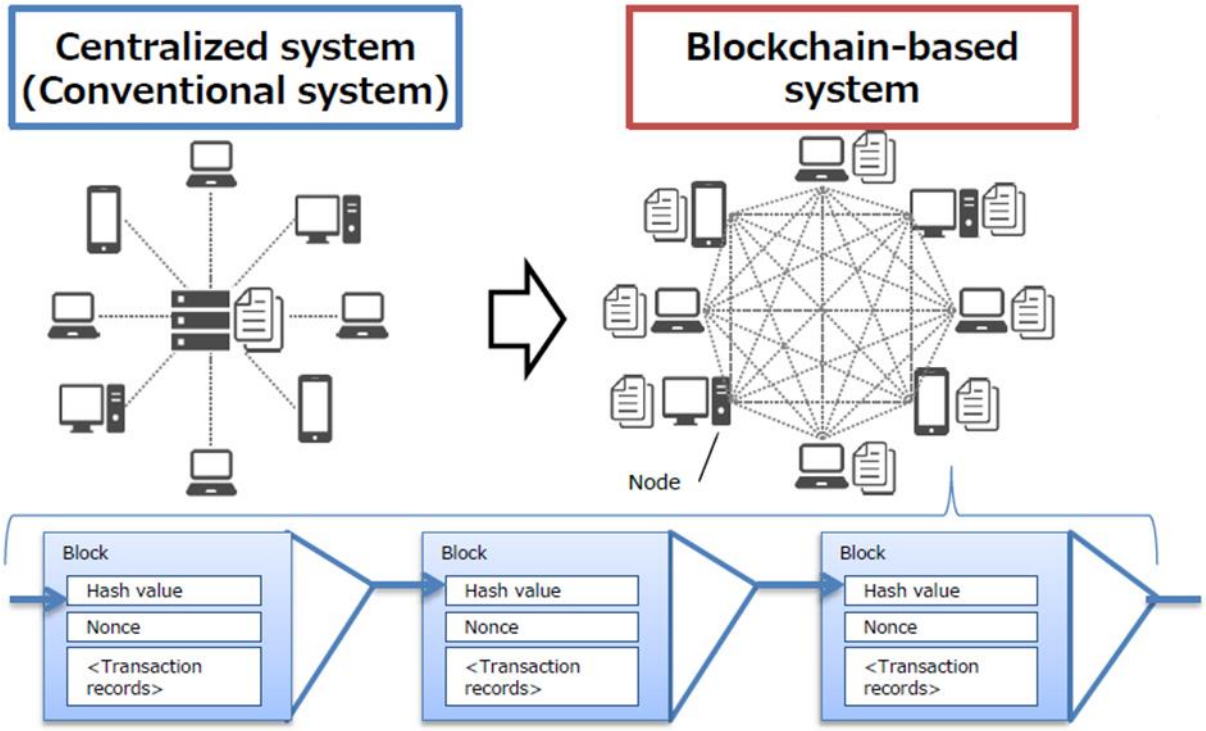

Figure 2-1 Comparison between Centralized and BC systems (METI, 2017, p.1).

BC uses DLT, which is a sort of database that allows transaction data to be immutably recorded without any constraint by geographical dispersion (Navroop, Nathalie, Alexandra, Robert & Arianna, 2018). DLT primarily aims to establish trust throughout the system in the absence of any central authority, which imposes no trust among users (Akhtar, 2019). At this point, DLT functions as an administrator to manage data structures, which are collectively consisting of the technology itself (Akhtar, 2019). Although each DLT carries out a distinct mechanism and runs an individual data model, they generally rely upon three constituents: (i) distributed P2P network, (ii) key cryptography to update the ledger and (iii) consensus algorithm through which transactions will be approved in the relevant order (Akhtar, 2019). An overall illustration of how BC technology operates through a P2P network is presented in Figure 2-2.

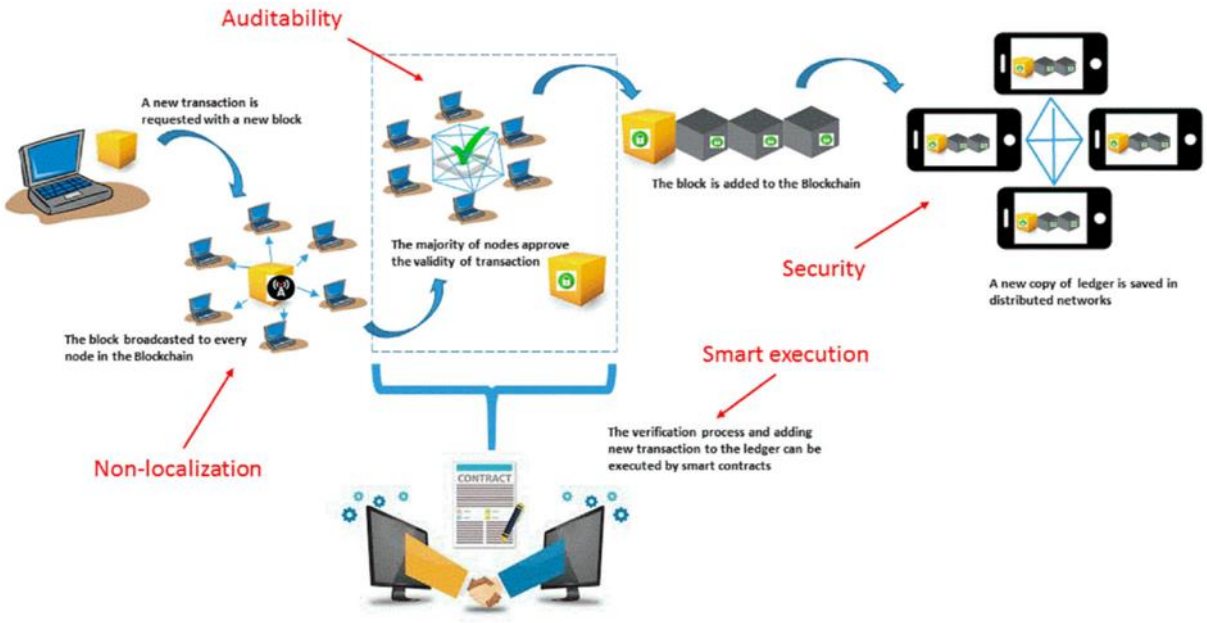

Figure 2-2 Steps in BC Information and Transactions (Saberi et al., 2019, p.2119).

2.1.3 Forms of BC

Regarding openness and accessibility, there are fundamentally three forms of BC: (i) public, (ii) private, and (iii) consortium (i.e., hybrid) (Sultan et al., 2018). Figure 2-3 represents an overall view of the classification among these BC forms, together with some popular cryptocurrencies associated with each group.

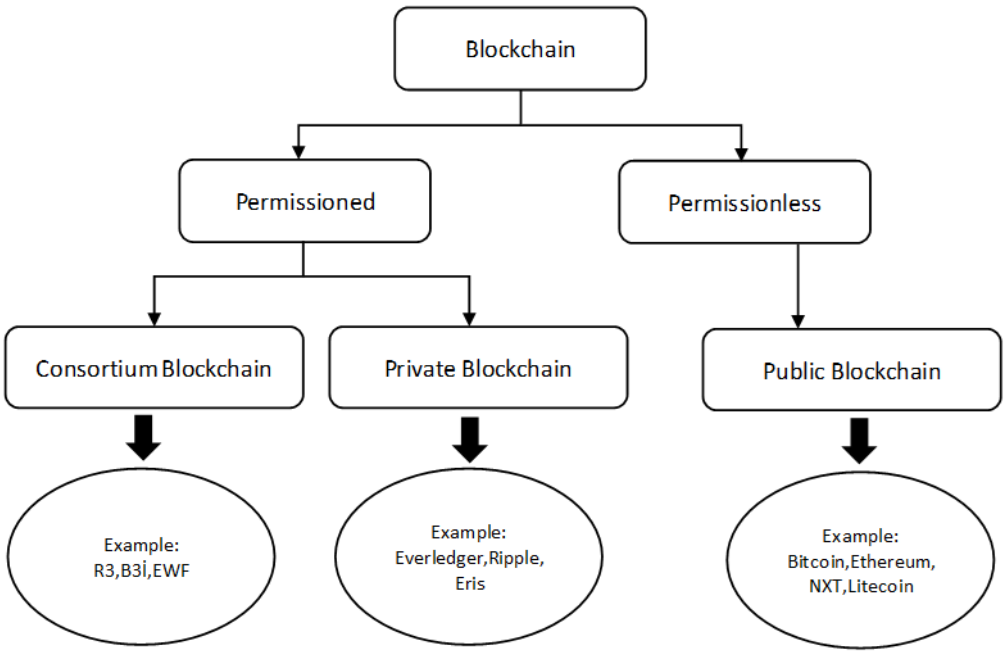

Figure 2-3 Forms of BC (Atlam & Wills, 2019, p.10).

Public BCs are known as permission-less ledgers and can be modified by any user, whereas private BCs take into account as the read-and-write allowance for any modification through the

BC (Zheng et al., 2018). In between, consortium (i.e., hybrid) BCs are open to privileged parties through a partially decentralized network (Sultan et al., 2018). Zheng et al. (2018) outline the differences between these forms of BCs in Table 2-1.

Table 2-1 Comparisons among Forms of BC (Adapted from Zheng et al., 2018).

Property	**BC Types**		
	Public BC	Consortium BC	Private BC
Consensus determination	All Miners	Selected set of nodes	One organization
Read permission	Public	Could be public or restricted	Could be public or restricted
Immutability	Nearly impossible to tamper	Could be tampered	Could be tampered
Efficiency	Low	High	High
Centralized	No	Partial	Yes
Consensus process	Permissionless	Permissioned	Permissioned

Public BC

In public BCs (e.g., bitcoin), there is no single owner, meaning the BC itself is visible to the public as the name implies, while the consensus process is fully decentralized and open to all participants (Sultan et al., 2018). Any user can join the network to post transactions and also participate in the mining and consensus mechanism where new blocks are added to (Farah, 2018). This form of BC usually uses PoW and/or PoC for consensus mechanism (Farah, 2018). PoW and PoS are open-source consensus algorithms, which are used in the validation of transactions and transparency throughout the network (Khan, Zahid, Hussain, Farooq, Riaz & Alam, 2019). Furthermore, these algorithms give rewards to miners who use them to ensure the security of transactions (Khan et al., 2019). Representation of a public BC structure is given in Figure 2-4.

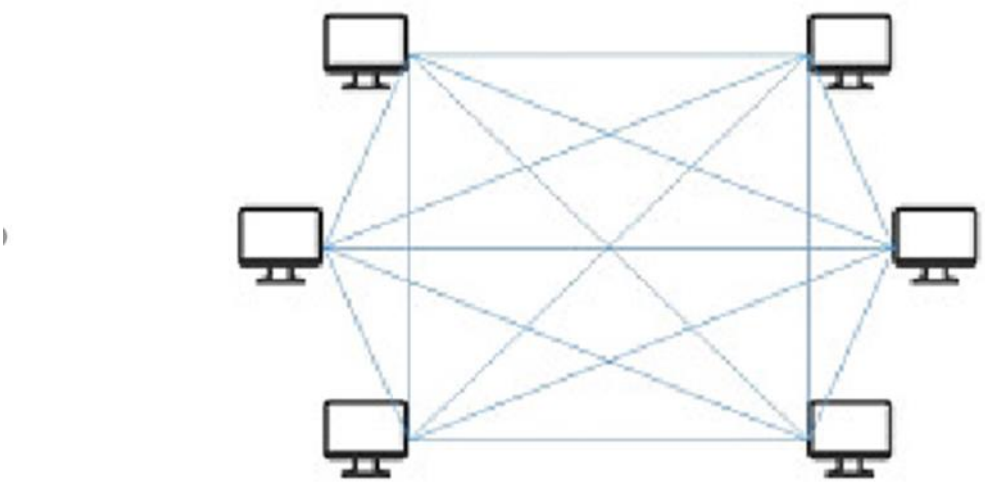

Figure 2-4: Illustration of Public BC (Lin & Liao, 2017, p.655).

Private BC

Private, which is also called permissioned BCs, have control over user access to the network as well as the read-and-write authentication of users (Sultan et al., 2018). Since a single entity owns the control over block generation, consensus algorithms and mining are generally not included (Sultan et al., 2018). Yaga et al. (2018) assert that the blocks published by users must be authorized by some form of authority, which is, in this case, the single entity standing for network administrators. Tapscott and Tapscott (2017) suggest that this form of BC may be more applicable to the companies who seek to adopt BC technology but have more concerns about leaking sensitive corporate information to the public. Figure 2-5 illustrates an exemplary structure of a private BC.

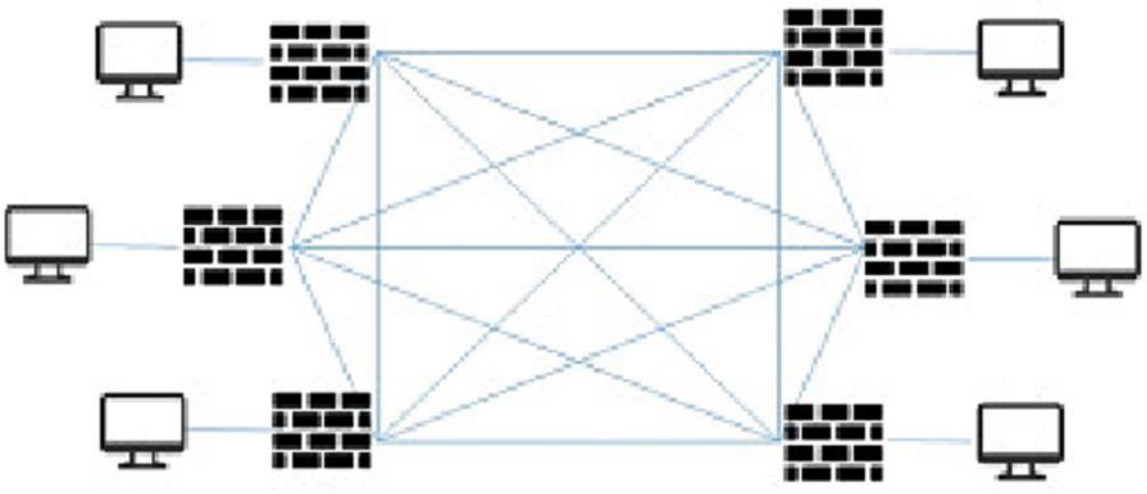

Figure 2-5: Illustration of Private BC (Lin & Liao, 2017, p.655).

Consortium BC

Consortium, also known as hybrid BCs, is also permissioned to privileged parties and the consensus mechanism is managed by selected servers, where these servers apply a predetermined list of regularities agreed upon by all parties (Sultan et al., 2018). Since the consortium is only open to certain participants, implying that verified copies of the distributed

ledger are only available to those included among authorized users, and thus the network is partly decentralized (Sultan et al., 2018). The difference between private and consortium BCs is that private BC requires permission from administrators or authorized authority whilst in the consortium BC, a set of companies or organizations take charge of the permissioned network (Khan et al., 2019). Furthermore, the data in the consortium BC, sometimes called federated BC, can be open or private in a partially decentralized construct (Farah, 2018). In some settings, hybrid BCs can be considered as a mixture of public and private BCs, considering the fact that access permission is handled by a certain group of privileged users for the private part, whereas the public part acts as an open-source environment (Farah, 2018). An example of a consortium BC is given by Figure 2-6.

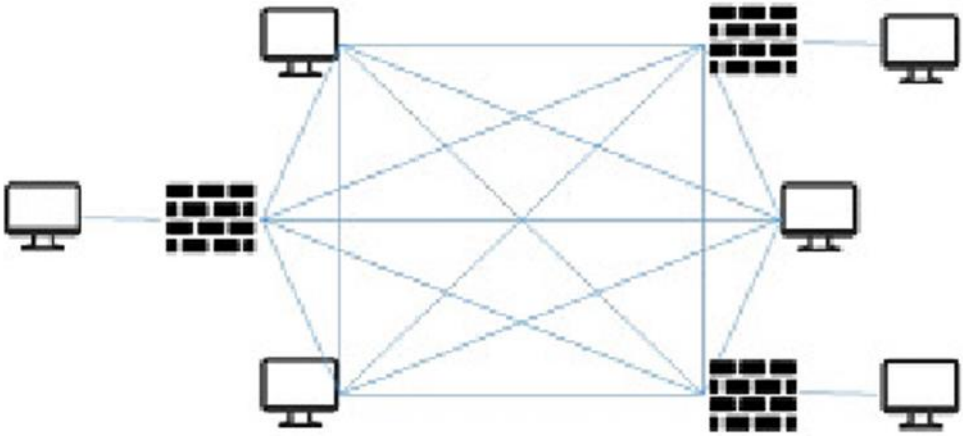

Figure 2-6: Illustration of Consortium BC (Lin & Liao, 2017, p.655).

2.1.4 BC Characteristics

This section scrutinizes the fundamental characteristics of BC, based on the mainstream literature that we went through to construct a solid foundation for BC technology. To assemble an inclusive list covering prominent aspects together with their key elements, Table 2-2 represents the diversity of terms used by different authors who describe the notable features of BC technology through their studies. Working through all these studies, the following characteristics of BC are listed and further elaborated to cover various aspects of this technology: (i) transparency, (ii) decentralization, (iii) immutability, (iv) security and data integrity, (v) smart execution, and (vi) versatility.

Table 2-2: Concept Matrix of the Reviewed Literature on BC Characteristics

References	Characteristics														
	Decentralization	Immutability	Transparency	Better security	Integrity of Data	Smart contracts	Open source	Autonomy	Anonymity	Privacy	Auditability	Versatility	Reliability	Persistency	Peer verification
Abeyratne & Monfared (2016)	✓	✓	✓		✓										
Atlam & Wills (2019)	✓	✓	✓	✓											✓
Kouhizadeh & Sarkis (2018)	✓	✓	✓	✓		✓									
Khan & Salah (2018)				✓	✓					✓	✓		✓		✓
Khan et al. (2019)	✓	✓	✓												
Lin & Liao (2017)	✓	✓	✓				✓	✓	✓						
Nofer et al. (2017)	✓		✓	✓	✓	✓			✓						
Saberi et al. (2019)	✓			✓		✓					✓				
Seebacher & Schüritz (2017)		✓	✓		✓					✓		✓	✓		
Sultan et al. (2018)	✓	✓	✓												✓
Tian (2016)	✓		✓				✓		✓				✓		
Tijan et al. (2019)	✓		✓	✓											
Viriyasitavat & Hoonsopon (2019)	✓								✓		✓			✓	✓
Wüst & Gervais (2018)			✓		✓					✓					✓
Zheng et al. (2018)	✓								✓		✓			✓	

Decentralization

Decentralization is one aspect of BC attributes that permits participants to interact through a P2P network (Zheng et al., 2018). Kouhizadeh and Sarkis (2018), refer to the decentralized

database architecture as the core of BC that enhances the reliability of recorded transactions through consensus algorithms (i.e., PoW and PoS). As opposed to any centralized networks that have a list of vulnerabilities including a single point of failure and scalability, BC's decentralized architecture that incorporates a distributed ledger exploits the processing capabilities of every user through the BC network to diminish latency and prevent the single point of failure (Atlam & Wills, 2019). Since there is no need for any central authority to perform a transaction among peers within the network, BC is promising to considerably lower the server costs (i.e., the development and operational costs) and alleviate any insufficient performance through the central server (Zheng et al., 2018; Viriyasitavat & Hoonsopon, 2019). Having said that, a centralized database is technically more vulnerable to be breached in different forms, including hacking, corruption, or crashing (Tian, 2016), whereas decentralization provides increasing data validity and verifiability through the accessibility of transaction records via distributed public or private ledgers (Crosby et al., 2016).

At this point, all forms of BCs have the feature of decentralization to different extents, by which the common goal is to ensure the integrity of data and avert the single point of failure (Viriyasitavat & Hoonsopon, 2019). Public BCs operate through an entirely decentralized setting that enables the establishment of trust among the initial anonymized users (Sultan et al., 2018). Private BCs operate in a trusted environment that places a control mechanism over user accessibility where the extent of decentralization is designated through the node selection under the surveillance of a single entity (Viriyasitavat & Hoonsopon, 2019). Consortium BCs, on the other hand, are run by consortium policies to assign membership status to any given node, where a relatively higher degree of decentralization is established without any control mechanism privileged to a single entity (Viriyasitavat & Hoonsopon, 2019).

Immutability

Data and information stored in a BC are immutable, which is an essential feature of the BC technology that derives from the persistent nature of transaction records included in a BC ledger (Viriyasitavat & Hoonsopon, 2019). The term immutability here stands for the fact that records cannot be altered and are free from adulteration without any particular consensus among network players (Kouhizadeh & Sarkis, 2018) unless more than half of the nodes in the network is simultaneously controlled by a specific user (Lin & Liao, 2017). However, a collision can occur here if the majority of miners that vote for transactions decide to remove or change a transaction in a public BC (Kouhizadeh, & Sarkis, 2018).

Transparency

The data stored in the BC system is accessible for each member, making the origin of any data traceable for tracking asset lifetimes (Sultan et al., 2018). Transparency of the records including both the stored data and the updates is a prerequisite for public verifiability through the BC network (Wüst & Gervais, 2018). The term transparency can lead to confusion, considering privacy as another characteristic of BC technology. The distinction here is that each node has an anonymized identity assigned by cryptographic algorithms that solely unleash public addresses encrypted by these algorithms (Khan et al., 2019). Apart from that, the entire system operates transparently as an open-source platform where any node can reach the provenance of a transaction (Tian, 2016). In this respect, BC architecture makes use of timestamps that enable higher traceability to prevent data manipulation (Kouhizadeh & Sarkis, 2018).

Security and Integrity of Data

BC technology manages information in the forms of blocks, each of which contains a hash value and a timestamp in connection with the previous blocks in the chain (Kouhizadeh & Sarkis, 2018). Hash values comprise distinct cryptographic configurations that deliver tamper resilience with data integrity (Nofer, Gomber, Hinz & Schiereck, 2017). Cryptography allows for authentication through transactions among anonymized users, which is an essential requirement for public BCs to establish trustworthiness across the entire system (Kouhizadeh & Sarkis, 2018). Due to the trustless logic of BC technology, user identities remain anonymous since no third-party involvement occurs through transactions (Tian, 2016). Decentralization is another aspect of BC technology that serves as a contributor to system security since information validity hinges on consensus norms established by network players, which aims to diminish data loss and manipulation and stand up to outside attacks (Kouhizadeh & Sarkis, 2018). Furthermore, the use of BC technology is promising to eliminate the single point of failure, which is a frequently encountered security problem with centralized systems (Ølnes, Ubacht & Janssen, 2017). Accordingly, the nonexistence of any third parties mitigates the risk of data tampering since the integrity of data is enhanced by allowing direct interactions among network users through public-key cryptography (Seebacher & Schüritz, 2017).

Smart Executions

Smart execution is a new generation of transactional actions that ensures trust, transparency, and traceability across software programs regulated by business rules, which are called smart contracts (Saberi et al., 2019). These contracts automatically execute transactions in compliance with the terms of agreements imposing rules, policies, and penalties that are agreed upon through validation by contracting parties (Chu, Olickel, Saxena & Hobor, 2016). As opposed to the case with traditional contracts, the involvement of an intermediary (i.e., financial incumbents, legal authorities) can be confined to a minimum level by using smart contracts, which may then lead to the improved efficiency and cost reduction across business operations (Kouhizadeh & Sarkis, 2018). Smart contracts can verify the existence of negotiated terms for approving transactions and record them into the ledger, where any change afterward is subjected to specific terms attached to these smart contracts (Delmolino, Arnett, Kosba, Miller & Shi, 2016).

Versatility

As BC technology transcends the limits of its applicability to financial operations, it has started to be more versatile in the sense that participants acquire capabilities to develop programs that can be incorporated into the BC architecture (Seebacher & Schüritz, 2017). Khan et al. (2019) introduce the advancement of BC technology starting from the very early stages (i.e., BC 1.0) up to the state-of-the-art version of this technology (i.e., BC 4.0), which is described by Table 2-3. Regarding this, BC 1.0 represents the distributed ledger technology that allows financial transactions through digital cryptocurrency (e.g., Bitcoin), BC 2.0 refers to the use of smart contracts that enables tamper-proof, secure, and hence trusted interaction among two parties, BC 3.0 stands for the initiation of decentralized applications that takes it beyond the financial transactions and BC 4.0 offers autonomous decision-making capability to support various industrial use cases (e.g., supply chain), thanks to the integration capability of this technology with Industry 4.0 constituents (e.g., IoT) (Khan et al., 2019).

Table 2-3: Advancement from BC 1.0 to 4.0 (Adapted from Khan et al., 2019).

		ENABLERS	VALUE DRIVER
1	BC 1.0	Decentralized Consensus	Transaction Cost
2	BC 2.0	Smart Contracts	Added Services
3	BC 3.0	Decentralized Applications, Storage and Computing	Organization Boundaries
4	BC 4.0	Decentralized Artificial Intelligence	Autonomous Decision-Making

2.1.5 Challenges and Risks

As is often the case with almost every disruptive technology, BC technology typically involves challenges to face, sooner or later (Mendling et al., 2018). Since it is likely to exercise influence over established relationships within the supply chain, partners of the mechanism need to be proactive against those challenges by considering them as opportunities to progress, rather than threats to freeze off until embracing it (Saberi et al., 2019). Regarding this, deployment of BC technology to a supply chain network and information management system as a governor is likely to be challenging issues, specifically for the sustainability aspect of this network (Saberi et al., 2019). Though the practices with the use of BC technology have broadened through the recent years, adoption and implementation of this technology in the supply chain harbor many obstacles to overcome, which needs to be evaluated comprehensively in different contexts (e.g., organizational, technological, and social) (Crosby et al., 2016).

Since BC technology is in the early stages of its evolution through non-financial areas, embracement and diffusion of this disruptive technology require the implementation of technology acceptance models as in line with diffusion theory, which then entails direct and interactive collaboration among multiple shareholders associated with the application area (Kouhizadeh & Sarkis, 2018). When it comes to the comprehension of the term ‘sustainability’, it can be even more ambiguous to participants of a supply chain, since it may revolve around different interests and expectations that can weaken to head for shared business objectives (Kouhizadeh & Sarkis, 2018). Furthermore, this ambiguity may either restrain diffusion if not everyone bends to the idea that takes side with BC’s potential on sustainability or relieve it in case supply chain decision-makers and stakeholders may see a silver lining to obtain greater

homogeneity and standardized sustainable aspects (Kouhizadeh & Sarkis, 2018). This will lead to the idea that functionalities, practices, and understanding of SSC can provide varying roles in the adoption process of such a disruptive technology.

Company profile, industry dynamics, product features, and market competition may each impact the embracement of BC technology for SSC (Saberi et al., 2019). As an example, there may be a higher adoption rate of transparency-oriented BCs to promote sustainability in SCM, if the related industry has a lack of reputation, which may then lead to the examination of reputational shortcomings by legitimacy-building (Kouhizadeh & Sarkis, 2018). Similarly, various supply chain concerns (e.g., trust, sourcing, relationship management) can be an indicator of any context, respectively. In this regard, leveraging the aspects presented by Saberi et al. (2019) as a baseline, together with a set of supporting articles, the following list of challenges and risks with the adoption of BC technology is presented to cover all related contexts of evaluation (i.e., organizational, technological, and social).

Immaturity of BC Technology

BC Technology is still in the preliminary stages of its evolution, especially when it comes to its further use of implementation into non-financial areas (Tian, 2016). To exemplify, as of now BC's Bitcoin has a limited transaction capacity that permits processing 7 transactions per second because of the scarce capacity of blocks, which is insufficient to satisfy the exigence from billions of transactions through real-time processes (Zheng et al., 2017). Another challenge in this respect is the vagueness of how to tackle the continuously growing size of the BC for storage and synchronization (Tian, 2016). The project implementation lifecycle of BC technology is quite time-consuming, which is why compels companies to acquire a solid foundation of this technology together with extensive technical competence before launching the project (Helo & Hao, 2019). Accordingly, uncertainties with technical conformity and copyright management may cast a shadow over the potential adoptions of this technology. For supply chains, scalability restrains early adoptions of BC since there is a need for computational power from each node participating in the network, which leads to compromise on efficiency to tighten the security (Helo & Hao, 2019). In this context, partners in the BC are allowed to make use of transaction data without any particular data protection (Atlam & Wills, 2019), which necessitates constructing concrete boundaries to prospective use cases of BC technology. Furthermore, the use of decentralized and distributed ledger through public BCs entails intense utilization of consensus algorithms that boost power and energy consumption, which potentially brings in increasing environmental degradation on the downside (Mougayar, 2016).

Awareness and Technical Competence

Although BC technology has drawn striking interest from various industries, the understanding of how it functions across non-financial environments is commonly deficient (Banafa, 2017). Accordingly, higher awareness and technical competence are needed to be acquired so that stakeholders can develop a better understanding of various aspects concerning the use of BC technology, which includes application scope of the technology, process management, data management, people's involvement, performance management, regulatory issues, and security concerns (Angelis & da Silva, 2019). Thus, long-term training and development in technical expertise are essential to derive higher adoption rates (Helo & Hao, 2019).

Organizational Collaboration

Deployment of BC technology requires collaborative efforts from all the associated stakeholders, which can be a compelling endeavor in various incidents (Kshetri, 2018), as is the case reflected by Everledger Founder and CEO Leanne Kemp who stated that it was a progress of nearly 18 months to polish off negotiations for the relationships required to get started with the Everledger service (Clancy, 2017). Likewise, Kshetri (2018) points out that it is also a challenging task to huddle the supply chain and trading partners together to deploy and operate BC-related applications through the supply chain network. Regarding this, replacing the existing built-in centralized systems (i.e., central ERPs) with a decentralized architecture (i.e., BC database) entails a grounded basis to gain apparent superiority vis-à-vis the prevalent system (Angelis & da Silva, 2019). Nevertheless, it is even more crucial to sense that BC-based industrial solutions primarily require cooperative involvement of stakeholders with utmost willingness so that they can build consensus on gaining BC knowledge and capabilities with value-added practices for all affected parties (Helo & Hao, 2019).

Change Management

Change management is a notable issue with the adoption of BC technology, as it is a determining factor of the success with the deployment of any futuristic and disruptive technology. During this process, organizations are highly susceptible to face a list of challenges: facing resistance while adjusting current revenue models (Michelman, 2017); facing resistance from supply chain third parties and other representatives since one of the focus points of BC is to eliminate third parties (Zhao, Fan & Yan, 2016); and depending on a situation, supply chain associates might resist and reject to serve valued knowledge in real-time on a decentralized and allocated database (Queiroz & Wamba, 2019; Wang, Han & Beynon-Davies, 2019). What is more, considering the high degree of computerization needs, it is known that many countries are not prepared for the implementation of BC-based solutions (Kshetri, 2018). When it comes to the adoption and control of BC, most supply chain partners who are situated in the very field of developing and least developed countries are not even close to being set for it (Kshetri, 2018).

Cost and Functionality

Replacing the current system with a new one will cause costs and will be time-consuming, from the point of infrastructure modification most particularly (Lin & Liao, 2017). Hence, practitioners need to ensure that this disruptive technology will generate economic benefits and fulfill the needs of supervision as well while being linked to the conventional system and taking on struggles from inside out, as it is today (Lin & Liao, 2017). Changing and adjusting the current business details, agreements, and models based on the prerequisites of emergent BC technologies brings out many migration duties that need to be carried out, which is called bootstrapping issue with BC technology (Atlam & Wills, 2019). An illustrative example for this is the case of land ownership, where there needs to be conformity and equivalence between the existing forms and the BC form, implying it is a time-consuming process that costs a lot (Atlam & Wills, 2019). Potentially, BC technology entails enormous adaptation costs, together with high levels of energy and computational power needs that may raise environmental concerns (Kamble et al., 2020).

Legal and Compliance

BC technology can establish connections among various users across the world without entangling any law case or code of compliance to comply with, which is inherently one of the primary issues that both manufacturers and service providers need to deal with before opting for the adoption of this technology for the sake of their business operations (Asatryan, 2017). Conforming with the permitted and regulatory model of authority is a requirement for any use cases of BC technology, where most of the world has not been following the regulatory guidelines yet (Kamble et al., 2020). Modified regulatory and permitted limits from the authority may diminish the value proposition offered by BC technology since the modern BC architecture can skip the authority interferences (Kamble et al., 2020). Furthermore, the worldwide supply chain networks that operate through inextricably embedded structures need different groups of stakeholders to act in compliance with multifarious rules, modifications, and establishments, which includes nautical laws and regulations, commercial principles, and rules associated with ownership and control of multiple authorities in the maritime transportation (Kshetri, 2018). In this connection, deployment of BC-powered solutions can be an extremely tough and complicated process to manage because all these codes of regulations are arranged through international agreements prevailing over trans-boundary waters (Casey & Wong, 2017).

BC cannot pressurize a user code of conduct even if the BC network can implement business governs and descriptions (Yaga et al., 2018). Therefore, it raises a concern in permissionless BC networks considering the anonymity applied to user identities and the nonexistence of a functionality that allows one to one matching among network players (Yaga et al., 2018). Permissionless BC networks are likely to reward users to encourage them to comply with code of conduct but in some cases, few may prefer to seek malicious acts if it seems more yielding (Yaga et al., 2018). The vulnerability of the BC mainly stems from the attacks of selfish miners (Zheng et al., 2018). In general, it is assumed that nodes that have control over 51% of computing power within the network can invert BC, and hence the existing transactions. From this point on, selfish miners can edit the transaction data that may result in double-spending (Karame, Androulaki & Capkun, 2012; Rosenfeld, 2014), cease the blocks authenticating transactions (Lin & Liao, 2017), and interrupt mining activities for honest miners (Lin & Liao, 2017). Moreover, the implementation of BC technology does not rule out subsistent cybersecurity risks that entail the existence of a well thought out and self-initiated risk management strategy (Yaga et al., 2018). Considering interventions in any private networks get easier day by day as hackers acquire more knowledge of BC networks and their weaknesses, the need for a powerful cybersecurity agenda continues to be a preeminent quality that every organization looks up to (Yaga et al., 2018). Nevertheless, current standards and guidelines deliver a solid foundation for eluding cyberattacks, as long as a set of adjustments are made in conformity with BC technology (Yaga et al., 2018).

2.2 Blockchain-integrated Supply Chains

SCM and control have become more challenging in connection with the globalization of supply chains, where BC, as a distributed ledger technology that places utmost attention to transparency, traceability, and security shows potential in the alleviation of some global SCM problems (Saberi et al., 2019). The key performance indicators for any logistics and supply chain settings are transparency and traceability, where the lack of easily accessible and reliable

information resources within the supply chain poses the most challenging problem the traditional supply chain has to deal with (Kamble et al., 2020). Furthermore, conventional supply chains mostly rest against centralized, disparate, and self-reliant information management systems, which include ERP systems, that have pitfalls depriving sustainable organizational performance (Saberi et al, 2019). Another issue is introduced by Abeyratne and Monfared (2016) who bring up the need for higher trustworthiness that supply chain partners expect from an individual organization or intermediary to store their sensitive and critical information. Moreover, a single point of failure is a problematic aspect of a centralized IS that leaves the system wide-open to errors, illegal treatment, and outside attacks (Dong, Zhou, Liu, Shen, Xu & Luo, 2017). Figure 2-7 illustrates the difference in structure between centralized and decentralized networks. Sueur, Deneubourg and Petit (2012) introduce three different network types: (i) start network, (ii) centralized network, and (iii) equal network, where the star and centralized networks are highly oriented to be controlled by a central authority, whereas equal network represents a decentralized structure that allows distributed information sharing and data recording in the absence of a central authority.

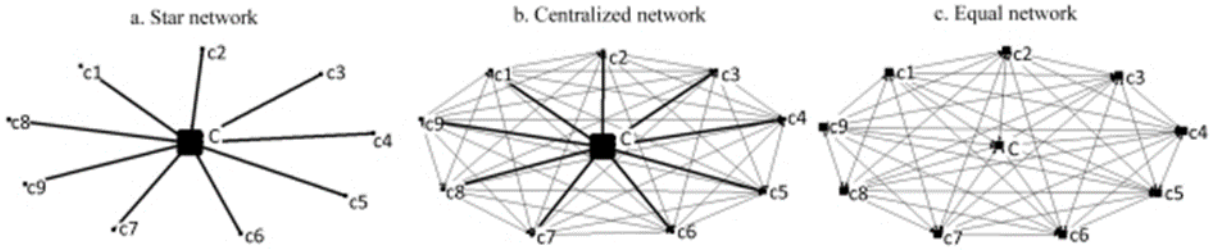

Figure 2-7: Representation of Social Networks (Sueur, Deneubourg, & Petit, 2012, p.4).

According to Kouhizadeh and Sarkis (2018), certain aspects of BC technology can be leveraged to attain sustainable and green supply chains, yet decision-makers and practitioners need to pay heed to warnings and comprehend potential barriers, benefits, and facilitators to support the diffusion of this innovation. In this context, the supply chain contains a great number of both intra-organizational and inter-organizational operations, which are classified into main headings by Kouhizadeh and Sarkis (2018) as follows: (i) upstream vendor management issues (e.g., supplier selection and development); (ii) upstream purchasing, inbound logistics, and inventory management; (iii) internal operations and production activities; (iv) downstream activities (e.g., delivery, green marketing, product marketing); (v) recycling activities (e.g., reverse logistics, reuse, remanufacture, reclaim). When it comes to the sustainability aspect of SCM, additional activities and resources can be included such as waste management, energy conservation, and product design concerns (Kouhizadeh & Sarkis, 2018).

A BC-integrated supply chain comprises the potential to be consistent in the management of supply chains with higher traceability and security, even though its backbone entails the elimination of intermediaries that are responsible to audit the information flow throughout the system (Helo & Hao, 2019). Employing BC to follow-up the details of actions through the supply chain (e.g., performers, timeline, location) is a fundamental functionality by which supply chain partners can obtain a tighter control over inbound and outbound logistics processes via higher tracking ability (Kouhizadeh & Sarkis, 2018). What is more is that easier tracking ability is likely to contribute to performance measurement in the supply chain, together with higher transparency in product quality. Hence, a BC-integrated supply chain network propounds a considerable potential to decrease workload, to obtain higher traceability and

efficiency, to reduce cost, and to deliver higher quality products in a more secure transaction medium (Helo & Hao, 2019).

Saberi et al. (2019) present five essential product dimensions that BC technology can address the questions what, how, how much, where, and who, standing for the following product features, respectively: product definition, product quality, the quantity of product, the location of product, and the ownership of product (i.e., who is the owner at any moment). Starting from this perspective, BC eliminates the need for a trusted central authority that runs the system and enables clients to monitor the whole process from raw materials to delivery without any outside interference on transactions (Saberi et al., 2019). Transaction data regarding each of those product aspects listed above can be recorded into the distributed ledger with accurate verification (Kouhizadeh & Sarkis, 2018). A detailed illustration of the workflow throughout an average supply chain, together with its transformation by the disruption of BC technology is given in Figure 2-8.

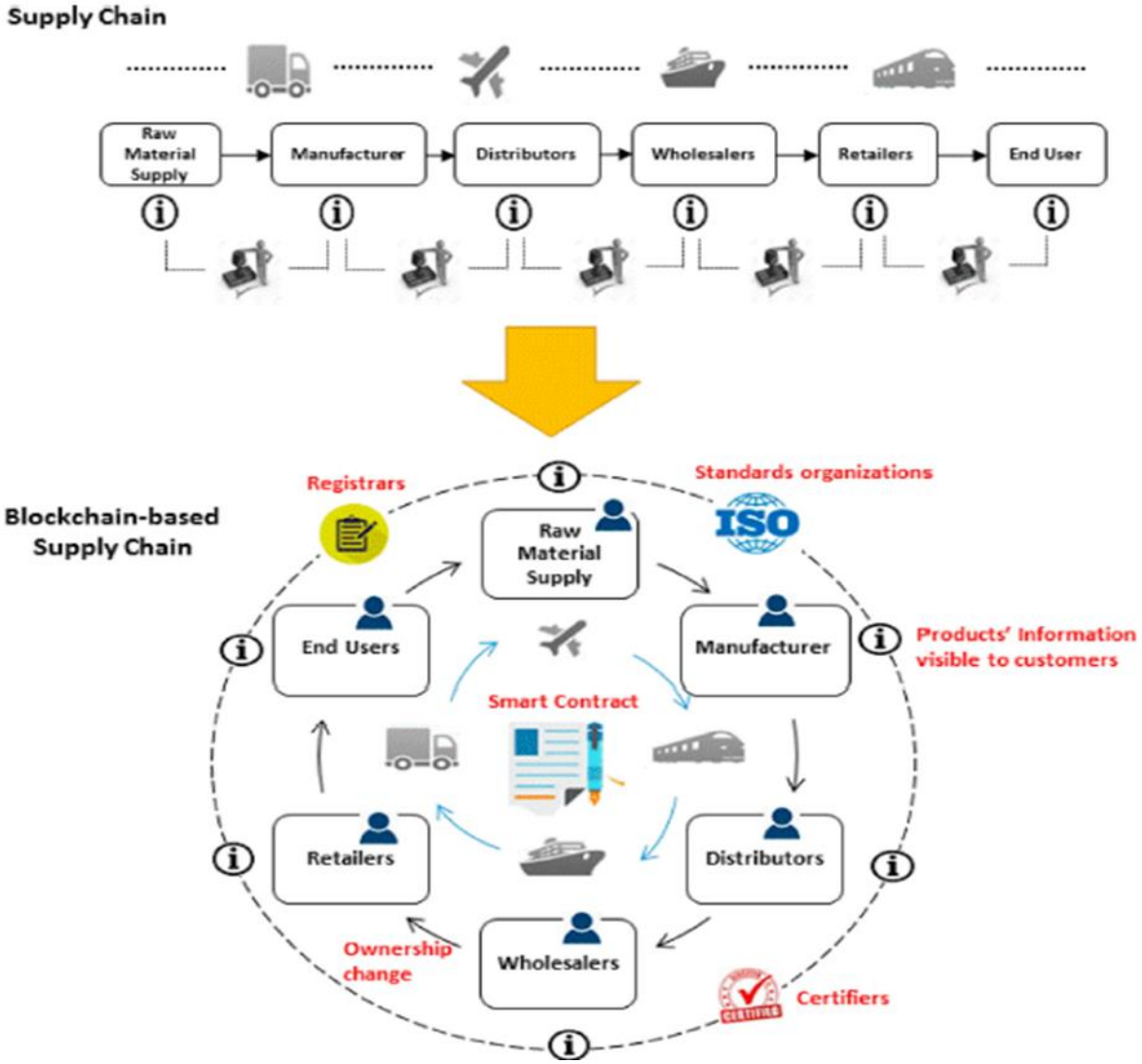

Figure 2-8: Supply Chain Transformation (Saberi et al., 2019, p.2121).

2.3 Aspects of Sustainability and Sustainable Supply Chains

2.3.1 Sustainability

The idea of Sustainability can be drawn-back to the mid-1960s and early 1970s, particularly after the realization of the UN (i.e., United Nations)) conference on Human Environment held in Stockholm in 1972 (Abbasi, 2012). Tay and his colleagues mentioned that the Brundtland Report defines sustainable development (SD) as "invoking the needs of future generations counterbalanced to the current unmet needs of much of the world's population" (Tay et al., 2015, p. 892). The SD is now a household name in the globe that every sector is trying to embrace, for which some of the activities include reducing environmental degradation, achieving social amenity and equity, increasing economic growth, promoting global trade, providing financial effectiveness, and obtaining improved marketability (Abbasi, 2012).

Furthermore, sustainability has strategically established as a fundamental element that must be implemented by companies to strengthen operational processes and gain competitive advantages over other organizations (Hart & Milstein, 1999; Bansal & Roth, 2000; Matos & Hall, 2007; Mann, Kumar, Kumar & Mann, 2010). However, globalization and increasing levels of outsourcing have birthed the dispersion of supply chains across the globe. Consistently, the concentration of research in sustainability has been transferred from local optimization in an individual organization to the whole supply chain (Seuring, Sarkis, Müller & Rao, 2008). At this point, the TBL framework consists of three contextual pillars (i.e., economic, social, and environmental) for entities (e.g., governments, organizations, individuals) to keep in step with the SD agenda (Standing, Jackson, Chen, Boudreau & Watson, 2008). These aspects are further discussed in the following sections.

2.3.2 Aspects of Sustainability

Through the literature, numerous studies address the TBL framework as a means of SD practices (Bansal & Roth, 2000; Matos & Hall, 2007; Vachon & Klassen, 2007; Santiteerakul, Sekhari, Bouras & Sopadang, 2015). The TBL framework is composed of three elements (Figure 2-9) that add up to the overall sustainability performance of an entity or society, which are listed as economic performance, social performance, and environmental performance (Elkington, 2013). Elkington (1999 cited in Elkington, 2013) affirmed that for businesses to achieve corporate social responsibilities, it is of utmost importance to measure and report economic, environmental, and social performance. Winter and Knemeyer (2013) establish that some researchers use different terms such as 3P's (profits, planet, and people) and 3E's (economics, environments, and equity) to highlight their standpoints related to that of TBL. Bals and Tate (2016) mentioned that the three-pillar approach of 3P's should be implemented for sustainability to be met. They proceed to state that the economic aspect of TBL is commonly used by business organizations with a strong foundation for understanding whereas environmental and social aspects are being underused since they are hard to measure. According to Saeed and Kersten (2019), the architect behind the TBL is for companies to achieve reputable social impact, to reduce environmental degradation, and to contribute to environmental sustainability. Moreover, organizations have been faced with a significant amount of pressure both internally (e.g., employees, partners) and externally (e.g., legislators, customers) that forces them to be better off with environmentally and socially sustainable initiatives (Seuring & Müller, 2008).

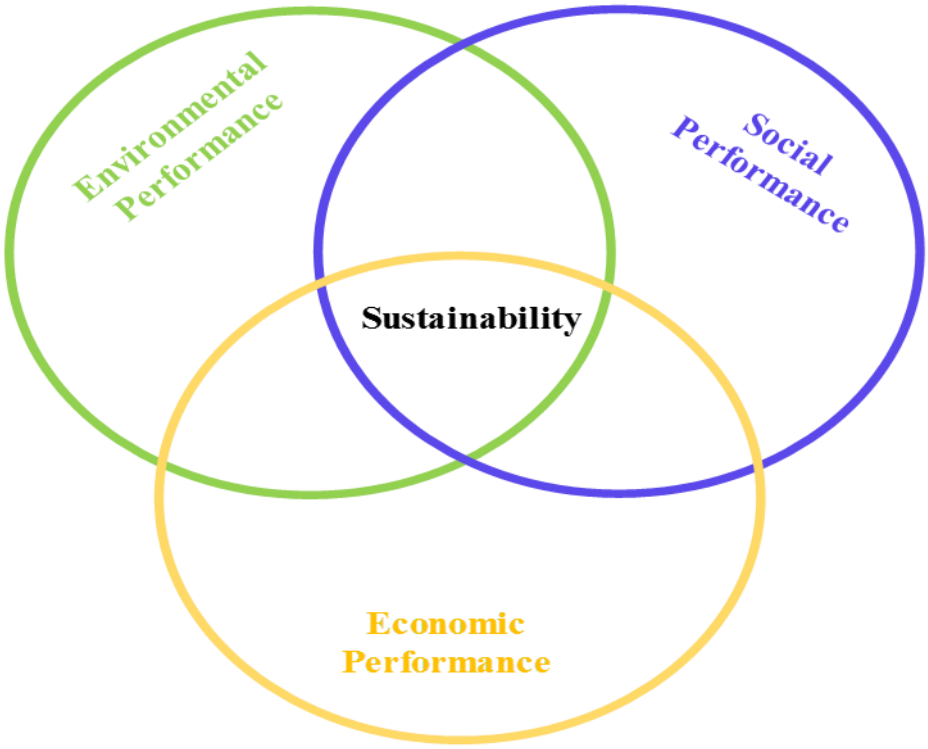

Figure 2-9: Three Pillars of Sustainability (Adapted from Carter & Rogers, 2008, p.365).

Environmental Aspect of Sustainability

The environmental aspect of sustainability involves strategies, techniques, and procedures that encourage extensive environmental practices and responsibilities inspiring the invention and diffusion of environmentally friendly technologies (Vachon, Stephan & Klassen, 2008). A notable number of researchers have placed heavy reliance on this aspect of sustainability up until today (Lehtonen, 2004). It might be unfair to conclude that business organizations have been solely concerned about environmental issues when they are coerced or compelled by the government or customers, considering some companies have already had built-in systems that take environmental sustainability into accounts (Mann et al., 2010). For instance, a nuclear power section which is controlled by governments in every country is required to have strict regulations concerning the disposal of radioactive waste (Mann et al., 2010). Krikke, Le Blanc, and Van De Velde (2004) highlight that life cycle analysis and construction materials enable recovery in which reverse logistics plays a significant role when integrating environmental sustainability practices within the production system of a firm. As established by the World Commission on Environment and Development, sustainability means ‘’Meeting the needs of the present without compromising the ability of the future generation to meet their own needs.’’ (Naik & Moriconi, 2005, p.1).

Economic Aspect of Sustainability

Winter and Knemeyer (2013) confirm that the everlasting impactful accomplishments and competitiveness of an organization is the foundation of the economic aspect of sustainability. On the contrary to social and environmental aspects of sustainability, the economic aspect is mainly perceptible or measurable and it is concentrated towards the effective management of

resources and realizing an ROI (Rumelt, 1974 cited in Winter & Knemeyer 2013). They further claim that it is almost impossible to quantify or analyze the three aspects through the same framework as contradictions may occur within one aspect (e.g., individual versus collective interest within the social aspect) and/or between distinct aspects (e.g., economic and environmental aspects relating to expenditure dimensions). Therefore, it might be of paramount importance to take into account dynamic interactivities between the three pillars. In this regard, Pagell and Wu (2009) deliver an illustrative study, where case studies are conducted to analyze supply chain mechanisms of different organizations to uncover which practices are subservient to companies to stand out in terms of sustainability performance. Their results reveal that the companies' activities that enable more SSC are a combination of best practices in conventional SCM and the latest proactive behaviors towards sustainable operations. For instance, due to the high possibilities of gaining financial benefits, organizations have been motivated to implement reverse logistics practices as a means of cost reduction policies (Chan, 2007), which then contributes to their overall financial performance. What's more is solid commitment and proactiveness seem to be reliable factors for efficiency as long as a company's business model is appropriately aligned with social and environmental components of sustainability, not solely with financial performance indexes (Pagell & Wu, 2009). As argued by Mann et al. (2010) sustainable practices such as impactful and efficient reverse logistics provide organizations with the capabilities to financially perform better.

Social Aspect of Sustainability

The social aspect of sustainability is somehow double-sided as it alludes to both individual and organizational levels (Winter & Knemeyer, 2013). As stated by Lehtonen (2004), the concrete inconsequential circumstances rely on the social aspect, but the social phenomena are inconsequential themselves and hard to analyze. Winter and Knemeyer (2013) explain that stakeholder proposition or hypothesis acknowledges the presence of other stakeholders, with the possible exception of owners who influence the permanence of an organization directly or indirectly. This hypothesis has enabled researchers in investigating the responsibilities of or interactivities between different stakeholders (Winter & Knemeyer, 2013). According to Matos and Hall (2007), these stakeholders can be categorized into two groups: (i) primary stakeholders such as customers, consumers, suppliers, technology consultants, complementary innovators, policymakers, and regulators; and (ii) secondary stakeholders that includes local communities' representatives, activist groups, traders' associations, religious establishments, environmental groups, safety, and social advocates. They hereby reflect that these groups are social forces to reckon with by organizations due to their influence on societies.

2.3.3 Aspects & Enablers of SSCM

When it comes to driving SSC, the pillars of TBL can be divided into subsections for which organizations need to set activity plans and monitor customized key performance indicators. According to Carter and Rogers (2008), the aspects of SSCM can be categorized into four sub-headers (Figure 2-10) as in line with the TBL framework, which are strategy, organizational culture, risk management, and transparency. The three major aspects of sustainability can be met by constructing a complementary working mechanism among them (Carter & Rogers, 2008). These aspects are enabled by a list of drivers that we highlight and explain briefly through the following sections as taking the framework provided by Saeed and Kersten (2019) as a baseline, which then will be shared out to the relevant contexts of SSCM, respectively.

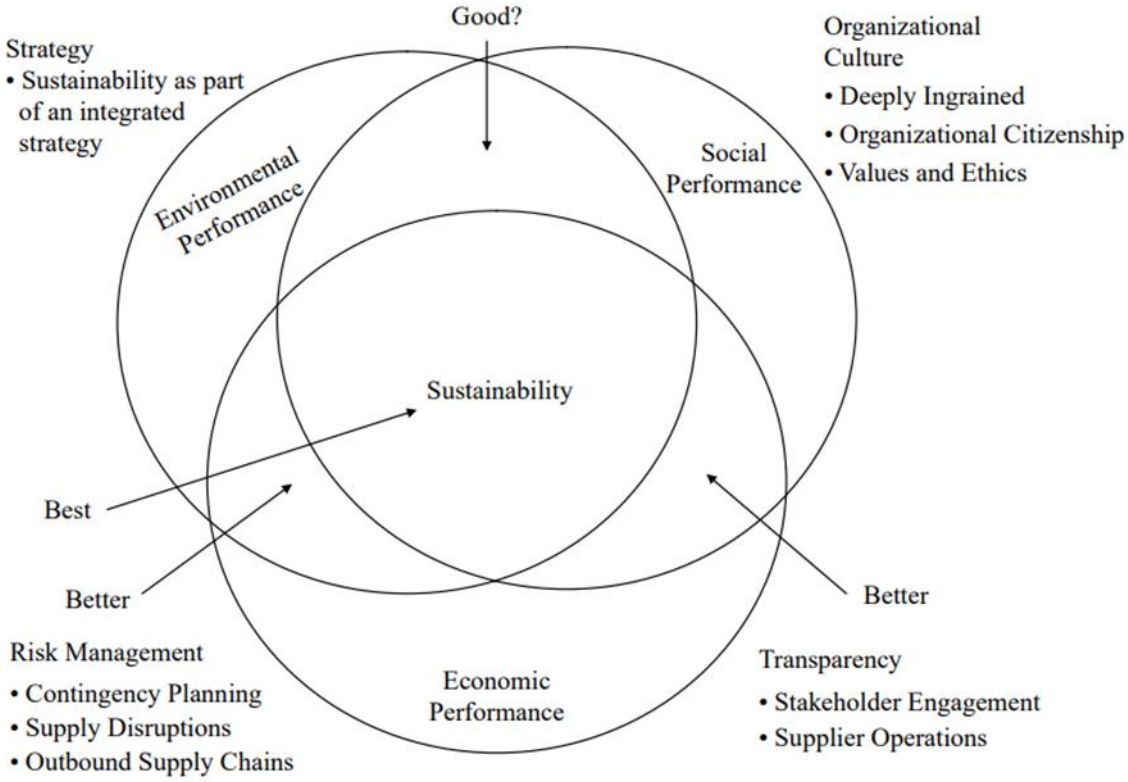

Figure 2-10: Aspects of SSCM (Carter & Rogers, 2008, p.369)

Government Legislation

Government legislation is a primary enabler for the sustainability aspect of SCM, which is referred to as a pressure agent by Saeed and Kersten (2019) that drives organizations to take actions in compliance with SSCM principles. Organizations strive to avoid fines from local governments by taking environmentally sustainable initiatives such as applying compliant waste management policies looking to lower carbon emission (Saeed & Kersten, 2019). The literature shows us that government legislation is a type of driver that needs to be included in the environmental aspect of SSCM.

Customer Awareness and Pressure

According to Saeed and Kersten (2019), organizations strategically strive to match their internal resources to the external demands of stakeholders to achieve SSCM goals. At this point, customers' sustainability awareness can put heavy pressure on the executive boards of companies, forcing them to adjust their organizational strategy to the sustainability agenda (Saeed & Kersten, 2019). From this perspective, customer awareness and pressure are a part of the economical aspect of SSCM.

Competitive Advantage

Gaining a competitive edge over rivals is a driver with which an organization goes for improving all three pillars of the sustainability aspect of their supply chain (Saeed & Kersten, 2019). Having said that, it is directly related to the economical sustainability of a supply chain, whereas feeding both social and environmental sustainability of an organization through brand

and reputation management. Therefore, competitive advantage is a driver for organizations that may contribute to all three performance aspects of SSCM.

Competitors' Pressure

Many organizations are now striving to be ahead of their competitors by taking green initiatives. Some of them are disrupting the market by producing eco-friendly products demanded by customers while their competitors are left with no choice than following their food steps (Saeed & Kersten, 2019). In doing so, this pressure is a reliable driver for organizations to implement sustainable practices in their supply chain. Therefore, competitors' pressure can be related to the economic performance of SSCM.

Cost-Related Pressure

Saeed and Kersten (2019) argue that organizations that run their businesses as in line with sustainability norms are likely to reduce their expenses considerably. In today's fiercely competitive business markets, cost is an indispensable and incontestable indicator for businesspeople more than ever. Organizations gaining awareness of sustainability through the upper management level tend to be more cost-effective through their business operations (Saeed & Kersten, 2019). Having said above, cost-related pressure is a driver for increasing economic performance with SSCM.

Organizational Culture

Organizational culture, which includes several qualifications and standards such as socio-cultural responsibility, innovativeness, code of business conduct, information dissemination, health, and safety policies, is an important driver for SSCM (Saeed & Kersten, 2019). Organizations that stick to their moral obligations tend to meet social expectations from stakeholders (Saeed & Kersten, 2019). An innovative mindset established in a business environment is further promising to derive sustainable products (i.e., eco-friendly) that may satisfy demanding customers in this respect (Saeed & Kersten, 2019). Having a code of business conduct, a culture of supporting information sharing, and being credible in health-related and safety-oriented issues are all some other internal aspects of an inclusive organizational culture that may lead to pursuing a reliable sustainability agenda (Saeed & Kersten, 2019). Having said all above, organizational culture is a driver for the social aspect of SSCM.

Awareness of Top Management

Awareness and dedication of top management is another type of pressure from stakeholders concerning sustainability, which is a forceful driver for an organization to adapt to sustainable policies (Saeed & Kersten, 2019). This approach can facilitate saving costs and boosting the economic indicators (Saeed & Kersten, 2019), which are primary aspects that any given profit-oriented organization places the utmost reliance on. Because of this connection, it can be categorized under the header of the economical aspect of SSCM.

Employee Pressure/Involvement

Engaging pressures from employees can force organizations to adopt a sustainable approach in their supply chain, by which they can acquire experience and skill sets pertinent to sustainable

policies (Saeed & Kersten, 2019). Furthermore, employees can either act individually or as part of a union to press their organization close to implementing sustainable business practices (Saeed & Kersten, 2019). Thus, employee pressure/involvement is a driver that can support the social aspect of SSCM.

Non-Governmental Organization (NGO)'s Pressure

NGOs create public awareness among stakeholders (e.g., media, societal communities, academics) and reflect joint efforts to influence organizations for improving their supply chain operations in compliance with sustainable policies (Saeed & Kersten, 2019). Furthermore, NGOs can raise consumers' awareness of poor social and environmental practices applied by certain organizations, while also encouraging various stakeholders to embrace the concept of sustainability with its corresponding norms (Saeed & Kersten, 2019). Hence, NGO's pressure can be addressed as a driver for social sustainability through supply chains.

2.4 Summary of the Literature Review – Conceptual Framework

2.4.1 Consolidation of BC Characteristics

Decentralization

As a fundamental characteristic of BC technology, decentralization eliminates the need for a central authority, constructing an environment where the data can be recorded into a distributed ledger and shared among BC members.

Immutability

It is an essential feature of BC technology that builds up a tamper-proof architecture to provide data integrity with the use of immutable ledgers.

Transparency

Any member of a given BC network is allowed to track the processing details of each transaction.

Security and Integrity of Data

The integrity of data is provided through the capability of each node to verify published transactions since they are all allowed to obtain a copy of transaction history recorded into the database. The more nodes participated in the system, the more secure the network becomes.

Smart Executions

Smart executions are carried out by smart contracts that allow automated transactions among network players without any intervention by intermediaries. Contract terms and regulations rely upon a consensus mechanism established among network players and stored as digital contracts.

Versatility

It ranges from the preliminary practices of transferring digital currencies to existing and potential industrial use cases of BC technology, including the integration with Industry 4.0 constituents such as IoT devices and RFID tags.

2.4.2 Consolidation of Challenges and Risks with BC

Immaturity of BC technology

This aspect of BC technology includes limited transaction capacity, scalability, latency, uncertainties with technical conformity and copyright management, and intense utilization of consensus algorithms that may place a burden on environmental degradation if not managed properly.

Awareness and Technical Competence

Lack of awareness and lack of technical competence are major issues to deal with when it comes to the adoption of BC technology across non-financial environments.

Organizational Collaboration

Cooperative involvement of stakeholders (e.g., upper management, retailers, suppliers) in any implementation process is crucial for the acceptance of BC as an emerging technology.

Change Management

Change management plays an important role, the absence of which may easily lead to failing in coping with resistance from various stakeholders.

Cost and Functionality

Substantial amounts of investment cost, together with high levels of capacity requirements for energy and storage are major challenges.

Legal and Compliance

Lack of regulatory laws and standards, selfish mining and cybersecurity risks are open issues that blur how to run a sustainable working mechanism for a BC.

2.4.3 Consolidation of SSCM Aspects

Environmental Concerns of SSCM

Environmental concerns of SSCM may be fulfilled by the employment of proper government legislation and the willingness of gaining competitive advantage in business markets.

Economical Concerns of SSCM

The economical aspect of SSCM is nourished from a list of drivers such as customer awareness and pressure; awareness of top management; cost-related pressure; competitor's pressure; and competitive advantage.

Social Concerns of SSCM

Organizations may accelerate their sustainability practices through their supply chain networks in the social context which is driven by NGOs pressure; employee pressure/involvement; organizational culture; and competitive advantage.

2.4.4 Conceptual Framework

After going through the literature and presenting background information regarding our topic of interest, a conceptual framework that encapsulates three major themes has been created. These themes are listed in Table 2-4 as BC characteristics, challenges, and risks with the adoption of BC technology, and the aspects of SSCM. The purpose of this study is to explore the potential benefits of BC technology, together with challenges and risks associated with the adoption of this technology through the supply chain networks so that we can make some inferences on the potential impact of BC technology on the sustainability aspect of SCM. In this regard, after sifting through the mainstream articles, the essential features of BC technology are summarized and gathered in a group consisting of six elements: decentralization, immutability, transparency, security, and integrity of data, smart executions, and versatility. When doing this, the literature shows that there is a list of challenges and risks pertaining to the adoption of BC technology, all of which might be tipping the balance on the success of its applicability in the supply chain. These challenges and risks are presented as follows: immaturity of BC technology, lack of awareness and technical competence, lack of organizational collaboration, change management, cost and functionality, and legal and compliance. Last but not least, starting with the aspects of sustainability based on the TBL framework and expanding it to the drivers of SSCM, the three main aspects of SSCM are wrapped up. A final interview guide is constructed to search for correlations of these aspects with the fundamental features of BC technology.

Table 2-4: Conceptual Framework

Theme	Coding	Notions	Literature
BC Characteristics	BC	• Decentralization • Immutability • Transparency • Security/Integrity of Data • Smart Executions • Versatility	Sultan et al. (2018); Wüst & Gervais (2018); Khan et al. (2019); Tian (2016); Kouhizadeh & Sarkis (2018); Zheng et al. (2018); Atlam & Wills (2019); Viriyasitavat & Hoonsopon (2019); Lin & Liao (2017); Saberi et al. (2019)
Challenges and Risks	CR	• Immaturity of BC Technology • Awareness & Technical Competence • Organizational Collaboration • Change Management • Cost & Functionality • Legal & Compliance	Tian (2016); Zheng et al. (2017); Helo & Hao (2019); Kshetri (2018); Angelis & da Silva (2019); Lin & Liao (2017); Atlam et al. (2018); Kamble et al. (2020); Yaga et al. (2018);
Aspects of SSCM	A	• Environmental concerns • Economical concerns • Social concerns	Saeed & Kersten (2019); Winter & Knemeyer (2013); Elkington (2013); Carter & Rogers (2008); Pagell & Wu (2009); Matos & Hall (2007)

3 Research Methodology

In this chapter, the authors of this thesis explain the methodology selected for the thorough investigation of the research question and the rationale behind these selections. It explains the interpretive approach employed by using interviews as the source of qualitative data collection techniques. The interview technique and process are rigorously explained as it is divided into two parts, the pre-study, and the main study interview. The rationale for the choice of our interview's participants is also presented, followed by a data analysis strategy. These research methodology procedures are implemented according to the ethical and professional standards that ascertain the acceptable quality of the tools, techniques, and methods used to derive content-rich findings.

3.1 Research Strategy

The adaptation of a suitable research strategy is of utmost importance as argued by Recker (2013), where research questions are the main determinants of having an appropriate research strategy. As this study is concentrated on investigating whether the adoption of BC technology for SSC is a worthy disruption, it is of paramount necessity that the research method can serve as solid guidance towards answering the research question. In this connection, we argue that qualitative research is the most suitable to adopt, as Recker (2013) and Bhattacharjee (2012) have both affirmed that it is a befitting strategy when exploring a phenomenon which has not yet been fully understood, established or that is still in its emerging state. The field of IS seems to be rather immature when it comes to the evaluation of BC technology in the context of SSCM. We further contemplate that adopting a qualitative research strategy is highly convenient for answering the research question of this thesis since we aim to research into the potential impact of BC technology on the aspects of SSC, together with benefits, challenges, and risks associated with the use of BC technology. Furthermore, conducting a qualitative study through a contextual framework built around this highly emerging field of interest brings in a diverse set of ideas and viewpoints for us to reap.

As several research paradigms are included in the literature (Bhattacherjee, 2012; Recker, 2013), we decided to conduct an interpretive research study that relies on deductive reasoning since our phenomenon of interest stands for a relatively recent issue that needs to be further studied. Another reason of applying such an approach was that as Recker (2013) sets forth in his arguments, interpretivism tackles words, expressions, and hence more of a qualitative type of data instead of analyzing numerical data. Furthermore, considering the relative immaturity of our phenomenon of interest in the literature, constructing a conceptual framework around our implications from the literature was a more suitable option rather than theory-testing since our aim was not to carry out a case study or analyzing the technical implementation phases of BC technology in supply chains. Instead, we were off to reach out to a basis for future studies that can further work on building grounded theories regarding the use of BC in the SSCM context. Considering the rising popularity of BC technology to be integrated with supply chains, our first thought was to make use of some secondary data as well since there are also lots of quantitative materials (e.g., sustainability reports, financial reports, yearly or quarterly activity reports, etc.) studied by practitioners that can be related to our research topic. However, we then figured out that the adoption of BC technology is widely considered as a C-level or senior

executive level decision to make since it is part of gaining a competitive advantage in the market, which makes acquiring those materials even harder. Moreover, it is argumentative that incorporating quantitative data into our study might enhance the reliability of our findings even further, however, we needed to define a boundary to the range of content that we obtained, considering the time and resource limitations, especially after the frightening Covid-19 pandemics that makes data collection process more difficult. Therefore, we decided to stick with interviews so that we put all our efforts in this regard to find out the most reliable and suitable informants as many as possible.

3.2 Data Collection

3.2.1 Conducting the Literature Review

As we had firmly established that we would conduct a study on BC and SSC through a qualitative research strategy, we took the three-fold purpose of a literature review as a baseline, which is introduced by Bhattacharjee (2012). The first step was to conduct a literature review to scrutinize the current state of knowledge within the field of study (Bhattacharjee, 2012). The second step was that we highlighted the key findings and theories within the field of study; and the third step was to spot the knowledge gap in the literature (Bhattacharjee, 2012). We had meticulously scrutinized the existing literature to problematize existing theories and hereby develop our research question. Alvesson and Sandberg (2011) establish that in the process of constructing a research question, it is extremely important to formulate research questions that have the tendencies to create solid impacts on the literature, therefore, the concentration must not be placed on spotting gaps or building gaps in available theories; instead problematizing the existing theories and challenging the assumptions underlying the current literature should be the main focus. It is arguable if our literature review has been focused on gap spotting or problematization, nonetheless our literature review has been geared towards the explanation of Alvesson and Sandberg (2011) of problematization of the existing literature.

After going through the literature, we spotted that several studies study the BC technology and its features as is the case with many other studies revolving around SSC and their aspects. However, we identified that there are only a handful of papers covering the affinity between these two fields of operation, and to the best of our knowledge, there is almost no paper conducting a bilateral study with pros and cons of BC technology adoption in the context of SSCM. We have made use of Google Scholar and the Lund University Library search engine to search for a series of terms associated with our topic of interest. In this regard, the relevant literature is identified with the use of the following queries:

- (“Blockchain Technology” OR “Blockchain”) AND (“Sustainability” OR “Supply Chain Management” OR “Sustainable Supply Chains” OR “Sustainable Supply Chain Management”)
- (“Greening Supply Chains” OR “Green Supply Chains”) AND (“Blockchain Adoption” OR “Implementation of Blockchain” OR “Deployment of Blockchain”)
- (“Challenges with Blockchain” OR “Risks of Blockchain Adoption”) AND (“Blockchain in Logistics” OR “Blockchain in Supply Chain Management”)
- (“Types of Blockchain” OR “Forms of Blockchain”) AND (“Supply Chain Management” OR “Supply Chain Use Cases” OR “Logistics Industry”)

- ("Tripple Bottom Line" OR "Aspects of Sustainability") AND ("Blockchain" OR "Adoption of Blockchain" OR "The Impact of Blockchain")

Randolph (2009) reflects that it is beneficial for extracting further insights if researchers look into the references that had been used within the articles they covered. This is exactly what we applied as part of our literature review strategy from the very beginning of this research since it also brings us a chance to easily identify highly acclaimed papers in our field of interest. Furthermore, these secondary articles provided us to extend our fund of knowledge with different aspects and concepts associated with our topic of interest. Besides looking in mainstream journals and publications, we argue that this approach improves the accuracy and agility of our literature review.

3.2.2 Selection of Respondents

For a thorough data collection process to smoothly extract concrete answers for our research questions, our initial intention was to employ the technique of face-to-face and video conference interviews with the selected participants from different disciplines that are related to the adoption of blockchain for SSC. However, we had been left with no choice other than to only conduct these interviews through video and audio conferencing due to the COVID-19 pandemic virus that has brought the world to a standstill. We had directly contacted the interview participants via electronic mail (e-mail) or phone and indirectly researched out to some interviewees through LinkedIn messages and frequent trackers and reminders.

Since our study is a qualitative endeavor that entails collecting qualitative data, our primary source of data collection was interviewing, about which Bhattacherjee (2012) mentioned as one of the prominent techniques of data collection in a qualitative approach. The selection of respondents is very vital in this research and we used the idea of selecting respondents from different organizational levels and context with connection to BC technology in SSCM (Bhattacherjee, 2012). We strived to find out respondents that could be perfect fits to our topic of interest as helping us answer our research question. The interviews aimed to gain an understanding of the adoption of BC in SSCM, together with benefits, challenges, and risks, which were identified to collectively adds up to the reasoning of whether BC technology is a worthy disruption for SSC.

We chose three sampling methods that we believed were applicable to our work, which are convenience, expert, and snowball samplings (Bhattacherjee, 2012). According to Bhattacherjee (2012), convenience sampling entails selecting the available respondents and that was what we had done since we sometimes faced struggles in finding contacts through this process. The expert sampling is selecting the respondents that possess the technical know-how pertaining to the research topic (Bhattacherjee, 2012) and this was what we had executed by targeting people that have expertise on BC technology and SCM, preferably the ones working for corporate companies. Furthermore, the snowball sampling is done by reaching out to the target respondents with very high experience in the intended area of study and asking them recommendations for other experienced people to interview (Bhattacherjee, 2012). We had done so with the targeted respondents that we contacted through emails and LinkedIn.

We began searching for respondents that have the technical-know-how about BC and SSCM and also work for a huge supply chain or consulting firm. We looked into a set of suitable companies operating in this field of business and got in touch with their personnel through their

websites. This was challenging for us as we could not get direct contact with their personnel, which prompted us to utilize LinkedIn as a research engine for the most part. Again, we searched for big companies dealing with BC technology and that have extensive supply chain organizations. For this, we also went deeper to search for personnel working in the domain and who we believe has a suitable background to get insights from. However, due to the time and resource limitations that we encountered during this process, we also considered medium size companies to target. While concerning these criteria, we always stuck with the mindset of including a company or personnel that is obviously attached to BC technology and SCM in practice, which we believe enhanced the reliability of our research study.

To elaborate our respondent selection criteria a bit more, we selected respondents that were available but met our criteria for our research and also asked them for recommendations to connect us with other colleagues that are eligible as well. We managed to get eight eligible respondents through LinkedIn, apart from many that declined our requests by showing reasons regarding their unavailability, specifically due to certain issues that overburden their schedule after the prevalence of COVID-19 pandemic. Generally speaking, both the natural and legal people that declined our requests showed interest in our research area, though they could not make time for participating in our study. Reaching out to the maximum number of eligible respondents to the best of our efforts were included in our agenda since the very beginning, just to extract a big volume of data that would be sufficient for the analysis part. We strived to reach out to a distinguished list of respondents based on certain criteria, regarding which being a stakeholder of a supply chain in any given industry and having a solid foundation of BC technology were the ones that we placed utmost reliance on. Our contacts are given through the following tables (i.e., Table 3-1 and Table 3-2), who are working in various industries, which we believe militated in favor of the diversity of our findings.

Table 3-1 List of Respondent Details

Respondent Code	Location	Organization	Position & Designation
R1	Sweden	Anonymous	Operations Manager, Supply Chain Expert
R2	United Kingdom	Anonymous	Manager – BC-powered Supply Chain Operations
R3	The Netherlands	DSV Global Transport and Logistics	Director of Product Development-BC Expert
R4	United Kingdom	Anonymous	Director-Senior BC Market Specialist
R5	Sweden	PwC	Director of Digital Trust – Strategic IT Management

R6	Denmark	Deloitte Digital Nordic	Director, Lead of BC Operations
R7	United States	EY	Manager - Digital Supply Chain & BC
R8	Finland	Empirica	CEO, BC Lead – Consultancy to Arla Foods

Table 3-2 List of Interview Details

Interview Code	Respondent Code	Date	Interview Type	Duration of Record
Pre	R1	4/15/2020	MS Teams Audio Call	56:49
Main	R2	4/22/2020	Zoom Audio Call	1:03:33
Main	R3	4/23/2020	Skype Video Call	1:26:06
Main	R4	4/23/2020	Zoom Video Call	53:15
Main	R5	4/27/2020	Skype Audio Call	1:15:26
Main	R6	4/28/2020	Zoom Audio Call	1:31:05
Main	R7	4/28/2020	Zoom Video Call	1:44:47
Main	R8	4/30/2020	Skype Audio Call	1:56:13

3.2.3 Interviews

Since we had opted to conduct qualitative research, we had to use qualitative techniques for collecting data. Interviewing is one of the forms of data collection in a qualitative research study that can vary in context as descriptive, exploratory, and explanatory interviews (Recker, 2013). We claim that our interviewing technique was descriptive, as we intended to provide a substantial explanation of how people within the field of interest of this thesis viewed the

underlying phenomena so that we can model thorough descriptions around our theoretical framework (Recker, 2013). Regarding this, the list of our main phenomena in this study consists of the adoption of BC technology in SSCM, benefits of BC technology for supply chains, and challenges and risks associated with BC technology, all of which were expected to collectively reflect an overall evaluation on whether the BC technology is a worthy disruption for supply chains.

Furthermore, interviews may differ in nature as structured, unstructured, or semi-structured interviews (Myers & Newman, 2007; Recker, 2013). We argued that semi-structured interviews are the most appropriate for our study since we would like to conduct these interviews in a conversational and more flexible form where we could extract deeper insights by asking follow-up questions as needed (Myers & Newman, 2007; Recker, 2013). This also gave us room to discuss other topics that emerged during the interview. In this connection, all these auxiliary topics allow us to see an extensive range of aspects regarding our phenomena and also to formalize another subheading in Chapter 4 called “Other Empirical Findings", where we presented other critical issues that may set a course for future studies to work on. Semi-structured interviews come with benefits such as flexibility in communication, meaning the ability to confirm what is already known and seeking any opportunity for further learning (Recker, 2013). According to Recker (2013), respondents tend to discuss sensitive issues in a semi-structured interview more than they do in a structured interview format, of which we took advantage throughout all eight sessions we performed. In addition to that, we further applied some other interviewing techniques during these sessions that include the silent probe, overt encouragement, asking for elaboration and reflection (Bhattacharjee, 2012). We applied the silent probe in some instances so that the respondent gave more detailed information. We applied the overt encouragement of the words “Okay”, “Got it!”, “I see”, which motivated the respondent to go deeper into details. We also asked for elaboration in some instances from the respondent, which were generally a follow up to the previous question. We also reflect on their answer in some instances by repeating what they answered, just to affirm the accuracy of our understanding.

A list of preliminary interview questions (i.e., Appendix-2) was used as a benchmark to develop the main interview questions. In this respect, we developed our final interview guide according to the four steps of an interview concept introduced by Myer and Newman (2007), which avoids researchers being restricted to a manuscript. Firstly, we began by preparing the interview opening that consists of warm-up questions to be acquainted with the company and respondent profile; secondly, we organized an introductory part with questions towards the overall evaluation of BC technology and its potential use cases in supply chain networks; thirdly, the key questions were formulated regarding the nitty-gritty aspects of the research area (i.e., the relation between BC characteristics and the three pillars of SSCM); and finally, the interview closure is handled by a list of questions related to any further thoughts or clarification that the respondents may bring in. We often requested the participants to be more elaborative on any response that we found impactful or insightful. Lastly, when we realized that more information was required on a particular aspect, we requested further communication chances through e-mails or some short follow-up sessions if we deemed it necessary.

The Pre-Interview

Since we primarily intend to validate the suitability of our research topic, we arranged a pre-interview session to test the reliability of our standpoint and research questions. Before going into this session, we extracted a list of preliminary questions (i.e., Appendix 2) based on the

literature that we covered and sent them to the relevant respondent for his evaluation. Conducting a pre-study interview firstly brings us the chance of focusing on the right points regarding the aspects of BC technology and its relationship with SSC. Accordingly, we discovered further issues to consider by which we structured our interview questions and sharpen our demeanor to be clear on what we are trying to extract from this study. In this case, we built our interview guide from scratch, which then paves the way for asking more relevant and rightful questions around our field of interest. The respondent of our pre-interview was a middle-level manager who has been involved in supply chain operations for more than 20 years. He also reflected that he has participated in some sort of pilot projects regarding BC-integrated supply chains, which made him a feasible contact person to include in our respondent pool.

Main Interviews

The main interviews were conducted with BC and supply chain experts who possess extensive knowledge and profound skills in the area of our research topic. As Bhattacherjee (2012) and Recker (2013) explicitly reveal, qualitative interviews can be carried out in three different forms such as face-to-face, by forming focus groups or telephone/conferencing. We first intended to conduct most of our interviews face-to-face, which again has been affirmed by Bhattacharjee (2012) and Recker (2013) as one form of interviewing that allows researchers to extract deepest and latest expressions in addition to verbal responses. The original plan was performing a couple of online interviews as well when the conditions are not feasible to do it face-to-face. In this context, we envisaged identifying the differences at first hand between these two different types of interviewing techniques and their impact on our study. However, we could not find a chance to conduct any face-to-face interview with the COVID-19 pandemic coming into view. Nevertheless, our efforts in finding suitable contact people paid dividends so that we could reach out to a total of eight respondents which are all experts in both BC and SCM. After the last interview, we saw that data saturation was obtained and we were not acquiring any findings differentiating from the previous implications, and thus we stopped interviewing and kept on data analysis with a higher focus.

When planning the time schedules of our interviews, we ensured that the participants had the convenience to select anytime according to their time zones. This is in line with the affirmation of Schultze and Avital (2011) that interviews must be conducted according to the availability and comfortability of the respondents. Some of our interviews were conducted as video-conferencing as the respondent felt okay with that. The reason behind this was that we wanted to alleviate the disadvantage faced by the elimination of all chances to conduct face-to-face interviews. In this context, video conferencing was the closest type of interviewing for us as we sought to observe and interpret our respondents' expressions, body language, and outstanding statements as well (Bhattacharjee, 2012). On the other hand, five of these interviews were conducted as audio calls because of the privacy decision of the respondents, regarding which we stayed on the sidelines. We did not experience any miscommunication during these sessions as we sent our main interview guide to the respondents prior to each session, which made them familiar with the content and our intentions and let them prepared for accordingly. This also led us to have more room for follow-up questions during the session, by which we could extract some further and deeper insights regarding our topic of interest.

In addition, to be able to extract as much relevant information as possible, it was of paramount importance to identify the level that the participants are on and endeavor to blend our level to their own, in terms of language, the responsibility of the interviewer and interviewee, as well as the rightful disposal of implications (Schultze & Avital, 2011). Before the commencement

of every interview, we sought for the respondents' permission if the interview could be recorded and their names could be published (Bhattacherjee, 2012). Accordingly, we vouched for our demeanor by holding in high esteem to the confidentiality of their organizations as in line with Non-Disclosure Agreements (Recker, 2013).

3.3 Data Analysis

As Bhattacherjee (2012) and Recker (2013) addressed, qualitative data analysis techniques include coding, memoing, critical incidents, content analysis, and discourse analysis, where we used coding techniques to extract meaningful information from a large chunk of data. Furthermore, Basit (2013) sets forth that coding techniques are used for analyzing, organizing, and making sense of qualitative data, which is textual and unstructured rather than being numeric. Accordingly, as in line with what Bhattacherjee (2012) highlights the significance of, we transcribed our recordings after every interview and made sure that the respondent was neither misinterpreted in the analysis nor his/her quotes were inaccurately written out.

3.3.1 Transcribing

We carried out transcription in all of our interviews and mainly done with them after every interview. This has also been mentioned in Bhattacherjee (2012) that after every interview is completed, it should be transcribed to written text for analysis. According to Brinkmann and Kvale (2005), transcription is the conversion of oral data into written data. Recker (2013) argues that interviews should be transcribed, as they serve as a key source of evidence in data collection. When conducting the interviews, we asked the respondent if he/she is fine with the interview being recorded and in our case, they all agreed. This is also a part of research ethics and quality that should be followed, implying that interviewers should ask for the permission of the interviewee before recording the interview session (Bhattacherjee (2012). We did the transcribing separately after every interview and came together to review for any contradiction. The transcriptions of our interviews are showcased in Appendices 4-11. All our interviews were conducted in the English language, which made it easier for us to transcribe without any further translation. These transcripts helped us to generate a large amount of qualitative raw data by which we applied coding to be able to get meaningful information for the sake of our study.

3.3.2 Coding

Coding is the process of categorizing a large chunk of data into a set of codes to extract meaningful information (Bhattacherjee, 2012 & Recker, 2013). Recker (2013) argues that coding can be seen as data analysis, as it is an interpretation of data. We assigned codes and subcodes to the themes discussed during the interview. This helps in the reading of this paper by eventually being able to see patterns and correlations between the theoretical framework presented and the empirical findings (Bhattacherjee, 2012). We also applied color codes in the coding process to uncover similarities and differences in response (Bhattacherjee, 2012), which can be found in Appendix 4-11. We all participated in the selection of codes and subcodes for the sake of research ethics and quality, to avoid a one-sided evaluation (Bhattacherjee, 2012). We also discovered some auxiliary findings during the interviews for which we decided to

construct a separate category as "Other Empirical Findings". Though this was not our main focus per se, we deemed it necessary to include them in the part where we presented our findings, so that we could open other doors for future research. The coding scheme is represented by Table 3-3.

Table 3-3: Coding Scheme for Data Analysis

Themes	**Codes of the Themes**	**Notions**	**Sub-codes**
BC Characteristics	BC	Decentralization	BC – D
		Immutability	BC – I
		Transparency	BC – T
		Security/Integrity of Data	BC – SI
		Smart Executions	BC – SE
		Versatility	BC - V
Challenges & Risks	CR	Immaturity of BC Technology	CR – IM
		Awareness & Technical Competence	CR – AWC
		Organizational Collaboration	CR – OC
		Change Management	CR – CM
		Cost & Functionality	CR – CF
		Legal & Compliance	CR – LC
Aspects of SSCM	A	Environmental concerns	A – En
		Economical concerns	A – Ec
		Social concerns	A – So
Other Findings	OF	-	-

3.4 Research Quality and Ethics

3.4.1 Research Quality

As we strived to accomplish quality research, we applied the seven principles of an interpretive field study described by Klein and Myers (1999). This approach includes the following list of principles: the fundamental principle of the hermeneutic circle, contextualization, the interaction between the researcher and subject, abstraction and generalization, dialogical reasoning, multiple interpretations, and suspicion (Klein & Myers, 1999). Further elaboration on these principles in connection to our study is mentioned below:

- First, the fundamental principle of the hermeneutic circle suggests that achieving an understanding of the relevant phenomena requires a repetitive process between the dependent connotation of parts and the whole that they form. We aimed at developing an understanding of BC technology as a means of SSCM.
- Second, the principle of contextualization requires a detailed background of the research to comprehend the current affairs regarding the topic of interest. We aimed at getting the idea and a clear picture of what we are dealing with through our literature review so that we could achieve our goals in all the steps of our research.
- Third, the principle of the interaction between the researcher and the subject requires a critical review of how data is retrieved through a forward-backward questioning routine between the researchers and participants. We attached great importance to our interviews by conforming to all scientifically specified ethical principles.
- Fourth, the principle of abstraction and generalization requires doing a critical review, by interpreting, comparing, and contrasting the implications obtained from the results through analysis and literature review. We also analyzed our inferences and compared them with theoretical background through Chapter 5 in this thesis.
- Fifth, the principle of dialogical reasoning requires taking into account some potential overlapping between the theoretical background and the results of the analysis with a further routine of revision. This principle clearly explains itself and we carried it that way.
- Sixth, the principle of multiple interpretations entails a critical review of possible variances in the interpretations among participants saying the same thing differently. We carefully examined the answers of the participants to the questions asked to their knowledge of understanding, area of specialty, and morals.
- Seventh, the principle of suspicion requires taking into account possible prejudice and constantly twisted narratives collected from the participants. We took into consideration this principle by ensuring that the respondents were well informed about the scope and goals of this study prior to the interview sessions, which minimized the chance of obtaining ingenuine answers from them.

3.4.2 Research Ethics

Ethics, as defined by Bhattacherjee (2012), is an ethical difference between right and wrong and something unethical may not be essentially illegal. In this research, we strictly followed the code of ethics for the AIS (Association of Information Systems), which includes two categories, namely categories 1 and 2. Category 1 as mentioned in Bhattacherjee (2012), includes plagiarism and falsification of data, research procedure, or data analysis. Category 2 includes a

lack of respect for the right of research subjects, changing the original meaning or focus of a research project for personal interest, and using data or other resources of researchers without acknowledgment. In this paper, we had taken all precautions in the aspect of plagiarism by trying to reference or acknowledge any exterior material, discourse, or statement that did not belong to us. Furthermore, we never fabricated or changed the previous works done by researchers in the relevant area of study, implying that we held their work in high esteem. We carried out standard research procedures concerning our topic and we were neutral in the analysis. Regarding this, we paid utmost attention to the data integrity of our transcripts to ensure that we were not overlooking any data that could be used for our analysis. To put it in a nutshell, the data analysis was conducted neutrally and transparently in this regard.

Moreover, in this paper, we conducted qualitative research, in which interviews were the main tools of data collection as we completely adhere to the principles of ethics such as voluntary participation and harmlessness, anonymity and confidentiality, disclosure, analysis, and reporting (Bhattacherjee, 2012). Due to the restrictions that came up with the COVID-19 pandemic, we were obliged to conduct all the interviews online, before which the participants were informed through email and notified by occasional reminders whenever it was needed. Their participation in this project was voluntary, implying that they could withdraw at any point in time without any consequences or harm. As in line with what is reported by Bhattacherjee (2012), the authors sought the respondents' consent to record the interview for transcription purposes related only to this study. We also treated the confidentiality of our participants with utmost regard by keeping their identity classified, which was the same procedure that we also followed regarding the companies they are working for when they asked for anonymity in this respect. The disclosure principle (Bhattacherjee, 2012) was carried out as delivering the interview guides to the relevant participants to prepare them for interview sessions, which then also stimulates the efficiency of each succeeding interview with the use of feedback obtained from the previous session. Further in the process, as complying with the norms introduced by Bhattacherjee (2012), analyzing and reporting processes were fulfilled by accommodating ethical rights that prohibit disclosing any scientifically illegal or unexpectedly harmful findings. Finally, while maintaining originality throughout the entire paper, this thesis aimed to contribute to the existing fund of knowledge in the IS field of study by delving into the potential impact of BC technology on SSCM.

4 Empirical Findings

This chapter delivers the implications from the semi-structured interviews that we conducted to collect data and is divided into the associated themes in accordance with our theoretical framework that we presented through section 2.4.4.

4.1 General Overview

The respondents who participated in our study are all highly authorized in both fields of specialization composing the backbone of this thesis, which are BC technology and SCM. After conducting interviews, we have attained the implication showing that professionals working for different functions in various industries have a diverse range of reflections on BC and its potential impact on the sustainability aspect of SCM, which we have gladly perceived for the sake of content diversity in our study. Regarding this, having discussions with various industry professionals on different use cases of BC and prospective agendas in development pays dividends both in the consolidation of fundamental principles and the segregation of specific points regarding BC and SSCM.

R2, a manager in a consultancy company, who is responsible for carrying out BC-powered supply chain operations shared his overall view on the role of BC in supply chain operations:

"[…] what BC does is to give companies a way to share a subset of information to solve a common problem together, the traceability problem, the accountability problem, or just like tracing provenance furthermore, so it complements what the ERP systems are doing already for supply chains." (R2:4)

In this context, he/she states that BC is very applicable to the domain of supply chain since it aims at solving issues that are common for supply chains where information is considerably scattered and silos of data are not fully connected (R2:20). The integration of BC with the current ERP systems as a front-end application that sits on top of everything makes BC inclusive towards all the parties involved in the network (R2:20).

Meanwhile, R3, who is a BC expert and the director of product development at DSV Global reflects that the biggest promise with BC is that, once there is a predefined contract within the BC structure, an incumbent fills in an order that is being fulfilled with payments as automatically transferred from one party to another, which makes the whole chain of companies connected as increasing the speed of operations (R3: 6). The second aspect R3 draws attention to is supply chain finance, where BC potentially leads to a lot easier financial solutions through automation, handling payments that can vary through the process from procurement to the end product (R3:6). Thirdly, he points out that the BC technology establishes a direct interface between the ERP systems of buyer and seller, which ensures the existence of a one-way or two-way, secure connection without allowing data loss through information transfer (R3:6).

R4, who is a senior BC market specialist and a director at a leading consultancy company propounds that the star point of BC technology is having the ability for numerous people who don't trust each other to write to a single common ledger, where all the shared materials fly through it once this trustless system is constructed (R4:76). When it comes to the overall

evaluation of prevailing ERP systems, he/she also addresses the inflexible nature of these systems that require intense technical governance and legal compliance, where he believes BC facilitates the flow of operations with strictly defined working parameters to govern the network. Accordingly, R5 demonstrates the importance of this feature with different product segments as follows:

"[…] when I take receipt of the pen I have, a little code which opens up a little address that allows me to see all of the manufacturing steps that have happened with this pen all the way back to barrel of oil. Is it interesting in manufacturing pens? Not really. Is it interesting when it comes to diamonds, gold – Yes! Is it interesting with things like tobacco? Absolutely." (R4:6)

In this context, R5, who is a director of digital trust at a prominent consultancy company explains the overall view of how to manage BC technology by the following discourse:

"[…] Access and change management, as well as the environment itself, are managed in a controlled way, and the development is stringent and followed by some use cases and test cases. In terms of management –standards, governance, and establishing policies – BCs are quite similar to how many other technologies shall be managed. How to apply BC would be different, but the management of BC and many other technologies is alike to me in that sense." (R5:18)

R5 further explains the benefits of this technology by pointing out its key bringings, including transparency; more precise and structured governance; a bottom-up approach rather than the traditional top-down approach; efficiency and effectiveness, which we combined and attributed as functionality in our framework (R5:12). Accordingly, R3 also points out similar aspects by highlighting the decentralized database architecture of BC technology, data immutability, and security that gives a specific functionality and uptime, which are all invaluable aspects for SCM (R3:116). Regarding the same issue, R4 sees decentralization as an enabler for value creation through the shared networks (R4:66).

According to R6, who is the leader of BC operations at Deloitte Digital Nordic, BC is all about the ability to make sure whatever person A is seeing is the same that person B is seeing up to the end destination, meaning a massive improvement is put in place if there is a shared view of what is happening across all the different stakeholders participated in the supply chain network; whereas the second layer is where trust is established without the use of any intermediary; and third step is using smart contracts on top of everything such as financing and handling payments (R6:8). Regarding this, he adds that BC holds the potential of doing the most disruption and transformation one has ever seen associated with the SCM. As is the case with what R4 reflects, R6 brings forward that BC technology has the flexibility and maneuverability to be applied to a supply chain scenario, without any limitation in terms of performance (R6:12).

R7, who is a manager for the digital supply chain business at EY, describes that BC's value in a supply chain comes from the ability to create visibility between parties, which is a pretty similar reflection to the ones shared by R3, R5, and R6. He explains the essence of this contribution with the following words:

"As soon as the inventory leaves my system and it enters yours, I lose track of where it is. I'm not sure if you shift it to the retailer, I'm not sure if you put it in the basement and forgot about it, it is all point-to-point. So, what we envision with the BC is using it to share information. What if all of the supply chain parties could read and write, could have a shared ledger of all

of the inventory in the network? So, that is how we see the transformation of supply chains' visibility throughout." (R7:26)

Lastly, R8, who is a BC lead in a company that gives advisory services regarding the implementation of BC into supply chain networks, defines BC technology as an enabler rather than a specific supply chain solution, meaning it is a backbone for separate systems, a protocol for all the participants to join and act in compliance with the same rules without exceptions (R8:8). He further reflects that conventional supply chains that companies are involved in are very complex, long, and hard to manage where the lack of visibility is a downside for effectiveness (R8:6). Thus, R8 describes the transformation that BC has the potential to bring in as follows:

"[…] it is not only the company acting at the end of the chain that would benefit, but also parties having a role earlier in the chain because they would be able to see the demand at the end, plan their own operations, and schedule things, carry the stocks to be prepared for the fact that the order will come. So, overall, the end-to-end visibility in a secure way is the promise of BC solutions would have as opposed to traditional ways of handling the supply chains." (R8:6)

4.2 Aspects of SSCM & Correlations with BC Characteristics

This section presents the details and results collected from the views of respondents on the correlation between the six characteristics of BC summarized in our theoretical framework and the pillars of SSCM as in line with the TBL approach. Each pillar (i.e., environmental, economic, and social) is evaluated separately while the lines associated with the responses through interviews are given by some illustrated figures. In the end, the results are demonstrated in figures by the level of correlations on a 3-point scale, respectively.

4.2.1 Environmental Context

Regarding the issues occurring around the environmental concerns of SSCM, R2 centers upon the use of BC to stimulate paperless work and manual processes that are exchanged among different parties with a lot of opportunities for fraud (R2:22). R2 also reflects that BC supports increasing access to the market which can be related to the existence of incentives towards environmentally better applications through higher accountability in the networks (R2:22). On the other hand, R8 draws attention to the fact higher transparency offered by BC use cases through the supply chain networks can prevent greenwashing since the motivation that leads companies to take sustainable actions are generally originated from the obligation of concrete actions to be publicly announced (R8:10). Similarly, R5 points out that sustainability is becoming an issue to be judged by consumer decisions rather than yearly reports announced by companies to demonstrate their sustainability performance, which entails more stringent and transparent dedication to sustainable actions in business areas (R5:14). From the standpoint of BC technology, R6 mentions the logistics view of recycling and waste management, laying stress on delivery timing and conditions that constitutes great importance in the area, especially for pharmaceutical and food industries as well as other areas that have types of supply chains requiring utmost importance on load sizes and efficient use of capacities for cheaper transportation (R6:18). Furthermore, R3 evaluates the potential of BC in environmentally sustainable use cases from a logistics perspective, urging on the existing constraints of lead

times concerning raw material flow between nodes in a network (R3:20). That is, he addresses the increasing possibilities by BC that facilitates better management of raw material procurement in the supply chain (R3:20). R3 concludes that BC is highly beneficial for environmental sustainability in supply chains, whereas economic and social aspects are also likely to be affected positively to a medium degree, adding that social impact will potentially be a lot bigger in the long run with the evolution of public BCs through the supply chain networks (R3:78). Table 4-1 below represents the lines extracted from the interviews associated with the attributions of correlations between the environmental concerns and BC characteristics, respectively.

Table 4-1: Line Codes of BC Characteristics in the Environmental Context

Line Mentioned In Transcripts		Environmental Context						
		Interviewees						
		R2	R3	R4	R5	R6	R7	R8
Blockchain Characteristics	Decentralization	26,28,42	22,24	22,24,26,28	22	26,28	36,40,42,46,59	22
	Data immutability	30,42	26	22,24,26,28	24	30,32	36,42,48,57	24
	Transparency	32,42	28	22,24,26,28	26	34,36	36,50	26
	Security/Integrity of Data	34,36,42	22,30,32	22,24,26,28	28	38	36,52	30,32
	Smart Executions	38,42	36	22,24,28	30	40	36,54	34
	Versatility	40,48,50	42,44	24,28	32	42	44,56	36,38

Decentralization

The impact of the decentralization feature of BC technology on the environmental concerns of supply chains is seen differently by the respondents. In this connection, R5 reflects his view as follows:

"[…] I am not sure if the decentralized database architecture itself would impact the environmental concerns of a supply chain. I think there are other elements in this pillar that have more impact. I cannot really tell how decentralization would impact and why. I see no correlation." (R5:22)

R6 and R7 look upon decentralization as a feature that has a low impact that indirectly affects environmental sustainability through supply chains. Specifically speaking, R6 highlights that decentralization is not just a database and information flow, but a feature that makes the network more inclusive and resilient (R6:26), whereas R7 thinks that decentralization is not one of the prominent reasons that BC is being implemented into supply chains, but it solves the problem of transparency and traceability (R7:38). R7 further amplifies his response by asserting that by BC and Ethereum with PoW, the decentralized database structure has been even energy-inefficient for the environment up until this point, since it burns an extraordinary amount of energy through solving math problems and expending computing power (R7:40; R7:42). In this context, R2 agrees that there will be an adverse effect on the environment in the form of energy consumption, if there are many improperly merged nodes on the Bitcoin network, however, he also sets forth that this is not the case with the other types of BCs that are not power-hungry (R2:28). The only link that he/she can construct with the environmental concerns in this regard is energy consumption, meaning he sees no correlation with recycling, waste management, or any other greening activities (R2:26; R2:28).

On the other hand, R3 considers decentralization as a highly related aspect for the environmental context of SSC, since it stimulates information sharing between different nodes bringing up to date so that it can add up to high-quality decision-making on the operations associated with energy conservation and recycling (R3:22; R3:24). Similarly, R4 and R8 count the impact of decentralization as high, where R4 sees it an essential feature of this technology to be in place to give environmentally sustainable outcomes and R8 speaks of the gainings in the environmental context in the following terms:

"[…] if there was a more sustainable supplier in the market, how would you even know? if they were a decentralized supply chain solution and it could enable the suppliers to just connect to that, and the buyers seeing them and enabling them to tackle less hassle to purchase from them, they could rank them based on other aspects than the price of the product. They could pay more for more sustainable production. The decentralized nature can prevent some greenwash. But it could also make sourcing more effective […]" (R8:22)

Immutability

Most of the respondents consider the impact of immutability on environmental sustainability through supply chain networks as high. However, R2 explicitly propounds that immutability does not correlate with the environmental concerns, it is just something that can be reached if the network is decentralized enough, where he/she mentions that it brings in the quality for transactions to be tamper-proof but it does not excel with a clear impact on the supply chain (R2:30). R3 and R8 expect a higher correlation as opposed to R2, where R3 mentions that it does not allow companies to make alterations of any previous record or report regarding their actions that do not comply with policies in recycling, waste management, or any greening activities (R3:26), and R8 similarly draws attention to higher consistency in audit trail records that enables to calculate the carbon footprint of any product easily and accurately (R8:24). But he also reflects that the magnitude of this impact depends on the volume of data points (i.e., nodes) within the supply chain network, meaning the fewer the data points, the lower the impact since it doesn't add up to any significant difference in this case (R8:24).

As is the case with decentralization, R4 considers immutability as a fundamental feature of BC technology that leads up to a higher performance in terms of environmental sustainability through supply chain operations (R4:22). Similarly, R5 claims that the immutable nature of BC networks paves the way for tracing each product or service up to its origin, which is a central quality being forced by the market (R5:24). R6 reflects that data immutability ensures to have a single source of the truth while eliminating a lot of inefficiencies and cheating within a multi-stakeholder supply chain where people may change any record to their benefit (R6:32). R7 views it from another angle by presenting his argumentation over an illustrative example as follows:

"SSC… So would one target of that being things like fair trade coffee, fair trade foods, responsible fishing, and farming, so if we want to talk about environmental concerns […] in those use cases immutability is key. The fact that when I create a product and I stamp it and I tokenize it on the BC and I ship it to the next person… The immutability between each party showing that each party received it and created some action upon it, that future is key for environmental supply chain use cases." (R7:57)

Transparency

For the discussion around environmental sustainability in supply chains, all the respondents consider transparency as one of the most predominant factors that BC technology brings in. R2 says that depending on the use case or the industry, higher transparency can have a huge impact on improving sustainability since the correlation in this context relies on the accessibility of everyone's input involved in the supply chain networks (R2:32). R3 goes in detail by the following expression:

"[…] Once the transparency is in the supply chain, everybody can see and even share what I will do in terms of energy conservation, recycling, waste management, etc. in a way that I need to report attached to it." (R3:28)

R4, R5, and R7 put transparency at the core of BC technology that would potentially provide one of the greatest benefits in terms of environmental concerns of SSC (R4:22; R5:26; R7:36). Besides the positive gainings, R6 and R8 also draw attention to the negative side of transparency, where R6 reflects that transparency has pros and cons unless it is managed properly since there is a certain aspect of transparency that can prohibit collaboration and make it extremely difficult to run a business if classified information is being shared among every member in the network (R6:34). Regarding this, R6 brings up the upcoming PoC *zero-knowledge proof,* which is the cryptographic way of giving information without revealing the data that can eliminate the negative side of the transparency feature (R6:34). Similarly, R8 sees it as a two-fold issue that creates a promise of making consumers more aware of environmental issues, while also bringing in risks if the classified information related to business strategies are being exposed such that companies may be excluded from the competition in the market (R8:26). As is the case with data immutability, he adds that the level of impact depends on the number of data points involved in the network (R8:28).

Security & Integrity of Data

Respondents foresee a considerable effect by security and the integrity of data on the environmental concerns. R2 and R5 estimate a medium impact since this feature creates more trust and quality data that can help to clean up supply chains and improve business operations in terms of the energy footprint of consumption (R2:34; R2:36; R5:28). However, R5 feels the need to make a distinction between security and the integrity of data in this context, implying that security is broader and takes hard measures as compared to data integrity since high standards of data integrity may not add up to being secure through information flow (R5:28).

R3, R4, R6, R7, and R8 draw attention to higher accuracy, trustworthiness, and stability that cannot be compromised for a multi-stakeholder network, especially considering the impact of these indicators on decision-making (R3:30; R3:32; R4:22, R6:38; R7:36; R8:30; R8:32). R8 fleshes out his response with an example of companies having false claims on their actions regarding greenwash, either through the way of using commercials or their yearly reports, which can be minimized by having data integrity in place (R8:32). When it comes to the security aspect, R8 states that with BC technology it is harder for some other party to falsify transactions and pretend to be someone else (R8:30).

Smart Executions

Smart executions are mostly seen by the respondents as one of the major qualities of this technology that can have a considerable impact on the environmental aspect of sustainability in supply chains. In this respect, R2 highlights that automation provided by smart contracts may be an environmentally positive aspect of the supply chain, meaning it will require less labor intension and make goods moving potentially faster (R2:38), which then leads to efficient use of man-power and lower fuel consumption, respectively. R4 expects lower impact by smart executions as compared to the features previously mentioned, however, he/she sees it more of a speed-related issue that may deliver an indirect impact on the environment (R4:26). R5 and R6 dwell upon agility and proactivity through lower friction that may decrease inefficiencies to a certain extent, while they also expect a higher impact in the long term by having more flexible business models in place (R5:30; R6:40). R8 foresees a certain level of impact of smart contracts by acknowledging automation as the promise, though he also addresses the need for creating new models of business transformation, which entails everyone to be on the same page in terms of process management (R8:34).

R3 and R7 consider even more correlation between smart executions and environmental concerns, where R3 draws attention to the functionality of smart contracts in handling payments out of unnecessary paper works and labor usage (R3:34). He adds that smart contracting is something that they continuously seek the right services to comply with to make money out of it (R3:34), which is also an aspect shared by R7 regarding their company's vision on the use cases of smart contracts (R7:75).

Versatility

The versatility aspect of BC technology is interpreted differently by the respondents as is the case with decentralization. R2 does not regard BC as a super-versatile technology since it is applicable to a handful of use cases as of now. He/she further amplifies his response as follows:

"[…] This is quite the hype as we were talking about earlier, BC is advertised as doing a lot of different things but when we go down to what it is really good at, use cases are quite targeted so I am not really sure about that!" (R2:40)

R7 and R8 attribute the position of BC to somewhere between BC 2.0 and 3.0, which are the use of smart contracts and the implementation of BC into industrial use cases, respectively (R7:44; R8:36). They both see the impact of versatility as low since it does not sound a key metric for supply chains, considering it might also cause some problems since the other technologies that BC may be integrated with is also at their early stages and having BC does not add up to value addition if the specifics are unclear (R7:44; R8:36). R4 calls versatility as an issue directly related to flexibility, which he/she does not take into account as having the utmost importance in the environmental context (R4:26).

On the other hand, R3, R5, and R6 give weight to versatility as it forms a basis for integration with other ever-evolving technologies, such as AI and ML. Regarding this, R3 reflects that the integration of BC with these technologies is likely to impact the way how energy conservation and other greening activities will be influenced (R3:42). By sharing a similar viewpoint, R5 says that BC's versatility consists of certain qualities such as adaptability, transparency, built-in functionality, and capabilities, which then collectively enables companies to trace back from

the supply chain to the consumer perspective (R5:32). Lastly, R6 claims that IoT, as a more compelling fit into the BC, provides the potential of controlling the identity and integrity of data to an incomparable extent, which is the outcome of the versatile nature of BC (R6:42). R6 further exemplifies his response as follows:

"[…] Every time we want to do a transaction on the BC, you need to know who is signing the transaction. So, I mean the cornerstone of more or less every BC solution is an identity key. What we also will see in the future is the identity of machines, the identity of stuff and the ability to control that on a level that makes sense and also make sure that if I have an IoT sensor at my exhaust pipe on my car, I need to make sure that I haven't counterfeited with that to have it sent a piece of different information than what it's supposed to do […]" (R6:42)

Table 4-2 below summarizes the responses from interviewees regarding the level of correlations on a 3-point scale between BC technology characteristics and the environmental concerns of SSCM.

Table 4-2: The Impact of BC Characteristics in the Environmental Context

		Level of Impact: N/A / Low / Medium / High	Environmental Context – Interviewees						
			R2	R3	R4	R5	R6	R7	R8
Blockchain Characteristics	Decentralization		Medium	High	High	N/A	Low	Low	Medium
	Data immutability		N/A	Medium	High	High	High	High	Medium
	Transparency		High	High	High	High	High	High	High
	Security/Integrity of Data		Medium	High	High	Medium	High	High	High
	Smart Executions		Medium	High	Medium	Medium	Medium	High	Medium
	Versatility		N/A	High	Medium	High	High	Low	Low

4.2.2 Economic Context

Regarding the economic concerns of SSC, R2 sees BC to have a high and positive potential impact on the networks through the prevalence of higher transparency since cleaning up the supply chain leads to the discovery of hidden inefficiencies, lots of lost revenue by malicious activities such as transaction fraud and counterfeiting (R2:60). R4 also points out this positive impact on eliminating inefficiencies that make the delivery of the goods and services cheaper than before (R4:12), stating that business cases will start to use one shared ERP rather than multiple ERPs established within each node in the network so that manufacturing costs can be taken down (R4:6). R7 underlines higher transparency together with automation through smart executions, both of which are directly related to economic concerns (R7:161). He summarizes his perspective regarding this aspect as follows:

"[…] as a supply chain consultant, I have clients who are implementing these projects, so my goal is to save them money that's both my job and their job. That's all they care about. The primary thing is cost reduction, everything else is a bonus. So, number one is economic concerns because if it doesn't make any financial sense, it is not going to happen! I would say social and environmental are tied for second place. But at the end of the day, it really comes down to economics." (R7:119)

Table 4-3 below represents the lines extracted from the interviews associated with the attributions of correlations between the economic concerns and BC characteristics, respectively.

Table 4-3: Line Codes of BC Characteristics in the Economic Context

Line Mentioned In Transcripts		Economic Context						
		Interviewees						
		R2	R3	R4	R5	R6	R7	R8
Blockchain Characteristics	Decentralization	56,58	48	26,36	34	44	61,63	40,42
	Data immutability	60	48	26,40	36	46	61,65,67	44
	Transparency	60,62	48,50	26,36,42	38,40	48	61,69,71	46
	Security/Integrity of Data	64,66	50,52	26,34,44	44,46	50	61,73	48
	Smart Executions	67	54	46,48	50	52	61,75,77,79,81	50
	Versatility	69,71	58,60,62	50	52,54,56	54	61,89,91	52

Decentralization

In the economic context, R2 sees decentralization to cause more investment cost than a standard centralized mode whereas pointing out that increased efficiency and security possibly lead to a considerable level of ROI (R2:56). R6 lays stress on the high potential that the decentralized database architecture creates by allowing value exchange that can be tokenized and subjected to a credit rating function, which is something that many people are looking for as a way of handling transactions more easily (R6:44). Considering the aspects that allow sharing the cost and getting the benefit regarding that, R8 also attributes a promise to decentralization (R8:40). However, he brings forward that the decentralization features also comes with a cost that could negate the benefit, though it contributes to the integrity of data which makes it harder for someone to exploit, attack, manipulate, falsify, or steal the data (R8:40; R8:54). Both R5 and R7 thinks of the impact level of decentralization as low on the economic concerns of SSC (R5:34; R7:63). The rest of the respondents, R2, R3, R4, R6, and R8, acknowledge the potential impact of decentralization on economic concerns, where the common reasons for that are increased efficiency, trust, and its bringings in the form of ROI (R2:56; R3:48; R4:36; R6:44; R8:48).

Immutability

Regarding the economic concerns, the general view that is preponderant among respondents is that the impact of data immutability would be low-to-medium. According to R2, R3, and R7, there is almost no relevance since immutability, as a feature and precondition rather than a benefit, is mostly related to the decentralized database structure so that the system can be hard to hack through records built upon copies at hand for everyone, whereas R2 sees no correlation at all (R2:60; R3:48; R4:38; R7:65). R4 further explains this standpoint towards this subject as follows:

"[…] Immutability sounds like a prerequisite since immutability itself does not deliver any value […] I mean you can share it to pretty much anybody, but you can be comfortable that they're not going to make any changes to it that haven't been approved by the network

mechanism. Immutability itself does not add any value. It is a precondition to give you the ability to create a decentralized sharing framework." (R4:40)

On the other hand, R5 considers the impact of immutability in this context as high since it will benefit from the higher quality and integrity of data and the trust built-in with the use of BC technology (R5:36). R6 also sees a high economic value by immutability by pointing out the fact that no record can be changed subjectively, which enables a full audit trail out of the immutable pieces of records (R6:46). Lastly, R8 states that the integration to start any BC to be transported to a specific accounting system might cause too much cost and negates the benefit of having some automation there, which is why assigning a medium impact to it instead of low (R8:44).

Transparency

Transparency is viewed by almost every respondent as the BC's one of the foremost features and benefits. R2 sees it as a great benefit for customers to have more visibility of things to buy and consume, where it is inherently a downside for bad actors involved in the supply chain networks since they will not be capable to take malicious actions such as injecting lower counterfeit quality goods (R2:62). R3 considers transparency as a facilitator for the sake of logistics operations in their business to have the flexibility and optimized material and product flow in place (R3:50) and concludes his opinion as follows:

"[…] Transparency will have a huge impact because the bigger the gray area, the more money I can make." (R3:48)

R5 also acknowledges that transparency is one of the major things to adopt BC technology within shared networks (R5:38) and sees no downside with it by arguing that the weight of opportunities is much more preponderant (R5:40).

R6, on the other hand, sees its impact at a medium level in the short term since it might be something that adversely affects certain operations, especially related to finance, however, the concept of zero-knowledge proof which means the sharing of information without sharing private data is the leverage for him that one can put heavy reliance on a high impact of transparency on the economic concerns in the long run (R6:48). Similarly, R8 set forths a possible problem that can arise due to the type of information acquired so that he sees its impact as medium-to-high (R8:46).

According to R7, transparency carries the highest possible value of BC technology to offer since their clients choose BC over any competing services in the market because of the higher transparency among supply chain partners that BC technology holds out (R7:69). He further clarifies his point by exemplifying a real-life case with Schneider Logistics located in the US, where the company takes advantage of BC to connect disparate ERPs to see the end-to-end material flow in the supply chain (R7:71).

Security & Integrity of Data

Security and the integrity of data are seen by most of the respondents as a preeminent characteristic of BC technology since it cannot be compromised under any circumstances. Thus, they all deem it to have a considerable level of correlation to economic concerns. In this

connection, R2, R3, and R5 consider the level of impact as medium level while the rest of the respondents give it high. R2 explains his reasoning relying on the fact that the quality of information and trust is higher by higher integrity of data processed and stored in a secure way, which can lead to a better estimation of a supply chain (R2:64). According to R3, the level of security and the integrity of data depends on how the trust in the BC is being dealt with, meaning if most people do not trust the philosophy of this technology then this feature does not add up to something anymore (R3:50), though from the logistics perspective, he acknowledges the fact that missing lead times can cause problematic issues for companies due to lack of integrity in data, especially for serving customers from the upper segment (R3:52). R5 stands out with a different perspective by bringing that in today's business environments, financial data are trustable to a quite high extent and this is not the greatest need to use BC technology (R5:46). However, he still ascribes a meaningful correlation to the economic concerns since higher quality standards in data management boosts the trust within the shared networks so that whoever gains access to the BC itself or the consolidated transactions will have the privilege of working in a more secure playground (R5:44).

On the other hand, R4 mentions that security and the integrity of data is an ally in the battle against counterfeiting, which exactly corresponds to the sustainability aspect itself in any case, and improved security, better provenance of the end goods and hence improved customer safety will lead to reduced costs through leveraging economies of scale (R4:34). He also sees it as a prerequisite to be able to share the data that can be seen as an outcome of data immutability and decentralization (R4:44). Similarly, R8 draws attention to security breaches and crimes around hacking systems that cost a lot to companies when dealing with cybersecurity and malicious attacks, which raises the importance of having a highly secure system that helps companies come out of the box (R8:48). R7 relates it to the transparency characteristic of BC technology where the integrity of data goes hand in hand with transparency, meaning it is the precondition to have transparency throughout the supply chain network (R7:73). Finally, R6 puts it in a nutshell as follows:

"… You cannot trust an economical something if your data is compromised or if the data is not following, I mean if suddenly it's a different currency, maybe it's a different invoice… I mean, regarding these aspects, that's extremely high." (R6:50)

Smart Executions

Smart executions are considered to be one of the most preeminent features of BC, where almost all the respondents give it a high impact on the economic concerns of SSC. R2 explains a standpoint regarding it as follows:

"[…] If you improve efficiency through smart contracts and special payment terms, in these types of things, then you could potentially increase the revenue. Yes, I think it has a high impact." (R2:67)

From the logistics perspective, R3 sees a tremendous value in smart executions, especially regarding payment terms that inherently involves a financial risk on each transaction, where smart contracts eliminate the negotiation on a shipment and minimize the overhead costs that can arise through these transactions (R3:54). R4 more focuses on the frictional costs that can be reduced by the use of smart contracts, addressing the raising standards in terms of meeting a specification of the delivered goods (R4:46). R5, R6, and R7 also consider the potential impact

of smart executions quite high regarding the economic performance in the SCM, where R5 points to the efficiency and proactiveness (R5:50) and R7 lays stress on automation, the prevention of data losses, disagreements, together with savings in terms of thousands of man-hours required in data reconciliation at the end of each quarter (R7:75; R7:79; R7:81). On the other hand, R8 reflects a different perspective that draws attention to more custom programming, integrations or even new business models required to relieve benefits from smart executions, specifically for small companies that have fewer resources as compared to bigger corporations and thus, give it a low-to-medium impact (R8:50).

Versatility

Versatility is considered to be a bit latent aspect of BC technology on which respondents do not settle in terms of its economic bringings to supply chains. R3 brings forward that the ability to integrate with other ever-evolving technologies (i.e., AI, IoT, ML) subsumes a huge potential for BC to improve economic performance even further, considering the hype it can pose to gain competitive advantage by delivering higher quality standards for products and services (R3:58; R3:60). R6 similarly thinks that it promises to have a huge impact by bringing the supply chain together with trade, finance, down to IT level credit rating functions, etc. (R6:54). R5 also embraces the idea of having more trusted solutions that can lead to more proper cash flow management so that he praises the versatile aspect by considering it as a dynamic technology (R5:56).

On the other hand, R2 does not see BC on the lower end of versatility as comparing it to cloud offerings, addressing that BC is suitable to a more narrow but specialized type of applications to use for (R2:71), whereas R7 claims that as of now, there is no way to determine the impact of BC's versatility in the economic context since its integration with aforementioned technologies don't add up to widely accepted use cases in practice, and hence the impact is not that lucent (R7:89; R7:91). Last but not least, R8 expounds that this versatility aspect of BC will potentially make it blurry and hasty for the supply chain stakeholders to comprehend the viability, ease of use, and scalability of the technology itself so that it seems to be more of a burden as it stands (R8:52). Table 4-4 below summarizes the responses from interviewees regarding the level of correlations on a 3-point scale between BC technology characteristics and the economic concerns of SSCM.

Table 4-4: The Impact of BC Characteristics in the Economic Context

	Level of Impact: N/A / Low / Medium / High	Economic Context						
		Interviewees						
		R2	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**
Blockchain Characteristics	**Decentralization**	Medium	High	High	Low	High	Low	High
	Data immutability	N/A	Low	Low	High	High	Low	Medium
	Transparency	High	High	High	High	Medium	High	Medium
	Security/Integrity of Data	Medium	Medium	High	Medium	High	High	High
	Smart Executions	High	High	High	High	High	High	Medium
	Versatility	N/A	High	Low	Medium	High	Low	Low

4.2.3 Social Context

Considering the social concerns of SSC, R4 reflects a perspective associated with societal issues rather than organizational performance metrics in the workplace, where he/she says:

"… What are the societal issues associated with anybody involved in the supply chain? Are they using child labor, for example? Are they getting paid properly? Are they working in inadequate conditions? So, if you think about; where this has come from to the sustainability perspective and how it is being brought together in a way that is ethical and proper, those are the parameters that need to be tracked." (R4:10)

On the other hand, R6's overall impression of what makes the real value in this respect is what happens in the transaction between companies, addressing the lack of ability of the current ERP systems to be fully connected to manage information flow, which is the promise of relevant BC use cases to establish and administer such an integrated network (R6:8). R7 reckons on traceability in the social context since it is about customers verifying the legitimacy of a product or service (R7:161). He amplifies his response by handling this subject from the point of relieving daily operations:

"… a transaction that currently happens via paper, an email, an excel, and phone calls, you can automate that logic between parties. What is the social concern of that? It gets rid of manual jobs, which is something that people do not want to talk about but that is realistically what is happening. And hopefully creating smoother communication in these processes because you are automating it, instead of email or phone call or an excel it just happens. So, with that in mind the social concerns I would say are better across the board because we are getting rid of a lot of the social interaction." (R7:93).

Table 4-5 below represents the lines extracted from the interviews associated with the attributions of correlations between the social concerns and BC characteristics, respectively.

Table 4-5: Line Codes of BC Characteristics in the Social Context

Line Mentioned In Transcripts		Social Context						
		Interviewees						
		R2	R3	R4	R5	R6	R7	R8
Blockchain Characteristics	Decentralization	73,75	68	26,54,56,66	58,60	56	95,97	54
	Data immutability	73,75	68	26,58,60	62	58,60	99,101	56
	Transparency	73,75	70	26,62	66	60	107	58,60
	Security/Integrity of Data	73,75	72	26,64,66,68	68	64,66	109	62
	Smart Executions	76	74	70	70	68	105,111	64
	Versatility	76	76	72	74,76	70,72	113	66

Decentralization

In the social context, decentralization is mostly considered as having a significant impact on SSC. R3 touches on the ability to derive lesser frustrations between operations and the IT department through the uptime of decentralized database architecture, which is always variable

and resilient towards connection losses (R3:68). Therefore, he thinks the effect would be medium-to-high on the inter-organizational activities (R3:68). R5 also estimates a medium level of correlation between decentralization and the social context of sustainability in supply chains since the decentralized database contributes to establishing trust among supply chain partners, while also bringing in the possibility of making it harder to change a certain supply chain setup (R5:58). R8 addresses this potential effect by an example of food safety, which needs to be strictly provided by trusted records of data associated with any product, leading to manual audit processes being relieved in this regard (R8:54).

Apart from all these, R2 hits on the distribution of control among nodes, which prohibits one actor or any powerful actor to have the upper hand within the network (R2:73). R4 brings up a different perspective from the organization standpoint, reflecting that organizations inherently rides on centralized systems where they own 100% of the control in place so that they might not see the value of the decentralized support frameworks (R4:54; R4:56). R6 further elaborates on this aspect, indicating that decentralization supports the ability to create incentives between actors, not just to hold their data records, but to optimize their perfect data repository (R6:56). Lastly, R7 adduces companies such as Facebook, Google, Airbnb, and Uber as monopolies, by having the sole purpose of managing user's data as an intermediary that makes the transaction happen (R7:97). In this connection, he reflects that BCs have a similar potential by being distributed systems through which companies can build up business processes without any intermediary who gains undue control over the network (R7:97).

Immutability

Regarding data immutability, most of the respondents expect a high correlation to the social concerns of SSC. According to R5, it is hard to tell how data immutability relates to social concerns because that does not seem to be a characteristic that only goes for BC (R5:62). From another perspective, R3 foresees an exclusion of several discussions around intra-organizational activities through the establishment of data immutability, while expecting synchronized information repository from the inter-organizational standpoint (R3:68). R4 thinks that organizations perceive immutability as a hassle that poses a risk in flexibility since they are always willing to intervene in faulty previous records (R4:58; R4:60). The global protocol over the distributed networks is being provided by the foundation of the immutable nature of BC technology (R4:64). R7 mentions about a similar protocol called Baseline that their company has developed for allowing private transactions on public BCs, which is also a similar type of concept with zero-knowledge proof that only requires to put the proof on the BC (R7:101). In that sense, data redundancy within the network, which is an outcome of data immutability, is not seen as a problem by R7 since it does not create any adverse impact on the management of social interactions (R7:101).

R2 and R8 touch upon the significance of data immutability in the social context in terms of data finality and accuracy that leads to higher trust among all the participants in the chain (R2:73; R8:56). According to R8, it facilitates audit trail back in time, so does the incumbents' work (R8:56). Finally, R6 thinks that immutability comes with a price to pay in terms of having better data management and a higher level of governance, otherwise, everything on the BC can then stay on the BC (R6:58). On the other hand, he thinks that it is one of the most critical aspects of BC technology that the members in the network can leverage for the sake of transaction trustworthiness (R6:58).

Transparency

In the social context, transparency is evaluated from different standpoints by the respondents. R3 sees its impact not that significant for the social concerns since he thinks that prevailing systems provide a certain level of transparency to get the job done in the organizational context (R3:70). R6 recalls the concept of zero-knowledge proof to have a transparent but secure interaction that can eliminate the sharing of classified information or the ownership of individual data (R6:62). He explains that the market needs to adapt to a new reality where transparency is not what organizations have the most of right now, instead the crucial point is establishing a structure that allows smart implementations of the solution that can lead to information sharing rather than data sharing (R6:62). Regarding the transparency aspect, R8 highlights the growing consumer interest in knowing the origin of a product (e.g., food), together with the potential relief both in inbound and outbound logistics operations that supply chain officials would take advantage of (R8:58; R8:60). R2, R4, and R5 acknowledge that higher transparency will provide solid evidence, co-hosted transaction flow, and information sharing among counterparties through the consolidation of data (R2:73; R4:62; R5:66). Lastly, R7 expresses his standpoint with the following metaphor:

"[…] you can say it is guaranteed that the fish is going to be caught in an ethical manner." (R7:107).

Security & Integrity of Data

The impact of security and the integrity of data in the social context is generally considered as above average by the respondents. R6 asserts that this feature cannot be compromised but it also requires to have a mass scale adoption and active participation over a distributed ledger (R6:64), which may then add up to some tradeoffs (R6:66). Accordingly, he sets forth that people have some security concerns around BC since most ledgers would most likely not fulfill globally accepted security standards and norms (R6:66). R8 points out that organizational data needs to be managed by certain safety measures that entail an uninterrupted surveillance system through the network (R8:62).

R2, R3, and R4 see this feature a real positive that has a high impact in the social context, meaning it provides uncompromising data consistency from both inter-organizational and intra-organizational standpoint (R2:73; R3:72; R4:66). R5 underlines that security and the integrity of data lead to higher trust in transactions which then contributes to more precise and straightforward decision-making (R5:68). R7 emphasizes the fact that this feature is highly effective in proving the legitimacy of a certain product involved in the supply chain network (R7:109).

Smart Executions

Regarding the impact of smart executions, R5 sees it more included in the economic or environmental context rather than the social context (R5:70). R7 does not attribute it a significant impact unless it is considered to be a facilitator of making workloads and processes smoother and relieved (R7:111). R8 points out that the use of smart contracts require further actions depending on the use case, where the cost associated with it may be too high such that it can outweigh the benefit (R8:64).

Furthermore, there are also opposing views coming from R2, R3, R4, and R6. R2 associates it to the transparency aspect as follows:

"[…] Smart executions' context is pretty close to the transparency argument because a smart contract means that there are stakeholders who can go and see what is in the smart contract. So that could have positive aspects also here, there is no black box, there are no processes that happened fully behind the closed doors. That could be positive here." (R2:76)

R3 draws attention to the less human interaction through the covered processes in the supply chain since most of the things are automatically executed through smart contracts once an order is being fulfilled (R3:74). R4 also estimates lots of value in smart executions, further elaborating his/her answer that it can also be done in isolation rather than using shared ledgers because separate smart contract frameworks that everyone subscribes to can be created outside of the organization (R4:70). R6 also positions smart executions on the high-end by laying stress on their role in the removal of intermediaries, manual processes handling by people, and hence a better flow of the supply chain (R6:68).

Versatility

The versatility aspect of BC is again divisive among the respondents such that they have different standpoints towards it in the social context of sustainability in supply chains. R2 and R5 see nearly no correlation between versatility and social concerns through the supply chain networks since they don't relate it to any feasible use cases (R2:76; R5:74). Similarly, R7 has a precautionary approach towards this aspect by asserting that he does not see it of any value in the social context (R7:117). R4 has a different perspective regarding this, claiming that it would probably cause problems since organizations do not want to put up control to lead the system to a big democracy where all the members in the network are all subscribed to the system (R4:72).

On the other hand, R3 thinks that the integration capability of BC with other evolving innovations (e.g., IoT) will make inroads into a whole new discussion around inbound and outbound logistics, in which their interaction with other companies will alter beyond all recognition (R3:76). R6 thinks that it will reshape the entire flow of the supply chain and create unexpected challenges since investments put into place for the digitalization of individual silos within the supply chain will reveal a difficult transition to get adapted to (R6:70). R8 similarly sees a downside of versatility since he expects that it is more of a source of confusion than something that any organization could easily benefit from (R8:66).

Table 4-6 below summarizes the responses from interviewees regarding the level of correlations on a 3-point scale between BC technology characteristics and the social concerns of SSCM.

Table 4-6: The Impact of BC Characteristics in the Social Context

	Level of Impact: N/A / Low / Medium / High	Social Context – Interviewees						
		R2	R3	R4	R5	R6	R7	R8
Blockchain Characteristics	Decentralization	High	Medium	High	Medium	High	High	Medium
	Data immutability	High	Medium	Medium	N/A	High	Medium	High
	Transparency	High	Low	High	High	Medium	High	Medium
	Security/Integrity of Data	High	High	High	High	Medium	High	Medium
	Smart Executions	High	High	High	Medium	High	Medium	Medium
	Versatility	N/A	High	Medium	N/A	High	Low	High

4.3 Challenges and Risks

Immaturity of BC Technology

Immaturity of BC technology is viewed from different standpoints by the respondents. R5 does not find the technology immature, and hence regards the impact of this aspect as low (R5:84). R4, R6, and R7 think that the theoretical maturity is already there and it is not the technology holding the deployment of BC technology back, instead, it is more the ability of incumbents and officials involved in these projects to establish and adapt it to business use cases (R4:78; R6:76; R7:125). R4, R5, R6, R7, and R8 address the current situation with throughput issues on which people carry some concerns around. R4 counts on the theoretical maturity of the technology from the perspective of public BCs, however, he sees the application of BC in an enterprise concept as an immature area to work on (R4:78). R5, R6, R7 and R8 agree upon the point that transaction throughput should not be a problem with the proper use of existing methods (R5:84; R6:90; R8:52), regarding which R7 particularly address the use of proofs on public chains where incumbents can batch transactions together so that the system would operate faster and cheaper (R7:153). He concludes that private BCs have already been able to create high transaction throughout, whereas public BCs are expected to accommodate this quality in the near term (R7:105). On the other hand, R2 and R3 give it a high impact where R3 assert that it is also part of gaining a competitive advantage towards the prevailing infrastructures in the market since it affects the reliability of the technology (R2:80; R3:84). R8 similarly finds it something that is hurting the adoption by which he further explains the existing situation as follows:

"[…] Companies keep hearing these stories that it is immature, it is really in the early stages, and also, they see some sort of failed projects, but they are also waiting to see the real benefits. In that regard, there is a high impact. Fewer companies want to be the pioneers to pay the higher price while waiting for whatever the prevailing BC technology or solution to come." (R8:72)

Awareness and Technical Competence

Besides R7, all the respondents address the lack of awareness and technical competence as a big problem for the adoption of BC technology in supply chains. Thereagainst, R7 states that he does not see it as a core problem since he runs across executives and supply chain officers through the projects who are aware of what this technology is all about, which makes him

conceive that their market is educated on this topic (R7:127). R3 draws attention to the point that it is hard for technical people to convince the upper management who has a lack of awareness and understanding of the use and perks of this technology (R3:86). He further adds that fishing out tactical people who know a lot about BC and its integration capabilities with other mainstream technologies is also challenging since it requires distinct technical competencies together with an outstanding business manner to have in place (R3:76). R4 and R5 see it as the biggest issue when adopting BC technology since it may also lead to wrong use cases (R4:84; R4:98; R5:12; R5:84). R6 addresses the BC skills being one of the most crucial and in-demand skillsets in the technical market as of this year (R6:78), while R8 refers to the misconceptions and false expectations that may cause disastrous project failures through bad choices regarding the platform (R8:74).

Organizational Collaboration

Organizational collaboration is not seen as the highest challenge by more than half of the respondents, yet it is accepted to be a certain one that poses risks for the success of business use cases. R2 refers to the decentralized database structure that requires consensus on the rules through collaboration since there will be more than a single entity to control and govern the system (R2:8; R2:82). R3 also estimates a medium level of influence, bringing up the importance of collaboration after making sure that the upper management is being involved in the process (R3:90). R7 makes a distinction for public and private BCs regarding the effect of organizational collaboration, explaining that public BCs have already solved this problem since there is no issue of one party gaining too much power through the network, whereas there can be a heterogeneous breakdown of power in private BCs (R7:129). R8 underlines that organizational collaboration should be built upon a specific type of BC solution that addresses the needs of the organization comprehensively (R8:76). R5 refers to the potential benefit for higher awareness and understanding of the technology that can be acquired by organizational collaboration (R5:84). R6 assesses the issue in detail, unveiling that there is a need for people to opt-in on the same rules since the system will be something that can move across multiple silos and ERP solutions (R6:12). R6 sees BC as a strategic C-level (i.e., CEO, CIO, CFO) decision to have in place because it specifies the standards on how to connect with the stakeholders, how to exchange information, how to capitalize on data, and how to create completely new market models (R6:80).

Change Management

Besides R7, all the respondents consider the impact of change management as high, whereas R7 thinks that it is a precondition to get all the parties in a room to agree on the sets of rules and process management (R7:131). R2 thinks that the governance of BC applications and hence the impact of change management through the adoption of BC technology is significantly involved in this discussion (R2:8; R2:82). R3 brings up a client-oriented approach to the subject, referring to that customer retention is a significant factor for companies in this respect, where then change management will be the driver from the owner of the private BC (R3:94). R4 and R5 similarly argue that certain aspects of such a system need to be glued together from a business transformation point of view, which requires a solid change management strategy (R4:90; R5:86). However, R5 adds that organizational learning and training should be taken into account in this case (R5:86). R8 also draws attention to the need for radical changes in the corporate strategy and business models, which is a nontrivial issue since there is a lack of standards in the adoption of BC technology (R8:78). R6 discusses that getting people to

transform into a new model is a slower process than setting up the structure of a discovery (R6:70), where he further elaborates on his response as follows:

"[…] most of the time I say to our auditors that they don't need to audit on transactions and/or check balances because it is all completed and automated by themselves when the transaction is initiated. That's something they don't understand because they have been doing so for the last 2000 years! That has been how they have been auditing all along. Reshaping that into a new way of thinking is difficult." (R6:82)

Cost and Functionality

Regarding costs derived from investments in the technology, respondents' opinions are a little scattered through different perspectives, as is the case with views on BC's functionality. R5 thinks that considering its bringings into the workplace, BC's ROI outweighs the cost of investment, and there is no functionality-based problem with BC if it is properly established and integrated into the current systems according to the use case (R5:96). R2 claims that it is more of a challenge to demonstrate the cost benefits efficiency-wise since there are only fewer proof points to reveal what the overall cost will be and how efficient the system is going to operate (R2:86). R6 more focuses on the benefits side rather than cost, which seems to be not much of a big deal to him (R6:84). He reflects that when it comes to functionality, having scale and people to collaborate through the system are more crucial subjects since there is no point in having a BC network without any participation, even if it is being the best solution in the world (R6:84). R7 lays stress on the cost associated with the integration of BC with prevailing ERP systems (R7:137), saying the technical implementation cost is getting lower by the year while cost saving by the automation of processes is high (R7:133). Regarding functionality, since the solutions integrate with the current systems to have a seamless functionality in place, he does not deem any functionality problem in practice (R7:135).

R3 and R4 see the impact of cost and functionality much higher since they both believe the maturity in the lack of integration is quite costly and it can stop working where it is applied in a real sense (R3:100; R4:92) if it is not properly managed based on the use case. R8 also estimates a high impact by the following words:

"[…] There has to be a clear driver to go through the project. So, the stake has to be high enough for you to benefit in order to make this investment. What it does for you is how your organization would benefit from it. It requires a lot of custom things to happen, and not just technical things, changes in the internal processes, maybe strategies, business models, etc. Too many changes… It is not like buying a new ERP." (R8: 82)

Legal and Compliance

Legal and compliance are mostly considered to have a medium level of significance as a challenge or risk in the adoption of BC technology. Regarding this, R2, R3, R4, R6, and R7 give it a medium impact, where R2 does not see it as an inherent struggle associated with BC, but an aspect of getting multiple parties to collaborate efficiently around a legal framework (R2:88). R3 addresses the use of smart contracts to eliminate any issue with legal and compliance, where standard liabilities in the logistics market can be introduced through these contracts (R3:108; R3:110). R4, R6, and R7 point out that legal and compliance has been one of the foremost challenges up until now but its impact starts to go into a decline by the collaborative efforts on issuing the regulation, the maturation of the technology itself, and the

highest priority given to cybersecurity issues (R4:96; R6:88; R7:141). R7 also extends his response to the role of BC characteristics in alleviating legal and compliance concerns, where data integrity and automation through smart executions primarily comes into play in terms of removing humans and risk from the process (R7:143). On the other hand, R5 think that legal and compliance poses a risk to have third-party assurance over the BC setting in place which creates ambiguity on how to adhere to such a system (R5:98). Lastly, R8 also thinks there is a huge impact in this context and demonstrates his opinion as follows:

"[…] a good example is Lufthansa, who has been using BC to store their loyalty points […] if they were using a traditional database to store the same information, they wouldn't need the license. Even if they are not using any type of cryptocurrencies, the regulator sees that the use of BC correlates quickly to the use of cryptocurrencies and the wallets being holding assets of value. As such, Lufthansa as a provider has to have some sort of a cryptocurrency wallet provider license so they would be taking or assuring the government that their users are safe with them, even if we are talking about loyalty points, not massive amounts of Bitcoins or feared currencies. So, regulation has a lot of impacts." (R8:86)

Table 4-7 below summarizes the respondents' rates regarding the impact of listed challenges and risks on the adoption of BC technology.

Table 4-7: The Impact of Challenges and Risks on the Adoption of BC Technology

Level of Impact		*Interviewees*						
N/A		**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**
Low								
Medium								
High								
Challenges & Risks	**Immaturity of BC**	High	High	Medium	Low	Medium	Medium	High
	Awareness and Technical Competence	High	High	High	High	High	Low	High
	Organizational Collaboration	Medium	Medium	High	High	High	Medium	Medium
	Change Management	High	High	High	High	High	Medium	High
	Cost & Functionality	Medium	High	High	Low	Medium	Medium	High
	Legal and Compliance	Medium	Medium	Medium	High	Medium	Medium	High

4.4 Other Empirical Findings

4.4.1 Public, Private, and Consortium BCs

When it comes to benchmarking of public and private BCs over certain aspects and limitations, the respondents deliver many different perspectives regarding the existing and prospective situations. R3 believes that public BCs will not work in the supply chain in the coming 10 years since there is no trust yet to be established among companies to work together (R3:16). The reason behind this view is that third parties being eligible for taking access into private BCs can expect a significant ROI over long-term contracts offered by the controlling company and hereby the objective of a private BC is to add value to a specific supply chain (R3:16). He finds the adoption of private BCs easier since clients will force their suppliers to integrate with their systems so that transactions and payments can be handled faster, where speed is considered to

be a pillar of gaining competitive advantage (R3:16). R3 addresses the public sector as a key to success since it automatically leads to a mass scale adoption of this technology by companies that have to comply with the total chain and its regulations once the public sector starts to deploy such systems (R3:80; R3:114).

R4 reflects that the only useful BC that is run in a public sense now is Bitcoin, which is a protocol that is exposed to 7 billion people every day that potentially can try to hack it (R4:16). R5 addresses the ease of private BCs to adopt since they are quite structured, more adaptable and simpler from the technical aspect, meaning the number of blocks in each chain is lesser as compared to public BCs (R5:18). R8 further adds that major public BCs are highly immutable and decentralized, whereas in private BCs there is no need for using any cryptocurrency to pay for the transactions unless there is a group of companies and a distributed data technology (R8:20).

R7 points out that regulation is particularly attuned to private BCs and limited work has been done on public BCs, while their company estimates that more projects will target public BCs to get them into use because of the increases in privacy (R7:24). Accordingly, he affirms that as of now, public BCs have a lack of privacy as compared to private BCs (R7:155). He accentuates the fact that a successful BC implementation on the supply chain requires easy access, maintenance, and integration capability, together with a cost-effective working mechanism, all of which is considered to be covered by a public BC's functionality if the privacy issues are solved (R7:28). On the other hand, private BCs require costly investments to onboard parties through separately built, custom created infrastructures, which is why R7 sees it as the root cause of failed projects in supply chains (R7:28; R7:34). To eliminate potential security problems associated with any forms of BC, their company envisions a platform where network members only put in proofs of transactions rather than their private data (R7:151).

Regarding the use of consortium BCs, R6 brings up the potentially increasing efficiency through which entities are looking for collaboration with their competitors (R6:12). Their company reckons the existence of more hybrid activities in the near term, where system interoperability is sustained in a way that allows swapping value between different business systems (R6:22). He suggests that in any case, it would be easier to start with a permissioned (i.e., private) BC since then participants could be identified by ensuring the existence of some sort of controller who can monitor every aspect of transactions (R6:20).

4.4.2 Privacy, Zero-Knowledge Proof, Data Ownership

Privacy

R3 considers privacy as the main barrier of public BCs to be adopted within supply chains whereas private BCs are already being adopted in some companies (R3:16). R6 also sees privacy as an issue that requires being subjected to further legislation, however, he does not expect radical changes in the short term regarding this until larger deployments are being adopted in the workplace (R6:90). He also adds that privacy is not an upfront concern but something that can come afterward as is the case with Facebook (R6:90). Instead, he believes that the critical issue is to build out an ecosystem with standardization in operation, in which people, even though they are competitors, can join through an incentive model (R6:12). R8 evaluates privacy concerns from a transparency standpoint, which he sees as a two-fold issue consisting of both promises and the revealing of classified information about business strategy

that can negate the leverage of a company in the competition (R8:26). According to R7, privacy is the real limiting factor that creates barriers against the adoption of public BCs (R7:44; R7:123). Nevertheless, he prescribes that privacy problems will be alleviated through the use of a zero-knowledge proof mechanism (R7:153).

Zero-Knowledge Proof

Regarding the control and management of privacy through a transparent BC network, respondents R6 and R7 harp on about the concept of *zero-knowledge proof*, which is considered to have great potential to eliminate distrust within the supply chain by allowing the stakeholders to share information without sharing data (R6:8; R7:147). R6 propounds that transactions in the supply chain could be done faster, cheaper, and with the lower granularity by incorporating zero-knowledge proof into operations (R6:56). He further explains that the concept seems to be one of the key solutions for alleviating concerns around transparency and mitigating some of the risks associated with it, which is also what R7 believes to be one of the hottest topics regarding public BC applications in the multi-stakeholder networks (R6:74; R7:16).

Data ownership

R3, R6, and R7 touch upon the concerns around data ownership, meaning who will be the owner of the BC within a multi-stakeholder supply chain network. Regarding this issue, R3 makes a clear distinction between public and private BCs, where he thinks public BCs will not be for real in the next ten years since data ownership is still a matter of subject for these networks (R3:96). He also foresees that they would have to adopt a private BC if any of the indispensable clients ask them to integrate with a system in which the client itself will be the data owner (R3:96). R5 also considers data ownership as an issue with extremely decentralized systems (R5:58), where R6 and R7 refer to the significance of zero-knowledge proof in this regard, meaning they expect it to solve regulatory issues and challenges regarding data ownership and privacy (R6:90; R7:151). According to R7, data ownership issue in the private BCs can be completely solved in a close future, since he thinks that there will be no private data on the BC by that time, instead, it will all be proofs of transactions taking place (R7:149).

5 Discussion

This chapter intends to demonstrate and discuss empirical findings in comparison with the literature. By doing that, addressing the conceptual framework together with its themes is the primary orientation so that the summary of the implications can be extracted while identifying both the similarities and differences between the literature review regarding the area of interest and the findings obtained by this research.

5.1 BC & Aspects of SSCM

5.1.1 Environmental Context

Supply chains consist of several activities impacting environmental sustainability: downstream activities (e.g., green marketing); product design; initiatives associated with recycling (e.g., reverse logistics, reuse, remanufacture, reclaim); waste management and energy utilization (Kouhizadeh & Sarkis, 2018). At this point, specific aspects of BC technology can contribute to greening supply chains, as long as decision-makers bear in mind the sensitive points and adjust business processes accordingly (Saberi et al., 2019). Regarding this, our respondents estimate lots of perks for SSC with the use of BC technology. The list of bringings includes the elimination of paperless work and manual processes (R2:22); increasing access to the market that can stimulate incentives towards environment-friendly applications (R2:22); higher transparency with increasing accountability that can prevent greenwashing (R8:10); improved delivery timing and conditions that may lead to more efficiency in capacity planning and cheaper transportation (R6:18); and better management of material procurement (R3:20). Comparing our findings with the literature, we can conclude that a considerable impact in the environmental context can be expected by the use of well-established BC solutions within the supply chain networks.

5.1.2 Economic Context

Supply chains arise from sophisticated, built-in, multi-stakeholder networks where BC technology can offer higher traceability for products and services (Saberi et al., 2019). Our literature review reveals that the primary objectives in the enterprise medium are decreasing workloads; eliminating inefficiencies; reducing associated costs; and delivering higher quality products, all of which are expected to be positively influenced by BC use cases either directly or indirectly (Helo & Hao, 2019). According to the results that we obtained from the interviews, some hidden inefficiencies, undue costs, and/or lost revenues can be discovered through BC solutions developed for supply chain use cases (R2:60; R4:6; R4:12; R7:161). As one of our respondents reflect, when discussions around sustainability come to the table, companies are more prone to evaluate economic returns firstly (R7:119), which seems to be one of BC's strength to be implemented into multi-stakeholder networks since the use of this technology is directly addressed to automation in the workplace. Therefore, supply chain is considered to be a perfect fit for adopting BC.

5.1.3 Social Context

The social aspect of sustainability can be tackled at both individual and organizational levels (Winter & Knemeyer, 2013). In this study, this subject is evaluated at the organizational level since supply chains, as multi-stakeholder networks, consist of many intra-organizational and inter-organizational operations. These operations include upstream vendor management issues (e.g., supplier selection and development), upstream purchasing, inbound logistics, inventory management, internal material and information flow, production, and outbound logistics (Kouhizadeh & Sarkis, 2018). Since conventional supply chains are generally built upon centralized architectures with discrete ERP systems (Saberi et al., 2019), BC technology seems to be a major disruption that can start over the levels and types of interaction in the supply chain networks. In the literature, major returns in the social context are listed as higher trustworthiness, anti-counterfeiting (Yaga et al., 2018), and a more balanced distribution of workload (Helo & Hao, 2019). Regarding its potential impact on the social pillar of sustainability, the transparency aspect of BC is touched upon so many times by our respondents (R4:10; R4:74; R5:66; R6:8; R7:161; R7:163). Accordingly, higher traceability is addressed in the social context since end-consumer would have the privilege of verifying the legitimacy of a product or service (R7:161). Lack of ability of the current ERP systems to be fully connected to manage information flow is the main issue with the conventional supply chains, whereas BC technology offers smoother communication in this process through automation. Social interactions through e-mails, electronic spreadsheets, and phone calls that are all part of the manual processes in the workplace can be diminished by a certain degree. Another aspect of this discussion is resilience against malicious attacks towards the network, which is supported by private BCs and expected to be developed even further by handling transactions over the zero-knowledge proof mechanism. In the social context, considering the multifaceted nature of inbound and outbound logistics operations, transparency, and smart executions seem to be the most promising features of BC technology to benefit from.

5.2 BC Characteristics

5.2.1 Decentralization, Immutability and Versatility

Decentralization

Decentralization is addressed as one of BC technology's core features that enhances the reliability of recorded transactions (Kouhizadeh & Sarkis, 2018), which is also a facilitator to prevent the single point of failure encountered in the conventional supply chains (Viriyasitavat & Hoonsopon, 2019). Most of our respondents interpret decentralization as a feature rather than a benefit, meaning it is considered as a facilitator that establishes a ground for the other qualities of this technology. In this case, there is no obvious consensus around the correlation between decentralization and environmental concerns of SSC. However, a few respondents estimate an indirect environmental impact since it supports high-quality decision making through reliable records, which may then add up to making better business decisions on greening activities (e.g., energy conservation, waste management, recycling). In the economic context, certain scholars draw attention to the fact that eliminating central authority during transactions may lower the server costs (Zheng et al., 2018; Viriyasitavat & Hoonsopon, 2019). Again, there is no unanimity amongst our interviewees, regarding the impact of decentralization on the economic

aspect of SSC. However, a few of them are more focused on its indirect effect in forms of increased trust and efficiency (R3:48; R4:36; R6:44; R8:48), which may then bring ROI into the forefront against the investment costs of building a decentralized database structure. In the social (i.e., organizational) context, decentralized systems are technically more resilient than centralized databases against hacking, corruption, or crashing (Tian, 2016), thanks to increasing data validity (Crosby et al., 2016). In this regard, our respondents also see at least a medium level of impact since there will be a democratic allocation of control, a more consistent data repository on each chain, and hence higher trust among nodes.

Immutability

Our literature review reflects that data immutability is the feature of BC technology that provides a tamper-proof nature (Kouhizadeh & Sarkis, 2018) unless more than half of the nodes in the network start to be controlled by a specific user (Lin & Liao, 2017). Our interviews also reflect that as is the case with decentralization, immutability is not considered as a benefit but a feature of BC technology that supports data integrity and security. Nevertheless, for certain cases, there might be some variations in effect regarding the pillars of SSC. In the environmental context, higher traceability supported by data immutability may lead to calculating the carbon footprint of any product accurately (R8:24). In the economic context, some of the interviewees consider immutability as a facilitator to obtain full audit trail records through accounting systems (R6:46; R8:44). However, there is no consensus around any obvious impact in the economic context. When it comes to the organizational level of evaluation, data immutability is comprehended differently. Some respondents touch upon its influence on establishing higher trust among all participants (R2:73; R8:56), while others address synchronized information repository from an inter-organizational perspective (R3:68). Though it is not unanimous, the majority of our respondents see a considerable impact on the organizational concerns.

Versatility

BC is considered as a versatile technology by certain scholars (Seebacher & Schüritz, 2017; Khan et al., 2019) since participants may implement different types of programs into the BC architecture. After conducting our interviews, we see that versatility created the biggest ambiguity in our respondents' minds. Most of them do not regard BC as a super-versatile technology since its application is rather limited to certain use cases as of now. In this respect, some see it as a burden for the current systems with the reasoning that even BC technology itself is at the early stages of adoption per se. However, its integration capability with some ever-evolving technologies (i.e, IoT) is noted by some of the respondents (R2:94; R6:42), In all three aspects of SSC, there is no obvious consensus on the impact of the versatility of BC technology on SSC.

5.2.2 Transparency, Security/Integrity of Data and Smart Executions

Transparency

In any logistics and supply chain setting, perhaps the biggest challenge is the lack of easily accessible and reliable information resources, regarding which transparency and hence higher traceability are being the ultimate qualities provided by BC technology (Kamble et al., 2020). However, the term transparency may cause confusion as if it necessarily creates a lack of

privacy, which is generally not the case (Khan et al., 2019). In this regard, most of our respondents address transparency as the reason why BC technology is incorporated in supply chain use cases (R4:22; R5:26; R7:36). On the other hand, certain concerns revolve around the transparency aspect of BC technology, especially for public BCs where privacy, to a certain extent, continues to be a major issue to sort out. In this regard, a concept called zero-knowledge proof that allows information sharing without revealing personal data is introduced by certain respondents (R6:34; R6:48; R7:153). They assert that zero-knowledge proof promises to alleviate privacy concerns around transparency. As opposed to our literature review, implications from interviews show that transparency can be a two-fold issue, especially for the control of financial data which needs to be classified in any case. In the environmental context, all of our respondents agree on the fact that transparency will have a huge impact on SSC. The other two pillars of SSC are also expected to be influenced to a certain extent and the factor here is again indisputable, which is higher traceability obtained by transparent supply chains.

Security & Integrity of data

The trustless logic of BC technology ensures that user identities remain anonymous since there is no intervention by a third-party when transactions are being processed (Tian, 2016). At this point, decentralization contributes to the system's reliability since data integrity relies upon a consensus mechanism that aims to lessen data loss and the impact of malicious attacks (Kouhizadeh & Sarkis, 2018). Our interviews reflect that security and the integrity of data is a feature of BC technology that cannot be compromised since it goes hand in hand with transparency, implying that it is the prerequisite for setting transparent supply chain networks. As is the case with decentralization, security and the integrity of data leads to higher trust in transactions, which is expected to bring more precise decision-making ability (R5:68). Furthermore, this feature is likely to be highly effective in proving the legitimacy of products coming out of supply chain networks (R7:109). Although there are still some security concerns due to lack of globally accepted standards and norms (R6:66), security and data integrity is considered as one of the golds of BC technology by almost all interviewees who participated in our study. Regarding all three pillars of SSC, most of our respondents estimate a significant impact of this feature.

Smart executions

Smart execution is another prominent asset of BC technology that is seen to be a facilitator for improved efficiency and cost reduction across business operations throughout the supply chain networks (Kouhizadeh & Sarkis, 2018). Smart contracts stand for business rules defined in the BC network to automate transactions in a securely operating medium (Saberi et al., 2019). All but one of our respondents expect significant value for supply chains through the use of smart contracts. Accordingly, that specific interviewee looks upon smart executions as speed-related issues (R4:26), the absence of which he thinks might not be so impactful for sustainability concerns in supply chains. His reasoning here mostly relies upon an argument that SSC can still be fulfilled as long as the first four characteristics (i.e., decentralization, immutability, transparency, security and integrity of data) are well-established in place. Apart from this, most of our respondents address the automation capability acquired by the use of smart contracts that can eliminate friction in payments and contracts. Accordingly, the economic impact is expected to be the largest, whereas the influence of smart contracts on social and environmental concerns is foreseen to be nearly medium scale.

5.3 Challenges and Risks

Immaturity of BC Technology

The immaturity of BC is often cited as a challenge to implement this technology into non-financial areas (Tian, 2016; Helo & Hao, 2019). At this point, transaction throughput (Zheng et al., 2017), a growing need for storage and synchronization (Tian, 2016), privacy concerns (Helo & Hao, 2019), and outstanding level of power and energy utilization (Mougayar, 2016) have been parts of the issue through which most people consider BC technology as immature at its early stages of evolution. Even though there is some sort of variance regarding this challenge, the majority of our interviewees predominantly think that the technology itself is mature enough to be adopted (R4:78; R5:84; R6:76; R7:125). To be specific, most of the respondents agree that throughput becomes less of a problem (R5:84; R6:90; R7:153; R8:52) such that private BCs have already solved this issue whereas public BCs are likely to do so in the near term through the use of proofs instead of private data sharing (R6:62; R7:153). Privacy continuous to be a problem for public BCs which prevents their use through supply chain networks, however, it is expected to be alleviated through the use of the zero-knowledge proof mechanism (R6:8; R7:101). When it comes to high levels of power and energy utilization, permissioned (i.e., private) BCs do not have those heavy requirements of energy consumption (R2:24), which are more proper use cases for supply chains in the short term. To wrap it up, BC technology's maturity is comprehended differently by our interviewees, so that there is no consensus on this issue whether it has a powerful impact on the adoption. This is because it seems to be a discussion around many different aspects of BC technology, all of which should be evaluated distinctly.

Awareness and Technical Competence

The literature reflects that lack of awareness and technical competence is a prominent factor that affects the adoption of BC technology significantly (Banafa, 2017; Angelis & da Silva, 2019). In this context, Helo and Hao (2019) assert that organizational development and long-term training are essential to derive higher adoption rates regarding BC, which is totally in line with R5's reflection about the growing need for higher awareness and technical expertise (R5:86). Almost all of our interviewees arrive at a consensus around this challenge to have a high impact on the adoption, except R7, who thinks quite the opposite of the common view here, explaining that lack of awareness or technical competence does not appear to be a core problem since he witnesses that their market is well-educated on this topic (R7:127). The reason for this might be the fact that he is leading implementation projects with his team by collaborating closely with the mid-level supply chain managers and C-level executives of companies that they provide advisory services for, considering that all those officials are carrying the ultimate liability regarding these projects.

Organizational Collaboration

Lack of organizational collaboration is addressed in the literature as one of the biggest challenges for the adoption of BC technology in the enterprise concept (Kshetri, 2018; Helo & Hao, 2019) since it restrains the organizational learning, and thus delay the progression of the implementation process (Clancy, 2017). Although it is not seen the highest challenge by more than half of them, our interviewees agree on the impact of this challenge that poses risks for the success of business use cases. Two of our respondents touch on the lack of organizational collaboration as a result of complex business cases and poorly structured BC solutions that

makes it even more compelling for people to comprehend specifics (R4:92; R8:76). In conjunction with change management, lack of upper management involvement and dedication is seen even more of a disadvantage, since it would create gaps as barriers among organizational divisions or elements within the supply chain (R5:90; R5:94; R5:108). One interviewee draws a longbow even further, propounding that practitioners will get midway across the project if it is supported by the upper management with full commitment and provenance (R6:80). This links our findings with the literature in which it is highlighted that cooperative involvement of all stakeholders is a crucial requirement to acquire knowledge and skills by building standards and regulations in the workplace (Clancy, 2017; Kshetri, 2018; Helo & Hao, 2019). To put it in a nutshell, our findings converge on the literature regarding the lack of organizational collaboration as an issue that needs to be addressed.

Change Management

Our literature review shows us that change management is considered to be one of the most challenging issues with BC technology adoption, as is the case with the adoption of almost every technology (Zhao, Fan & Yan, 2016; Michelman, 2017; Kshetri, 2018; Queiroz & Wamba, 2019; Wang et al., 2019). As in line with the literature, most of our respondents place great importance on this factor to govern the process and set the policies for supply chain use cases, where some of them see it as the biggest challenge that can lead to project failures (R6:12).. Accordingly, setting up the parameters properly from the very beginning and apply them through pilot projects seem to be crucial at this point (R4:10; R5:100; R5:106), which may then lead to a better alignment with the existing business model. The digital transformation process needs to be handled studiously such that stakeholders involved in the process can be easily adapted to what BC brings in (R8:12). One of our respondents also identifies a very close relationship between governance and legal aspects since bringing parties together to work collaboratively will require a novel legal framework. These are all the implications that bring us to the point where change management, organizational collaboration, as well as legal and compliance are the three issues that should be evaluated collectively when adopting BC technology.

Cost and Functionality

Cost and functionality appear to be a controversial topic that needs to be cautiously considered when adopting BC technology. In the literature, various aspects have been reflected by scholars, most of which revolve around a discussion regarding cost and performance ratio (Lin & Liao, 2017; Atlam & Wills, 2019; Helo & Hao, 2019; Kamble et al., 2020). BC practitioners need to examine whether the technology will generate higher benefits and fulfill the needs of businesses when getting linked to the conventional supply chain systems (Lin & Liao, 2017). Some of our interviewees reflect that theoretically, BC's ROI would prevail the cost of investment and there should be no problem regarding functionality if it is a feasible business use case and integrated properly with the current system (R2:86; R5:96; R6:84; R7:133; R8:82). There is also a project failure perspective regarding this issue, implying that failed projects are the essential reason why cost and functionality may become a concern (R3:100). Consequently, it all comes to the feasibility of business use cases where the stake has to be high enough to squeeze the benefit out of this investment. Customization appears to be a common issue at this point since each and every use case requires a certain type of business model transformation as a result of differentiating market strategies with changes both in the internal and external processes.

Legal and Compliance

Legal and compliance are often cited in the literature as an issue that has a significant impact on the adoption of BC technology (Asatryan, 2017; Lin & Liao, 2017; Kshetri, 2018; Zheng et al., 2018; Yaga et al., 2018; Kamble et al., 2020). The most addressed aspects involved here are the nonexistence of universally recognized regulatory rules and battles against cybersecurity attacks. In this context, most of our respondents estimate an average level of impact on the adoption (R2:88; R3:108; R4:96; R6:88; R7:141). The general opinion here is that legal and compliance has been a seriously impactful issue up to this point, though the impact is diminishing by favor of recent regulatory initiatives and the developments in the protocols associated with the technology itself. Nonetheless, it seems that there is still a distance to cover regarding legal and compliance since on certain occasions, it may be challenging for companies in terms of lacking proactivity towards instantaneous initiatives taken by rule-makers. Furthermore, legal and compliance do not seem to be an aspect that could be disassociated from change management and organizational collaboration aspects, as we stated earlier in this section.

6 Conclusion

This chapter outlines this research paper by laying stress upon key findings and inferences. The first section addresses the research question together with study purposes, whereas the subsequent section highlights the essential implications regarding BC and its correlation with SSCM, as well as challenges and risks with the adoption of this technology. The chapter ends up with some suggestions for further research to be conducted in the area of interest.

6.1 Research Question

The purpose of this research was to identify the benefits, challenges, and risks associated with the adoption of BC technology, which then leads to scrutinize its potential impact on the sustainability aspect of SCM. We hereby formulated the following research question:

"How does BC technology impact the sustainability aspect of SCM?"

Looking for an answer to this question, we constructed a conceptual framework that encapsulates the aspects of SSC and BC technology characteristics, together with challenges and risks associated with the technology. We used this framework as a blueprint for the rest of our study to delve into the use of BC technology within the scope of SSCM. In this context, we interviewed eight industry professionals, all of whom have solid expertise in BC technology and its potential use cases for SCM. One of these interviews, which was a pre-interview for testing the accuracy of our preliminary interview guide, brings us the chance of sharpening our interview questions even further. The interviewees who participated in our study were asked to assess the correlations between each BC technology characteristic and each major aspect of sustainability. Regarding this, they shared their views in detail and sum up with responses on the impact levels of relevant correlations on a 3-point scale, which we constructed as low to high. The structured part of our interview guide ended up with challenges and risks associated with the adoption of BC technology. Again, interviewees reflected their viewpoints with in-depth explanations and concluded with their judgments regarding the impact levels of these challenges and risks on the same scale previously mentioned.

6.2 Key Findings

By benchmarking the empirical findings acquired via interviews and the existing literature in similar contexts, this study presents some key findings that confirm the current fund of knowledge in the academic world, while also bringing in some points that contradict the literature covered through this study. Further in the section, some other implications are presented since they also seem to be critical for the evaluation of BC technology in the SSCM.

6.2.1 BC Characteristics & Aspects of SSCM

Decentralization, Immutability and Versatility

After collecting an extensive amount of data and making a thorough analysis, we identified that decentralization and immutability are the core features of BC rather than direct benefits to reap for SSCM. That is, these two features pave the way for the integrity of data since transactions are immutably recorded into shared ledgers over a decentralized database so that the reliability of records can be ensured and monitored. The findings of this thesis reveal that decentralization and immutability may only have indirect effects on the pillars of SSCM. Accordingly, they both are facilitators for BC's trustless network architecture so that it may be reasonable to expect some environmental, economic, and organizational impact as certain interviewees argue over specific examples. In the environmental context, immutable records may compel companies to comply with regulations on greenwashing since all the records are being forced to stay inside permanently. However, it is again argumentative regarding whether immutability is the facilitator of the system's operability or the actions taken for the sake of SSCM. In the economic context, there is no obvious correlation between any of these features and SSCM. In the social context, it may be reasonable to assert that decentralization and immutability are somehow effective on the sustainability aspect of supply chains since they collectively lead up to more accurate individual data repository for organization members to benefit from. When it comes to discussions around versatility, it is quite ambiguous to address it as a real asset of BC as of now. As opposed to the literature, many respondents see it as a burden for now since BC itself is at the early stages of its evolution in supply chains. Some of them even do not regard BC as a versatile technology since its practical applications are rather limited to certain use cases.

Transparency, Security/Integrity of Data and Smart Executions

Reflections from the interviews and implications obtained via the literature that we covered in this research show us that transparency, security, and the integrity of data, as well as smart executions, seem to be BC's three golden features that SSCM can leverage for the better. As in line with our literature review, transparency is addressed as the biggest reason why BC technology is applied to supply chain use cases. In the environmental context, it is considered as the biggest facilitator of BC for greening activities since it allows tracing a product back to its origin, and hence facilitates calculating the carbon footprint accurately. In the economic context, transparency is appeared to be a two-fold issue. It adds up to cleaning up the supply chain from process inefficiencies, undue costs, and lost revenues. However, it may also cause problems associated with privacy if standardization of rules and governance is weak, especially for the protection of classified information such as financial reports. At this point, two of our respondents bring up the concept called *zero-knowledge proof*, which is described as putting proofs into the transaction database rather than sharing personal data. Considering the automation capability that can be injected into various large and small operations in logistics, smart executions are seen by our respondents as one of the greatest contributors of BC technology to SSCM. Regarding this, smart contracts hold the potential to eliminate a large volume of workload, paperwork, conflicts, process lead times, and idle times associated with information and material flow. In the social context, security and the integrity of data is rated as having the biggest impact since it is a quality that simply cannot be compromised at the organizational level. This aspect of BC offers higher trust in transactions and hence paves the way for better decision-making ability.

6.2.2 Challenges and Risks

Immaturity of BC Technology, Cost and Functionality, Legal and Compliance

Regarding the immaturity of BC technology, our findings show us that it is an issue that creates certain concerns around the adoption, especially in the implementation phase. However, it is addressed by most of the respondents as becoming less of an issue by the day since significant developments are revolving around the technical aspect of BC technology. One of the aspects here was transaction throughput, about which the interviewees reflect that most of the concerns have already been alleviated, especially for private BCs which are now more adaptable to supply chains. Cost and functionality also seem to have a relatively lower impact, considering potential ROI by the use of BC technology and its adaptability to supply chain use cases. On the other hand, there seem to be some critical issues regarding this aspect, such as governance, the suitability of a use case, and the existence of standards and regulations in the workplace. As in line with the literature, the interviewees make no bones of the longstanding impact on legal and compliance. Nevertheless, it seems to be decreasing by favor of many collaborative initiatives taken by governments towards standardization and regulation.

Awareness and Technical Competence, Organizational Collaboration, Change Management

Lack of awareness and technical competence is addressed as one of the biggest issues that have been creating strong barriers against the adoption of BC technology. This is indeed in line with the literature that we covered through our study and it seems to remain on the top for a little while, considering that the technology itself is still at the early stages of adoption by supply chains. Change management is also seen amongst the top challenges posing high risks for the success of implementation projects. As addressed in the literature, our respondents reflect that resistances from various stakeholders against changing standards extremely slow down the diffusion of this innovation in the workplace. The impact of organizational collaboration is seen by our respondents as relatively lower than the first two, yet it still poses a significant risk for the adoption of BC technology. At this point, the upper management's involvement and dedication stands out as a major issue in our respondents' arguments since conducting a BC implementation project is a C-level decision and potentially disrupt every aspect of any given business.

Privacy and Data Ownership

As identified within the literature and observed through the reflections from many of our respondents, privacy continues to be an issue around which serious concerns are still accumulated. In this study, lack of privacy is included as a challenge from the maturity as well as the legal and compliance perspective. However, our findings show us that it is more of a discussion revolving around the forms of BC, where public BCs lead the charge in this respect. At this point, two of our respondents bring up the zero-knowledge proof concept to be a solution as we addressed several times through this research paper. Private BCs seem to be well-grounded and more mature in this regard.

The ownership of data, which is a discussion around who will be the data owner of a BC-integrated supply chain network, comes into view after conducting our pre-interview. The relevant respondent exemplifies his arguments from the supplier-retailer relationship perspective. The main interviews direct our implications on this issue to the distinction between

the forms of BC. That is, it is not much of an issue regarding public BCs since the absence of a data owner is the reason to have these systems in place. Regarding private BCs, it is again projected by some of our respondents that the concept of zero-knowledge proof will be the solution, implying that there will be no private data on the BC in the near term but proofs of transactions.

6.3 Further Research

Supply chains are built-in, sophisticated systems and have a diverse range of contexts to consider when implementing BC technology into any given operation. Regarding this, company size, the convenience of use cases, the technology's adaptability, product variety, project planning, implementation phases, the suitability of the existing standards and regulations are just a handful of subjects that authorities need to take into account before having a stab at deploying BC technology. In our study, we forced ourselves to tackle our topic of interest with a holistic approach as much as we could. This is because both the BC technology itself and SSCM are far-reaching artifacts to study in many different aspects. Our findings and analysis show us that the forms of BC, public, private, and consortium BCs, require further investigation to identify use cases that can be a better fit to supply chains. Therefore, future research could be built around an in-depth analysis of practical differences between the forms of BC and their prospects in SSCM. Furthermore, future studies could head for specific case studies structured by pilot projects around small pieces of mainstream supply chain operations.

Appendices

Appendix 1: Contacting Interviewees

Message delivered to invite respondents:

Title: Academic Interview about the use of Blockchain for Sustainable Supply Chains

Message:

Dear ...

We hope you are doing well.

We are a group of master's students at Lund University, who is working on a thesis related to the impact of blockchain technology on sustainable supply chains. Regarding this, we need to evaluate the benefits of blockchain to attain sustainable supply chains, together with some challenges and risks associated with the adoption of blockchain. Having said that, our main theme is to scratch if blockchain technology is more than hype for sustainable supply chains.

According to your schedule, would it be possible to carry out an interview with you by the midst-April? Though we would prefer face-to-face interviews, considering the uncertainty with this corona outbreak, the idea is to carry out an online interview with a duration from 60 min to 90 min. This interview will be recorded and transcribed in the thesis if you share your consent. We could also anonymize your identity if you would prefer.

In case you are not available, is there someone else that you can recommend us regarding this subject? We will be looking forward to your response.

Warm regards,

N.Yigit Kurtoglu
Muhammed Manneh
Abdulazeem Adesanya

LUND UNIVERSITY

Appendix 2: Pre-Interview Guide

The questions included here constitute the preliminary version of our interview guide. After conducting the pre-interview, the scope of questions was enriched and sharpened for asking the right questions through the main interviews.

Track 1 – Overall Evaluation

- How can the use of BC technology transform supply chains as compared to the prevalent ERP systems?
- What are the potential BC use cases for green and SSC?
- Does the BC universe rely upon more adaptable rules than other supply chain technologies? If so, what are those rules?

Track 2 – BC Characteristics

- How can transparency influence the adoption of BC technology?
- How can the integrity of data influence the adoption of BC technology?
- How can immutability influence the adoption of BC technology?
- How can reliability influence the adoption of BC technology?
- How can privacy influence the adoption of BC technology?
- How can versatility influence the adoption of BC technology?
- What are the impacts of those aspects (i.e., transparency, the integrity of data, immutability, privacy, reliability, versatility) as social, economic, and technological drivers, respectively?
- How beneficial are those aspects (i.e., transparency, the integrity of data, immutability, privacy, reliability, versatility) for safety and quality?

Track 3 – Challenges & Risks

- What are the organizational, technological, environmental challenges with the adoption of BC technology?

Appendix 3: Main Interview Guide

Background Check

- Would you consent to that we record and transcribe the content of this session?
- Are we allowed to use your company title, or would you prefer it to be anonymous?
- What prior experience do you have with BC, SCM, sustainability agenda?

Track 1 – Overall Evaluation

- How can the use of BC technology transform supply chains as compared to the prevalent ERP systems? What makes the BC architecture attractive to supply chains?
- Does the BC universe rely upon more adaptable rules than other supply chain technologies? If so, what are those rules?
- What are the potential BC use cases for green and SSC practices?
- How do you see the future of BC technology through the supply chain networks?
- According to your perspective, which industries will likely benefit most from the supply chain use case of BC technology?

Track 2 – BC Characteristics & Aspects of Sustainable SCM

⇒ Regarding Environmental Concerns of SSC

- How can BC's decentralized database architecture impact the environmental concerns of a supply chain? (e.g., energy conservation, recycling, waste management, greening activities, etc.) Why?
- How can immutability impact the environmental concerns of a supply chain? (e.g., energy conservation, recycling, waste management, greening activities, etc.) Why?
- How can transparency impact the environmental concerns of a supply chain? (e.g., energy conservation, recycling, waste management, greening activities, etc.) Why?
- How can security and the integrity of data impact the environmental concerns of a supply chain? (e.g., energy conservation, recycling, waste management, greening activities, etc.) Why?
- How can smart executions impact the environmental concerns of a supply chain? (e.g., energy conservation, recycling, waste management, greening activities, etc.) Why?
- How can versatility impact the environmental concerns of a supply chain? (e.g., energy conservation, recycling, waste management, greening activities, etc.) Why?

⇒ Regarding Economical Concerns of SSC

- How can BC's decentralized database architecture impact the economic concerns of a supply chain? Why?
- How can immutability impact the economic concerns of a supply chain? Why?
- How can transparency impact the economic concerns of a supply chain? Why?

- How can security and the integrity of data impact the economic concerns of a supply chain? Why?
- How can smart executions impact the economic concerns of a supply chain? Why?
- How can versatility impact the economic concerns of a supply chain? Why?

⇒ Regarding Social Concerns of SSC

- How can BC's decentralized database architecture impact the organizational concerns of a supply chain? Why?
- How can immutability impact the organizational concerns of a supply chain? Why?
- How can transparency impact the organizational concerns of a supply chain? Why?
- How can security and the integrity of data impact the organizational concerns of a supply chain? Why?
- How can smart executions impact the organizational concerns of a supply chain? Why?
- How can versatility impact the organizational concerns of a supply chain? Why?

Follow-up: Is there any other aspect of SSCM or BC characteristics that you would like to draw attention to? Why?

Track 3- Challenges & Risks with the Adoption of BC Technology

- How does the immaturity of BC impact the adoption of this technology? Regarding the extent of it, how would you rate it on a 3-point scale? (i.e., low-medium-high)
- How does the lack of awareness and technical competence impact the adoption of BC technology? Regarding the extent of it, how would you rate it on a 3-point scale? (i.e., low-medium-high)
- How does organizational collaboration impact the adoption of BC technology? Regarding the extent of it, how would you rate it on a 3-point scale? (i.e., low-medium-high)
- How does change management impact the adoption of BC technology? Regarding the extent of it, how would you rate it on a 3-point scale? (i.e., low-medium-high)
- How does cost and functionality impact the adoption of BC technology? Regarding the extent of it, how would you rate it on a 3-point scale? (i.e., low-medium-high)
- How does legal and compliance impact the adoption of BC technology? Regarding the extent of it, how would you rate it on a 3-point scale? (i.e., low-medium-high)

Follow-up: Is there any other challenge or risk that you can suggest to us to think of?

Closing

- Is there anything else you want to add before ending the interview?
- Would it work for you if we get back to you for anything to be clarified or if any other question arises?
- Thank you for taking the time to participate in our study, would you like us to send a copy of the study when it has been published?

Appendix 4: Pre-Interview – R1

Company: Anonymous

Interviewee: R1

Job title: Operations Manager - Supply Chain Expert

Interview Type: MS Teams Audio Call

Duration: 56:49

Date and time: 15th of April, 2020

Line	Person	Text
1	Researcher	Getting started, can we briefly touch on the industry, your company, what kind of business are you running, your role within the organization, etc.?
2	R1	Sure. As Food Impex International, we have been running our business in the food industry for 40 years. We have a major product line that includes deep-frozen fruits, berries and vegetables. I can tell our main focus is private label packing and direct supplies to the food industry. We offer private label products, customized blends and a range of packaging alternatives. We also deliver some products in our own brands like Simply Superior. Our headquarters is located at Helsingborg, but we also have a subsidiary in Spain, which we see as a substantial market for our business. I work as Operations Manager through the supply chain workstream in our company, running projects on operations management, food safety, lean manufacturing, product development and continuous improvement.
3	Researcher	Thanks for the detailed introduction. So to begin with, probably you have already seen our preliminary questions included in our pre-interview guide. After we got some feedback from you through this session, we thought that maybe we could structure our interview guide a bit more.
4	R1	Yes, that’s true.

5	Researcher	So we understand you have an overall perspective on our demeanor. We can start by asking how can the use of blockchain (BC) technology transform supply chains as compared to the prevalent ERP systems? We are asking this because right now, it seems to be a bit challenging to replace built-in ERP systems with promising blockchain practices from scratch. Regarding this, we think that there should be some practical challenges and risks considering complex mechanisms through supply chain networks. We don't know if it is more challenging in the food industry, but what can you tell us about the transformative function of BC technology in comparison with the existing built-in ERP systems?
6	R1	Well, first of all, I don't know if you guys are familiar with what Siemens is doing. Siemens is developing blockchain, I don't know if you've seen what they've done?
7	Researcher	Actually, not in detail but we had an overall view about it.
8	R1	What I think is that... where everyone would gain the most, in fact it is true as you say, all the information is built into the ERP systems today. You can find the whole traceability with the structure you have for products. Now I'm just talking about food processing. In the ERP system today, you have the possibility of having the raw material connected to the relevant supplier, you can have it connected throughout the ERP system, to be connected into different recipes, when you are using it into a recipe, how much you are using it, how much goes to waste, what films you are using in the production order, for example. There you can connect everything from everywhere and then, in the end this product ends up in a storage and then after storage it gets sent to a customer. To bring this out of the ERP system and make it visible, to even get a feeling of what we are doing with each product, it is totally impossible in an ERP system. With blockchain, where you can bring this to light, sort of say, where you can then add even more information and have information being put in by suppliers, all the activities along the line can be updated by different either the processor, the supplier, the trader, or the customer. It is so much easier to get an overview over the whole chain. That's where I see there is a potential with blockchain and where you can have all the information in one spot.

9	Researcher	I think it is more like a decentralized system that we can extract information from, let's say, one medium, one repository, and the critical term here should be "traceability" to our understanding, is that right?
10	R1	I think that's the whole use of blockchain. To make everyone sure about the traceability back to… for example, if we are talking about let's say avocado, you can trace it all the back to which field and which tree the avocado was grown on. And, that everybody knows where it comes to eliminate food fraud and other things.
11	Researcher	When we say everyone knows the origin of the product, is the customer allowed to see the origin of the product as well?
12	R1	I mean that's the critical question in the whole blockchain and that's why unfortunately I don't see that blockchain will be anything that… I mean I believe it is not going to be driven either by processors, growers, or traders because no one is in the interest of giving this information to the customer. Because, if all the information that the customer will get from this… Because you have to realize what's happening in the stores right now, more and more stores are going to be private labeled. For example, if we take a Swedish example, ICA, Coop, Axfood, if I am a supplier to them and I am supplying a brand, I've got my pack of brand on there, and I have made the whole blockchain and everything, I let the customer be a part of it, to take part of all the information in the blockchain, which means what I'm giving to customer now is a blueprint for them to go and make a private label product the day after, with another supplier. They have gotten all the information, all the data, and everything for just turning this over to another supplier. And the same goes if it is a private label product then they can just change the private label supplier in a heartbeat. Because all the information with grower, processor, trader, with the whole supply chain with everything from transportation, they would have all the information in one place. This is all my opinion but I think that's why the transparency in this will be something that the retailers, the end-customer will be very interested to take part of. That's their only interest because they want to take control and have the opportunity to change the supplier if the price is not correct. I think that's the fear with transparency. So, let's say then we have a blockchain, on which certain actors are allowed to see certain things, there must be someone that

		sees everything and that someone, which will be a company that supplies the software or whatever, they need to get paid. And who is going to pay for it? The ones paying for it will also be the ones controlling the whole thing. For the most part, all the prices are so squeezed in the market today, that money is at the top of the food chain, sort of saying. Money for development is owned by retailers so they will be the ones investing in having the blockchains. But will the suppliers be interested in putting in the correct information or the information needed to stimulate a perfect traceability and transparency through the whole supply chain? I don't know. That's the question!
13	Researcher	A follow-up question right here. Can we ensure the complete effectiveness of information sharing through the blockchain within the supply chain network? Because there are certain aspects that we spotted with this BC technology like transparency, integrity of data, immutability, reliability, privacy, versatility, etc. When it comes to these aspects, is there a certain procedure, or 100% certainty that this information sharing through blockchain technology is really effective throughout the supply chain network?
14	R1	I can't answer that! It depends on who put the information in there, where did you extract it from? Was the information true in the beginning?
15	Researcher	We are asking this because data is immutable within the blockchain, I think anyone can make a change throughout shared distributed ledger, these records are registered through chains as immutable data, so whenever an erroneous and faulty data is recorded through blockchain, it seems to be a bit hard to change and modify since it is recorded perpetually, so an erroneous data can be processed through the blockchain after all without being noticed, right?
16	R1	Yeah, but the whole thing is that if I am a grower in Peru for example, of avocado, if I put in to the blockchain that this was grown in this field, this particular batch of product was grown in this area, it was treated in this way, etc. meaning everything that's been happening to this product, and I put this into the blockchain, it goes to the next, let's say a packhouse, if they want to pack this product, they should bring this up and then it should extract this information from the blockchain and labelled product with this information, of course, because otherwise it's correct that then you can't

		temper with it whether this product is actually the correct product. The next step is, when it comes to Europe, to a warehouse, or wherever when they are going to ship it out to a retailer, if the retailer wants to trace back they can see that they got the product from a certain wholesaler, and all the information that's been put into it along the way, if you can temper with it at any stage, as I understand it, you lose the effectiveness or the idea with the blockchain. Was that the correct answer to your question or?
17	Researcher	If we get it in the right way, it is more about the integrity of data. The members of any supply chain would process all the information in the first place. But after that all the transactions need to be transparent. Our question was more related to the immutable nature of BC technology. Once a piece of information is recorded into a chain, it seems really hard to take it out of the blockchain later on, if we understand this in the correct may?
18	R1	Yeah, but you should not be able to take it out! If you take it out, you lose the whole idea with the blockchain as I see it!
19	Researcher	So another follow-up right here. At the end, it boils down to transparency and trustworthiness of participants, am I correct?
20	R1	Yeah, of course! Every single step needs to be 100% true when they put in their information because if they don't then there is no reason for having a blockchain at all. This is why blockchain has been something everybody starts talking about. For the food industry, there has been so much food fraud! So if you sell chicken, you say that chicken is from Germany but in reality if it is made by Ukraine instead, that's what we see today that somewhere along the line someone is changing for example the origin of the product, they re-label it somewhere in the process. But everyone that puts in data here needs to be 100% honest with the information they put in. The next level in the blockchain needs to extract that information to use it for their needs and repack it into the blockchain then after. For example, if you are a meat processor and buy meat, then you add different ingredients which you need to add into the blockchain as information. And by saying ingredients it can be packaging, pallets, etc.) For the meat, it goes back to where it came from. From the supplier of the meat, you put in what origin it is from. That follows then the product through the processor to the

		customer. The utopia with blockchain would be that you and me as customers we can walk through supermarkets and we can just scan a QR code on a piece of meat in the fridge. And then I can get up from exactly which farm this cow came from when it was slaughtered and everything. That's the utopia!
21	Researcher	I think it converges into traceability again at the end! The system would be more traceable along the way to the origin of the product. So the bottomline is traceability?
22	R1	Yes, exactly.
23	Researcher	Let's talk a little about green initiatives and sustainable supply chain practices through the use of blockchain. Because by the end of this study, our goal is to test whether we can correlate blockchain with sustainable supply chain management. You know there are certain aspects of sustainability when it comes to this kind of a discussion, like environmental, social and financial concerns, especially in the private sector. Regarding this, how can we position blockchain in the discussion of sustainable SCM, meaning what are the challenges, pros and cons, if we want to make a SWOT analysis sort of saying?
24	R1	The possibilities you have with blockchain... if you use it correctly and feed the blockchain with the correct information in every step, then you have a lot of data in the blockchain, which later you can translate to environmental impact sort of saying. You can have in the blockchain, for example all the transportation data, then you know the product has been transported from A to B, you know it is done with a truck, for each product you can go in and look at where it is being transported and you can see how much packaging has been added along the way, if it is meat, then you know how much meat that has gone, how much live cow has gone to the slaughter house, how much meat has gone to a specific product. You would be able to extract all these data and you can use it to figure out the carbon footprint for each product. But I don't see it as a system that you can run by pushing a single button, there needs to be continuous data feed. For example, if you have a certain packaging film coming in from the side of the product, let's say you take 10 grams of plastic and put it on, and you need to know what kind of plastic it is and what kind of environmental impact that plastic has and what is the carbon footprint per gram for

		that certain plastic. That will be quite hard to have all data for all plastics in one system. But at least you can extract what kind of plastics and how many grams you have put in.
25	Researcher	Okay, there we have another challenge to consider, scalability! How much data can be processed at what scale, volume, and pace?
26	R1	Just to make it an easy thing to understand, that's where you also see the opportunities with it! The hard part is when you have the data, you have to translate it into what kind of data you actually want! I mean when you look for carbon footprint, what is the carbon footprint for each component that has been put into the product along the blockchain.
27	Researcher	So we want to talk a little more about challenges and limitations with blockchain but before going into that direction, probably we need to discuss what practical aspects that we need to reconsider and use to structure our theoretical framework a little more? After going through the literature, we see that certain mainstream studies support the use of blockchain on sustainable supply chain management, whether there are also another set of studies reflecting challenges, vulnerabilities, risks, etc. Do you have a piece of advice in this regard?
28	R1	Honestly, I don't have a straight answer to it. I think what will be the hard thing here, or what will be your biggest challenge here is that if you want to pull anything out of a blockchain to have it as a benefit for environmental sustainability, I bet there is a lot of people that have written a lot of good things which you can get out of blockchain. First of all, if you boil it down to what will be to put into it, as I have understood with the blockchain, what I put in as a food processor for example, that is affecting the sustainability of a product, for example packaging, I will have that in the blockchain as how much I put in of a certain type of packaging material, you know what I mean? That's what you are going to be able to extract, maybe from which supplier it is. But how much will that help you? You can probably add up to how much paper, how much plastic, how much metal you have in total put into a certain type of product over a year. But, what should you do with that information? You will just get numbers. You can probably extract a lot of that information. But if it is going to be effective, then the ones putting it into the blockchain needs to put in all the other

		parameters as well! I mean if you are looking at how sustainable a product is, then you need to know… for example, what the carbon footprint is for this exact packaging material, then this needs to be put into the blockchain all from the beginning, if it should be able to get extracted in an easy way, or else you have to recalculate it afterwards. I think that's the only answer I can give you!
29	Researcher	When you say, you know, when we talk about these things in the first place, when you say you need to open your eyes to bigger questions, so how can you define the bigger question in one sentence? Because maybe we can just change our focus after getting feedback from you.
30	R1	The biggest question in this is who is going to own the data and who will the different steps in the blockchain be interested in putting in the information. Will there integrity be, you know, will it be enough so that they don't give away too much information to the next step because then you are interchangeable. That is the whole fear from every supplier nowadays when we have so much in the food sector. For example where we are talking about all this private label where you are exchangeable.
31	Researcher	So is it about scalability, I mean, you know, I think it just sounds like we are coming to information sharing once again.
32	R1	I think that is where everything starts, meaning you have to look at who benefits the most from blockchain like from well working blockchain.
33	Researcher	So who do you think will be the one to benefit most from the blockchain ?
34	R1	The one that could benefit the most is the retailer in the end because they can push the prices and they can find other suppliers that are willing to purchase the raw materials from the same source but process it cheaper.
35	Researcher	So when we talk about financial sustainability, I think it is kind of self-explanatory that this blockchain technology will add up to something and in environmental perspective, yeah, we have a concern on carbon footprint so, when it comes to traceability of packaging materials or how much packaging

		material will be added through the process, I think blockchain applies a certain tune to benefit for environmental sustainability. But when it comes to the social sustainability perspective, when it comes to interaction between members of the supply chain, employees, manager, executives, and all that stuff, so how can you reflect an example of the contribution of blockchain technology on social sustainability aspects of the supply chain?
36	R1	That, I don't have one clue about how to do that. The only way would be that you have a digital certificate that you send along. So, if I am a farmer and I have undergone a social audit, I could have a digital signature that I send with my product into the blockchain and then it is easy to say, I mean I own a number or whatever so that I am approved and that everyone has that and can send it along in the blockchain. I don't see any other way by which we could have any benefit from blockchain. I mean all the social audits or everything like that, I mean that is done by third-party auditors, so then you would have to for example, connect the blockchain to these different types of organizations but there would be so many organizations and so many systems. So I don't see that, maybe it is doable but I don't know.
37	Researcher	Can we just talk a little bit about the challenges and risks with the adoption of this blockchain technology within your industry or any kind of industries?
38	R1	First of all, you need to believe me that blockchain technology would be great to have in place where everyone adds all the information to a blockchain. You can extract all the components, all products going in, everything that has been happening to the products, which would be perfect to have. Because then in each level, you can add any certain points, you can look at the product and say: "Okay, it came from that place, it's been shipped there, it's been picked there, it's been, you know, farm there…" It would be great. But with that said, I think we will be back to transparency in the end where everyone is willing to give that transparency to the next step in the blockchain. For example, the retailers are interested in letting the people lower down in the blockchain to be able to see where they send the product, because that is also an aspect, for example, with blockchain would be easy to figure out for suppliers. For example, I have sent this much product to this customer and that customer has sent it to others… So, it could be easy for me to jump or cut one

		step of the supply chain and start selling directly to the end customer.
39	Researcher	I just wanna ask about the sustainability drivers, as we know, we just talked about the social drivers and I believe that customers are one of the major drivers that are actually one of the forces to reckon with, when it comes to social responsibilities for companies. So I just want to know about companies who actually adopt supply chain management, are they at the end of receiving, implementing or getting that social responsibility, I mean through blockchain, can they get a social sustainable driver so that they can attract more customers to what they are actually selling.?
40	R1	Yes, if you give away all the information… It would be attractable for customers but it would also mean a risk to give away all the information because you give away your whole business model at the same time. I mean of course, when we sell products, we only deal with companies in China, for example, that have undergone audits from companies like Serex or BECI, so they have done third-party audits at the supplier and/or the processor and we keep that information and we sometimes share the information with our customers but we have also seen that we have had customers that after one or two years they have decided to go directly to the process because they know where it comes from. So they have, for example, on a trade show, they have been able to look them up and have discussion directly with them and they have jumped one step in the supply chain. I don't say it is wrong because you should always do everything as efficiently as possible but for the whole system it is not good because with the fear of that happening, you lose the willingness to be transparent.
41	Researcher	Isn't it a kind of a problem with privacy concerns? I mean, the system will be transparent to everyone, to each member, especially for the customers but, you know, isn't it some kind of a problem triggering that customers can reach out to every information throughout the supply chain, even all the way up to the origin of the products or anything. But at the end, it is kind of classified information for companies. It is part of the competition, trademarks, exclusive rights, etc., right? Because you know, there needs to be a fair competition within the players of the supply chain network.

42	R1	Yes, because it would be easier for the end customer to see the whole picture and when they see the whole picture, it is easy for them to ask another supplier to do exactly the same but for less costs. That is what I think would be the biggest question for blockchain in the future and this blockchain will be shared from the retailer side and in the end if it is successful and retailers win this battle, they will implement this and have their suppliers to work with in the blockchain. However, it will not be the suppliers that are the driver of it, instead it will be the retailers because they have the most to gain from it. I would think that if I am a wholesaler and I push it backwards and implement this on all my suppliers, I will not be very keen on having the suppliers to know which customers I sell to. So somewhere in the blockchain there will be a stop. The ones paying for it will be the ones that set the limits and regulations for it. But of course, every customer is free to set whatever demands they want. For example, Carrefour in France says that if you are going to be a supplier to Carrefour , then you need to work with the well working blockchain and then that would be part of the game. Everybody that is willing to do it, would be a possible supplier and the ones that don't want to work with it, won't be a supplier either. But the suppliers would always think that it is a risk working that way with the customer because it is always a way for them to at any point extract all the information and give it away.
43	Researcher	On that perspective, I would say, you know it is a part of a fierce competition amongst suppliers because retailers would be the ones that try to select the best one amongst the numerous alternatives of suppliers. So it is part of a fierce competition. Sounds like it.
44	R1	Yeah, but what they would do is they will establish with the supplier a good blockchain but then, every year they need to reduce the price on their products, that is the part of their growth strategy. So, they need to decrease the price with a certain percentage.
45	Researchers	We are talking about retailers, right?

46	R1	Yes. So, year one, if I pay one Euro per kilo for something on a deal with a supplier, then with the year number two, I would like to pay 98 cents for the same product. During that year you have established the whole blockchain, all the information is in there, then that supplier can say: "No, I can't do that. It needs to be one Euro.". Then it is easier to go to the next supplier and give the information from the blockchain to that supplier and say: "Can you supply me with this product? It is packed like this. The packaging material is this much, it's purchased from this supplier, you have the raw material from this supplier and on and on…". I mean, the information would be easily transferable since the system is more transparent. There is the point where the transparency will be very helpful in changing out your supplier, if you are a retailer.
47	Researcher	Yes, but on the supplier side, I think it is part of a challenge for financial sustainability, right? Because they are investing throughout the whole year. Year after year they need to sustain a certain quality, that is part of their job, but at the same time, they need to be more productive at a cheaper price. Isn't it kind of an unbalanced situation for them to sustain financial toughness maybe.
48	R1	Yes, but equality is not something that is all the way up, it is the price that is at the top!
49	Researcher	I think that is all about your answer for this question, so maybe I jump to the second question after this?
50	R1	Yes, I need to go in a few minutes.
51	Researcher	Yes, we already passed the time limit that we agreed on. Thanks for your understanding. Just maybe one or two more questions and we are going to pack it up. Do you think that from the technical perspective, the blockchain universe is a medium that your industry would easily adapt to? Do you think that the blockchain universe relies upon more adaptable rules than other supply chain technologies? If so, what can be these rules when adopting blockchain technology through a supply chain network?

52	R1	I don't know if I understand you correctly. But I think the only way of making this is that the blockchain needs to be very adaptable to what you have today. Because there is not a whole lot of money to develop and do new things. I saw that Siemens talked about their blockchain technology and all the hardware and the software that are needed to be able to run the blockchain. All the companies have already invested in ERP systems, which already cost a lot of money. So, I think the only way is to have this blockchain to be able to work together with what is there already, and as smooth and easy as possible. I am not an expert, but if someone came to me and said: "I have got a blockchain application here for you, it is very easy, it is in the cloud and the only thing you have to do is that you have to open up your ERP system to let this system you have to extract information to the cloud of this software.". I think that is the only way it would work. I saw that Siemens, for example, were talking about having printers that print data onto the products on the packaging machines in the production. That is just another cost that no one would take.
53	Researcher	One follow-up question. If this technology is applicable to prevalent ERP systems in different industries, as it looks to be applicable to the food industry, it seems that it takes a lot of money to invest in such a technology. At this point is it possible to make a comparison between the investment costs of sustaining ERP systems and the offerings of a blockchain system? Other than that, if we want to see the practical implementation, it seems to be a bit ambiguous to clarify whether this technology is worthy of investment or not. Do you agree?
54	R1	I think the only way in which it will be integrated or if there would be any investment done towards blockchain, it would be by favour of a demand from the next level in the supply chain. For example, customers demand their suppliers to have it or that the blockchain would be integrated into the new ERP systems that are coming.
55	Researcher	Maybe it is just adapting the system to blockchain aspects rather than changing all the system from scratch.

56	R1	Yes, because that is what you are looking for in your ERP system, which is visibility, by which you can actually see what is going on, I mean not just numbers but happening everywhere. You can see the flow in the system. I don't know, maybe Microsoft can make something like this happen.
57	Researcher	Coming to the bottom line, from your perspective, the two biggest questions are: "Who is going to be the data owner?" and "Will the data be sufficient to enable 100% transparency through information flow?" I think it sounds more like a discussion or maybe a concern on scalability. That is to say, since it is a decentralized system that allows information sharing among equal nodes, so to say, data ownership and scalability would likely be the primary concerns, to my understanding?
58	R1	Yes, I hope you guys have gotten enough answers. I need to rush!
59	Researchers	Yes, thank you very much for your time. It was really effective and productive for all of us. We would try to get the best out of it. We are much appreciated for your time and efforts.
60	R1	Thank you. Goodbye.

Appendix 5: Interview Transcript – R2

Company: Anonymous

Interviewee: R2

Job title: Manager - Blockchain-powered Supply Chain Operations

Interview Type: Zoom Audio Call

Duration: 1:03:33

Date and time: 22nd of April, 2020

(A-En) - Environmental Aspect of SSCM - Green

(A-Ec) - Economic Aspect of SSCM - Yellow

(A-So) - Social Aspect of SSCM - Blue

(OF) - Other Findings - Red

Line	Person	Text	Category
1	Researcher	Alright, are we ready R2? So, the first question is what prior experience you have with blockchain, supply chain management, or sustainability agenda?	
2	R2	So, I have been working in lots of stages since 2017. I have a Computer Science background originally, the supply chain is one of the applications I have been focusing on historically mainly around traceability, track and trace stuff applications but I am also familiar with the sustainability field from my prior job. Prior to Deloitte, I worked with the United Nations development program in Indonesia where a lot of the work the agency was doing was around sustainable supply chain for palm oil, timber, pulp-and-paper, and some other types of commodities, so that's a bit of my background.	

3	Researcher	I think we have a perfect fit for our interview right now. So just to reflect the overall evaluation of our demeanor, we can start with the structured part of our interview, the first question was how can the use of blockchain technology transform supply chains as compared to the prevalent ERP systems, I mean what makes the blockchain architecture attractive to supply chains?	
4	R2	Ok, so overall, what blockchain does is to connect multiple parties to let them share information with one another and should this information is most of the time as your question alludes to be held in ERP systems that are within the boundary of one single company and so what blockchain does is to give companies a way to share a subset of information to solve a common problem together, the traceability problem, the accountability problem, or just like tracing provenance furthermore, so it complements what the ERP systems are doing already for supply chains.	BC
5	Researcher	Does the blockchain universe rely upon more adaptable rules than other supply chain technologies?	
6	R2	So, what do you mean by more adaptable rules?	
7	Researcher	We can just amplify our question like this, you know right now conventional supply chains have built-in complex systems, they are all embedded but when it comes to blockchain, it is a brand new technology and there are some pros and cons with blockchain as I see when it comes to the implementation of blockchain technology through a supply chain network, is it kind of adaptable technology for supply chains rather than the ERP systems because it sounds like a bit complex to our understanding?	
8	R2	Well, what's most complex about the application of blockchain in general, is the governance of it because as just mentioned before it requires the cooperation between	CR-CM, CR-OC

		multiple actors that comes together to solve a common problem. If you are looking in an ERP that a single company is managing then there is no real issue of coordination governance, harmonization, or whatever you call it because it is within the control of one single entity, whereas for blockchain a group needs to be agreeing on those rules and that's what makes it quite difficult. The technology itself, not simple but also you know, the cloud is not simple there are a lot of other technologies that are quite complex to implement as well.	
9	Researcher	I think it will be a follow-up question, right next to this according to your perspective, which industries do you think will likely benefit most from the supply chain use case of blockchain technology?	
10	R2	Yes, you see it already in some of the market examples around blockchain for the supply chain. Walmart has been working for quite a while on the traceability of their products through the supply chain, so let's say retail, food-agro, all of these are already quite advanced but also I think the automotive industry is somewhere by attracting a lot of interest, shipping is also something that requires keeping track of goods, special crops, borders because of a lot of supply chain is applicable.	
11	Researcher	Do you have any advanced examples in practice, like the implementation of blockchain through a supply chain network? I know IBM is conducting some kind of project like this…	
12	R2	Yes, that's why I was referring to the Walmart example.	

13	Researcher	When you think about the pros and cons, advantages and disadvantages, and the toughness with the implementation of this technology, how do you see the future of blockchain technology through the supply chain networks? I know it's a broad question but do you think this technology is more than hype for supply chains? Because according to a Gartner report nearly 85% of blockchain implementation projects through the supply chain networks have failed or likely to fail in the short term.	
14	R2	Yes, so your question is that is it hype or how is it real?	
15	Researcher	Yes, how do you see the future of blockchain technology through the supply chain networks?	
16	R2	After quite a long period of hype and I see a boom of 2017 -2018 that I think the discussion has changed quite a bit, companies that were really keen to invest in blockchain have… I think we were seeing that in any supply chain space as well. There might be a bigger focus on the permissioned aspect of it. I mean permissioned blockchain networks like Hyperledger fabric don't really have a lot to do with cryptocurrency so the conversation has to change quite a bit. Is it a hype or is it going to be a fixture of the technology we will use in the future? That's a thing that everyone's opinion is different. I would say we passed the biggest part of the hype, even though it might not be fully through the disillusionment from the Gartner hacker but the maturity is getting there.	OF
17	Researcher	So you are kind of positivistic about the future of blockchain technology, right?	
18	R2	Yes, definitely.	
19	Researcher	How can you amplify your answer about this side? Because a lot of people are saying	

		different things regarding the challenges and risks. As an overall question, how do you see the prospect of this technology to be implemented through the supply chain networks accurately? It seems to require a lot of effort and time, so many things to change. When it comes to that, do you think it is quite applicable through the supply chain mechanisms, or is it a more complicated case than we estimate that will spark a lot more discussion in the future?	
20	R2	Well, the domain of the supply chain is very applicable to blockchain in my opinion. Because it solves problems very common for supply chains about information being a little scattered, you know silos of data that are not fully connected. There are many ways to do that, but what blockchain provides could quite a bit answer for it. What is worth we can bring in is that in any sort of Information Systems, the blockchain bit is actually quite small. A small domain of the application, right? You have everything that sits on top of it, so your front-end application, like integration with existing ERP systems, all of which is the stuff that surrounded the blockchain parties within a quite small universe, in general.	BC
21	Researcher	What are the potential blockchain use cases for green and sustainable supply chain practices? In this session, when we proceed to the sustainability aspect of supply chain networks, there will be a discussion around environmental, social, and economic aspects… But as an overview, do you think that blockchain is beneficial for the sustainability aspect of supply chain networks?	
22	R2	There are a number of these cases that are interesting in terms of sustainability. The one that comes up the most is proof of provenance, having the ability to demonstrate where a product is coming from and that is very relevant when you are talking about certified industries, for example, I will take the example of FSC - Forest Stewardship Council - sustainably harvested wood. If you have in	BC

		front of you two logs that both claim they are FSC certified but one has come through a very manual process where you have paper documents are exchanged between hands, between different parties with a lot of opportunities for fraud and another one that has maybe less of those manual touchpoints but a lot of it is more automated and recorded on chains between different parties and that increases the level of trust that you have in the products. So, the proof of provenance is quite a good one, adjacent to that there is a presentation of its certificate, so an FSC certified product is a certification but how do you present it physically? Is it a piece of paper, is it a digital certificate that is issued by a company that can be verified very easily? So, that is also a common type of blockchain potential, per se, in supply chain and sustainability. Well, I guess increasing access to the market could also be a good application of blockchain in this context, right? If you create that kind of network of like, trusted parties that are trading then you might make it easier for companies to access these markets and start trading and demonstrate that they have higher accountability so that there could be better applications as well.	
23	Researcher	On the other hand, there are concerns around blockchain technology regarding the environmental aspect of sustainability, since the use of blockchain-based applications seems to take a lot of energy, computational power, electricity, and there need to be really capable servers to make use of. So when it comes to that, how do you see the impact of blockchain on environmental concerns?	
24	R2	Well, when we talk about the environmental impact of blockchain in terms of energy consumption, I think it's important to make a distinction between blockchain and reused PoW algorithms for data security and validation, such as Bitcoin. I think Bitcoin is	BC, A-En

		the main culprit here because it still requires a pretty heavy network organization system which is PoW, which was quite oriented from ten years ago. Since then you have many other types of blockchain or distributed ledger that don't require this type of heavy network radiation. Typically something like Hyperledger fabric, that is a permissioned blockchain, does not rely on the same algorithm and does not have those heavy requirements of energy consumption and you wouldn't run a blockchain for supply chain application on the bitcoin blockchain probably, but rather on those newer implementations of it like Corda…	
25	Researcher	After going through the literature, we just summarized six main aspects of blockchain, as you might have noticed in our interview guide, such as decentralization; data immutability; transparency; integrity of data and security; smart executions, which are done through smart contracts; and versatility. By saying versatility, we are just referring to Blockchain 1.0, 2.0, 3.0, and 4.0 as the evolution of this technology in time. At this point, Blockchain 1.0 alludes to the introduction of Bitcoin, Blockchain 2.0 stands for the use of smart contracts and Blockchain 3.0 implies the use of blockchain through different industries, and lastly, Blockchain 4.0 is the integration of blockchain technology with the other ever-expanding technologies within those industries. And when it comes to these six aspects, considering that we are trying to look for individual correlations between these and environmental concerns, and starting with decentralization, do you see any correlation between decentralization and environmental concerns like energy conservation, recycling, waste management or greening activities, etc?	
26	R2	So, I don't really see a link there or a causal impact. The decentralized aspect of blockchain only means that, for instance, instead of having a set of information in one place, you just have to replicate it across different locations so that it becomes tamper-proof and resistant. I don't think that it has an	BC-D, A-En

		impact on energy conservation, recycling, waste management, and greening activities.	
27	Researcher	We are asking this because to our understanding, decentralized database structure requires lots of distributed service usage at the same time, so doesn't it require the use of a lot more energy, computational power, which can be considered as a negative aspect of decentralization?	
28	R2	It depends on the type of computation you are doing and the type of information you are receiving. If you duplicate storage, yes you have a duplication of resources but that doesn't mean there is a heavy computation that is happening on all of them at the same time. Back to my example of Bitcoin vs others, if you have many more nodes on the Bitcoin network that just improperly merged, there will be an adverse effect on the environmental impact of it, mainly about energy consumption, but that is not necessarily true from other types of blockchains that are not as power-hungry. I don't see any link with waste management and recycling in this regard. I think energy consumption is probably the only one and may be linked to being actually decentralized across the network. It feels that a company has objectives of creating its own activities and they might want to invest in some types of blockchain applications rather than others that are underperformance energy-wise.	BC-D, A-En
29	Researcher	So, I think it's pretty much the same thing as immutability, right? We assume that this data immutability aspect could be either pros or cons of blockchain if some kind of erroneous data is recorded into a blockchain network. How do you see the effect of data immutability on supply chain applications?	
30	R2	You achieve the immutability of data if you are decentralized enough. Does immutability excel with a clear impact on the supply chain? I would say not really! Because transactions are immutable, meaning it can't be edited but	BC-I, A-En

		you can also add a transaction after that to invalidate it, right? If something was recorded incorrectly, I don't know, let's say if a port where a load retainer received container #36 while actually, it must be the container #37, additional transaction record can just say "ignore this transaction", it was a mistake, it was actually #37, that is added to the history register of that container, but if it comes to the correlation between data immutability and environmental concerns of a supply chain, I would say there is not much of a correlation!	
31	Researcher	We got it. So maybe we can just wrap up with environmental concerns by talking about the rest of the aspects that we've just listed, you know, transparency, the integrity of data, smart executions, and versatility… So when you think about those four aspects, is there any apparent correlation between any of those with environmental concerns of a supply chain?	
32	R2	Let's start with transparency. I think transparency is a high correlation to environmental concerns of a supply chain but in a positive way! If you have higher transparency that potentially leads to more sustainable supply chains by highlighting really what's happening on the supply chain, for example, related to fraud, inefficiencies, a lot of the information actually you have on the supply chain. The correlation relies on the accessibility of everyone's input involved through the supply chain, you could say that! It improves sustainability depending on the use case, depending on the industry, of course, but in general, is it a positive correlation? Definitely...	BC-T, A-En
33	Researcher	So, what do you think about the others, integrity of data, smart executions, versatility?	
34	R2	Security/integrity of data… I think it depends on the data itself, if there is more security of data, it means that you would potentially be less open to fraud, you might use it as a means of cleaning up some supply chains but that's very similar to the immutability of data	BC-SI, A-En

		argument.	
35	Researcher	This will be kind of a follow-up but when it comes to the integrity of data, could it be more related to energy conservation? Because when you have solid data, you might be really capable of how to make use of energy, how to optimize your energy consumption levels throughout all of your network, I mean for any kind of network, not solely for supply chain networks? To our understanding, the integrity of data might be correlated to energy conservation, right?	
36	R2	Yes, I guess if you have more trust, and quality data, data integrity then on top of that, you can improve your own business operations so that you can also potentially improve your energy footprint of consumption, if you are saying that, Yes that's a reasonable correlation there!	BC-SI, A-En
37	Researcher	Can we just talk a little bit about smart executions, we know it's being done by smart contracts as we go through the literature? The insightful information regarding this aspect is relatively a bit more limited. So technically speaking, can we just talk about smart executions a little more?	
38	R2	Yes, a smart execution is basically embedding some business rules into smart contracts so that it is executed when conditions are met. So, a good example is having smart contracts for the payment of a shipment. Also for my example of the container at the port above, you can very much have a smart contract that triggers a payment back to the originator when the condition is met and the condition is that the shipment has arrived. So, having this automation in place there may be an environmental positive aspect on the supply chain, it means it requires less labor intension, goods moved potentially faster in a more automated way so that would require quite a heavy type of study to demonstrate I believe, but that could be seen as having more efficient	BC-SE, A-En

		and more sustainable supply chains.	
39	Researcher	Last but not least, the versatility aspect of blockchain… Is there any correlation?	
40	R2	So, versatility… First of all, I don't know if you can call blockchain as a super-versatile as a technology because it is applicable to a handful of applications. This is quite the hype as we were talking about earlier, blockchain is advertised as doing a lot of different things but when we go down to what it is really good at, use cases are quite targeted so I am not really sure about that!	BC-V, A-En
41	Researcher	So, we have a 3-point impact scale like for example, low, medium, high, to clarify the level of correlation between BC characteristics and environmental concerns of supply chains. When it comes to that, how would you scale the correlation among them? Let's do it one by one.	
42	R2	I think it is a little more nuanced than that. But if we take the whole list, decentralization has potentially a medium level of impact, with data immutability I don't really see an impact, I will say low. For transparency, it's surely high. Security/integrity of data is argumentative, so to say, maybe low-to-medium. For smart executions, I would say medium but needs to be proven, so like, medium-to-high...	BC-D, BC-I, BC-T, BC-SI, BC-SE, A-En
43	Researcher	And, versatility?	
44	R2	So, what did you guys mean by the versatility of blockchain technology because that can be applied by many factors? Can you guys explain what exactly you refer to by pointing out versatility?	
45	Researcher	Sure. We know it seems to be a bit latent term by bringing forward it like this. As we go through the literature, we see that most of the scholarly works just refer to the evolution of blockchain technology starting with Blockchain 1.0 up to Blockchain 4.0. Blockchain 1.0 means the initiation of Bitcoin,	

		Blockchain 2.0 is more about the use of smart contracts, Blockchain 3.0 is the idea of using BC technology in some kind of mediums other than financial applications. And Blockchain 4.0 is more related to the collaboration between blockchain and artificial intelligence elements. So, it's kind of classification for different types of versions of this technology. When it comes to the term versatility, we are just referring to these differences in class.	
46	R2	Yes, okay?	
47	Researcher	So, when we ask about the versatility of blockchain here, we are just trying to figure out whether this emerging and ever-growing diversity have any impact on the environmental concerns of supply chains, that's what we are digging for.	
48	R2	Okay, then I would say low!	BC-V, A-En
49	Researcher	Because you think that blockchain technology is inherently not that versatile, right?	
50	R2	Yes, because it lends itself to specific applications, right? So...	BC-V, A-En
51	Researcher	Okay, we can just jump into the economic concerns, we believe it might incorporate more salient correlations, right? Can we just keep track of the same logic as we try to correlate those six characteristics to the economic concerns of a supply chain?	
52	R2	So, would that be just expressing the level of correlation on a 3-point scale?	
53	Researcher	Maybe we can talk about it a little more detailed than that.	
54	R2	Okay, sounds good.	
55	Researcher	So, first, we have decentralization again, has it any impact on the economic concerns of a supply chain?	
56	R2	Yes, so the economic impact of decentralization… How you replicated systems may cost more money than having a	BC-D, A-Ec

		standard (i.e., centralized) mode of any given architecture. However, if the network of the blockchain system is serving its right purpose, then I could also see some economic benefits as well, right? You're just running the network more efficiently, more securely but that requires a bit of enterprise for that, otherwise, it is not much of a network, so to say. So yes, a considerable correlation I would say.	
57	Researcher	So, can we say a high correlation in this regard?	
58	R2	Yes, I would say medium-to-high.	BC-D, A-Ec
59	Researcher	So, what about immutability?	
60	R2	I don't see any correlation, I would say low, so to say. But when it comes to transparency, I would definitely say there is a high and positive correlation to economic concerns of supply chains. Yet again, when you are cleaning up the supply chain, then you might discover a lot of costs and inefficiencies, a lot of lost revenue for fraud, counterfeiting, or anything like that.	BC, A-Ec
61	Researcher	At this point, it is just follow-up, but I'll just come up with a different question. When it comes to transparency, I think it is more of a use for customers/clients because they will have the privilege of transparently monitoring all the historical background of a product from beginning to end, right? So, is it kind of a disadvantage for producers, or retailers, since customers will know everything about any product, the origin, supplier info, list of distributors involved, etc.?	
62	R2	Yes, of course, it could be against the interest of a bad actor in the supply chain. So, if you are a bad actor that actually realizes the fact that supply chains are very opaque and that takes the opportunity to inject lower counterfeit quality goods, for instance, then you probably don't want to have too much transparency in the system. So that is a concern to balance. For consumers, yes, that would be great to have more visibility of things to buy, things to consume but that is not	BC-T, A-Ec

		to say it is everyone's shared view of the world private supply chains, depending on where they are on the spectrum.	
63	Researcher	Yes, thanks. So, we can just keep up with the security or integrity of data after this?	
64	R2	Well, I would say security or integrity of data has rather medium to high correlation with economic concerns because if the quality of your information and trust you have there is higher, you can make a better estimation of a supply chain. Yes, so to say, there is a positive impact in this regard.	BC-SI, A-Ec
65	Researcher	Can we just say medium to high?	
66	R2	Yes, medium to high.	BC-SI, A-Ec
67	R2	So, smart executions… Well, I think that is a high one also. If you improve efficiency through smart contracts and special payment terms, in these types of things, then you could potentially increase the revenue. Yes, I think it has a high impact. The versatility of blockchain, I am not so sure about this one.	BC-SE, A-Ec
68	Researcher	Can we just attribute it like low?	
69	R2	Yes, I would say low…	BC-V, A-Ec
70	Researcher	And what were you saying about the lack of versatility of blockchain? Because we are using the term differently from your understanding, but you are the expert. How do you call the versatile and not versatile nature of blockchain technology? How do you explain that blockchain technology is not really versatile?	
71	R2	Versatile to me means you can use it in a lot of different scenarios, and it lends help to a lot of different applications. So, if you compare blockchain to something like cloud, for example, you know you can run any type of application on a cloud instance, it can be a	BC-V, A-Ec

		banking application, it can be a governance site, it can be your own website, it can be many things but if you take blockchain itself as a technology, there is like a more narrow but specialized type of applications you can use it for. Managing digital assets is one, treating those imageable trails of records is another… So, to rank them in terms of versatility, I would say blockchain has been on the lower end of versatility. That is my understanding of versatility if that makes sense.	
72	Researcher	Yes, it was crystal clear. So, let's jump to social concerns then. Again, starting with decentralization is there any impact from decentralization on the social concerns or we can say organizational concerns, including intra-organizational and inter-organizational concerns. Let's address the social aspect of sustainability, to have sense-making a bit more.	
73	R2	Potentially having a decentralized system means that it is not in the hands of only one actor, or only powerful actors so there might be a positive correlation between decentralization and the social aspect here. So, I would rate it high. Coming to immutability, probably if you want to use the information that is part of the evidence for something, then that type of immutability is a positive thing. Transparency is the same thing, if you want to use the evidence provided by a more transparent system, then there is a positive correlation. Security, the integrity of data, I think it is quite similar to the immutability arguments, more trusting information.	BC-D, BC-I, BC-T, BC-SI, A-So
74	Researcher	On a 3-point scale, what would you say about each?	
75	R2	I would say high.	BC-D, BC-I, BC-T, BC-SI, A-So
76	R2	Smart executions' context is pretty close to the transparency argument because a smart contract means that there are stakeholders who can go and see what is in the smart contract. So that could have positive aspects also here,	BC-SE, BC-V, A-So

		there is no black box, there are no processes that happened fully behind the closed doors. That could be positive here. Versatility, I would say no because there is no correlation.	
77	Researcher	Is there any other sustainable supply chain management aspect or blockchain characteristics that you would like to draw our attention to?	
78	R2	I think a helpful thing in the analysis is to look at public versus private blockchains maybe… Because there are quite a lot of differences between the two. Maybe we can look at each of them because if you talk about bitcoin versus a more like business type of blockchains… We are talking about supply chains and ERPs, you have typically SAP, Oracle, and a lot of big integrations are run by IT companies, everybody has their own kind of blockchain offerings now and they are really like geared towards business applications of this and they are doing things very differently from what public blockchain like Bitcoin would do. So, that would be good in your analysis to maybe focus more on those business permissioned applications of blockchains or at least make a distinction between the public and private blockchains.	OF
79	Researcher	So, the last part of our interview guide is about challenges and risks with the adoption of blockchain technology. Again, we have a list of challenges over here, I do not know if you can see or not through your desktop or I just call them one by one.	
80	R2	I have them. We would just run through them quickly because I have another call to get on. The immaturity of the adoption of blockchain technology. So, Yes, immaturity has a high impact. For lack of awareness and technical competence, I would say high. When it comes to organizational collaboration…	CR-IM, CR-AWC

81	Researcher	When we say organizational collaboration, we are just referring to the cooperation and collaboration between employees and stakeholders when it comes to the adoption of blockchain technology.	
82	R2	Well, it is not the highest challenge, so I would say medium. The impact of change management on the adoption of blockchain technology, I would say high for this one because it requires working differently. In that case, there are a number of companies that need to work together and that takes quite a bit of change here. For cost and functionality, I would say low. The blockchain system is not considerably more expensive than a more traditional system.	CR-OC, CR-CM, CR-CF
83	Researcher	Oh really! Because a lot of people think blockchain technology is really costly. Is it a wrong belief?	
84	R2	I think again, it depends on which context we are talking about. If you were to run a couple of cloud instances with a concern/concept to the backbone of a blockchain network with a reasonable number of transactions, it is not a crazy Boolean. If you are talking about something like deploying a blockchain application on a cloud-based standpoint, I mean reliable types of cloud offerings of that size which then help you with the need you have to spend for what you are using, there is no inherent high cost from the blockchain itself. So here, I would say low to medium.	
85	Researcher	When we say functionality, I think that term might be some kind of inefficient over here because we were more referring to efficiency actually, that's why maybe functionality can be a more inclusive word here, but the thing is the essential concern is efficiency. So, when you think about the term efficiency, is it kind of correlated with the adoption of blockchain technology?	

86	R2	Then, if you are talking about efficiency, it is more of a difficulty to demonstrate the cost benefits in efficiency, which is an obstacle for adoption because you don't have a lot of add scale implementation of blockchain that then fewer proof points to demonstrate very tangibly what the costs will be and how efficient the systems are going to be. In that way, it is probably medium to high.	CR-CF
87	Researcher	Lastly, we have legal and compliance, in fact, you have already answered this a little bit but maybe you can just amplify your answer.	
88	R2	So, for legal and compliance, I would say medium here because it may require the cooperation of multiple parties and this may require additional legal compliance, which can be considered as hurdles or obstacles. However, they are not inherent to blockchain per se, it is more like how you get multiple parties to collaborate efficiently and have their legal framework around it.	CR-LC
89	Researcher	You drew attention to governance about all this as a challenge, right?	
90	R2	Yes.	
91	Researcher	Is there any risk or challenge that you can suggest to us to think of?	
92	R2	Governance is the main one because it requires, first, the willingness of different parties to come together and then a mechanism for them to work together and that might include a legal framework as well, the creation of new legal entities, these types of things… So, I think the governance and legal aspects are quite significant challenges…	OF
93	Researcher	One last question. I would like to ask if in the absence of blockchain technology, are there any other promising technologies that can actually be used to deliver sustainable supply chain management?	

94	R2	Yes, and it is more of a combination of technologies rather than one over the other. So, I would say the combination of blockchain and IoT, for example, can be really important for sustainable supply chain because, if the blockchain provides digital records of what is happening in the real world, you need to make a connection between the real world and the digital representation so, having efficient IoT devices that connect shipment to digital representation is very crucial. IoT and combinations are really important, the cloud is obviously, inexplicably useful and important. Mobile devices, for example, I think a lot of the smartphones that we use today can be used for like improving the efficiency and the security in sustainable supply chains. If you think about small gadgets that would record or authenticate some of what they produce using smartphones and that way entering that digital trail that the blockchain can create, so this doesn't have to be cutting edge technology but it has to be a combination of it with others.	OF
95	Researcher	Is there anything else you want to add before ending the interview?	
96	R2	No, I think that is all. I hope this was helpful in terms of input.	
97	Researcher	Yes, that really worked a treat. Thank you for taking the time to take part in our studies, we are really grateful for that opportunity.	
98	R2	So, if you have questions, you can reach out by email. Happy to answer your questions and also to see a little draft before the publication, just to review whether the input is beneficial.	
99	Researcher	Before we end, what do you think about our interview guide? Do you think that we are asking the right questions, or do you think that there are some kind of different aspects that we should focus on?	
100	R2	I think it is a good framework. It needs maybe to go on a little deeper on nuances. To me, the public and private aspects of blockchain as well and maybe what could be helpful is to	

		focus on a sample of industries and networks, maybe add some focus here as well. That's the feedback I have at this point.	
101	Researcher	So, would you like us to send a copy of the study when it has been published?	
102	R2	Ideally, before publication just to make sure the information accuracy is there.	
103	Researcher	Before we end the interview, is it okay that we include your company title and job description in our study?	
104	R2	Yes.	
105	Researcher	Thank you for your time and the valuable information you shared with us. It was really effective and helpful.	
106	R2	Thank you. Goodbye.	

Appendix 6: Interview Transcript – R3

Company: DSV Global Transport & Logistics

Interviewee: R3

Job title: Director of Product Development - Blockchain Expert

Interview Type: Skype Video Call

Duration: 1:26:06

Date and time: 23rd of April, 2020

(A-En) - Environmental Aspect of SSCM - Green

(A-Ec) - Economic Aspect of SSCM - Yellow

(A-So) - Social Aspect of SSCM - Blue

(OF) - Other Findings – Red

Line	Person	Text	Category
1	Researcher	Are we allowed to use your company title or would you prefer it to be anonymous?	
2	R3	No, it is fine you can use my title.	
3	Researcher	As the first question, can we talk a little bit about your prior experience in relation to blockchain, sustainable supply chain, and sustainability agenda?	
4	R3	Sure, first let me introduce myself and then automatically explain what I got about these topics. I am the director of product development of DSV Solutions. Doing that for 3 years now. Working for DSV for 6 years, previously as global business development director of DSV Industrial. My current function is that I am responsible for all new services, all new developments, and all innovations within the DSV Organization and that is quite broad. I have topics on my innovation agenda from 3D printing,	

		robotics, machine learning, artificial intelligence, blockchain and more or less, how can we use new technologies to improve our services or to create new services, that's generally what I do in my current position. In my previous function, I was the global head of the industrial sector within DSV. There I was following all kinds of new technologies that could impact my markets - industrial markets - as a whole. I am quite well-read into the topic of what it can bring us, what constraints there are for a company like DSV so I hope I can contribute to your research project.	
5	Researcher	Sure, it seems that we have a perfect fit for our study to interview. The structured part of our interview guide starts by asking, how can the use of blockchain technology transform supply chains as compared to the prevalent ERP systems? What makes the blockchain architecture attractive to supply chain management?	
6	R3	I think the biggest thought that you speak of is due to the fact that once you have a predefined contract within the blockchain structure, you fill in an order and it is being fulfilled with payments as automatically transferred from one to the other. So, the whole chain of companies is easily connected and brings speed into the supply chain much easier. Due to the fact that you have the right information or you can reach the right information from the blockchain infrastructure due to the fact that I don't need every information to fulfill my service but as it is available; it is easy for me to get. And I can add my information to the blockchain once going into the next step of the supply chain, which could be the receiving part in this case where we bring our stuff to. So that is an important one, that's speed. Next to that, is supply chain finance. Normally, you have a lot of interest in a supply chain, meaning once you pay from the raw material to an end product you'll have a lot of finance products in between that have payment terms of 90 days, some have payment terms of 120 days within the blockchain. You will see that there are a lot of lesser financial solutions due to the structure and how the payments are being held with the blockchain technology. So that is the second. The third one is security. Once you use blockchain technology it could secure the way how you receive your information but also how the information is transferred between different kinds of companies. Because what you see now is a direct interface between an ERP system of our customer and our system, that is a one-way	BC

		connection or two-way connection. It goes to them from us and from them to us which is also secure of course, but once my system is down; we cannot communicate with the customer. With blockchain technology, you still have the ability to be able to receive or to fetch the information. So those 3 are the most important things that will change the supply chain, those are not really very small items; speed is huge, it is a competitive advantage within the supply chain, which is the first thing that matters. Supply chain finance is also very important because there is a lot of academic new research on supply chain finance about how it will relate to the value of the supply chain. So, people are being more aware of what the supply chain finance brings to the service. And lastly security: once you see the way systems sometimes being shut down; for example, I remember it was the case for one of the biggest shipping companies. Actually, their systems were down. These are such big disruptions, which are very dangerous for a lot of supply chains.	
7	Researcher	As we go through the literature and also based on our prior experience through supply chain management professionally, maybe it's fair to say that right now conventional supply chain systems are complex built-in systems where it takes greater effort to change anything through the network. So does the blockchain universe rely upon more adaptable rules than other supply chain technologies? If so, what are those rules?	
8	R3	From a connection perspective, because it is how we should approach this, once we are currently in the connection with our customers from an EDI perspective, I mean once the connection is there you do not see many changes. Sometimes it is just a small change caused by a regulation change. So from a certification perspective, it could be that a specific company… you saw it for example with the Rosewood certification… One of our customers who is one of the biggest guitar producer, Fender, have Rosewood in their guitar and once China decided that the Rosewood Material needed to be certified, we had to change the connection because every inbound shipment needed to add in the communication in our system if this was certified or not. Because not everything in the shipment had the Rosewood Material in it. So, there we had to change again the interaction between the ERP of our customer and our WMS. So, I think that the rules of changing, in this case, adaptable	

		rules, are more or less easy to adopt as well as blockchain technology. Because in this case, I think what you need to change here is a predefined contract where you would state that the Rosewood Certification needs to be 1, and not 0. Due to the fact we can receive this shipment: yes or no. So, I think adaptable rules in the supply chain can be used in a way that the blockchain can adapt to it as easily as possible.	
9	Researcher	The reason I was asking this question is that we've seen a lot of reports from different sources, for example, one of the reports from Gartner tells that nearly 85% of supply chain implementation projects through the blockchain network have failed or will likely to fail in the short term. So, I think it is a bit complicated to implement the blockchain technology into the supply chain network, especially for certain industries.	
10	R3	Yeah, because the thing is what I just said. The way I set up my connection with my customer - I can do it in the implementation phase that would take 3 months, to get the communication with their ERP and our WMS. Once it is set it will work – is the same thing that I can do with blockchain. But then I only need to reassure that I made a contract on which I state I need to fulfill specific parts of a message about which I can be 100% sure in executing the service. Because I need to accept what I need to do, and I get paid by the blockchain. But I cannot do it due to the fact that I know everything. So that is only my part. Once I go into a shipper putting a container on a ship he also needs to get a part of the ERP system of the shipper company. And then the port handling company, because it's going from port A to port B. And they all have systems. So, once you would summarize it, you have the shipper that has a system. For example, let's say I am Fender; I make guitars and I sell them. But I make them in the USA. I have my own system that I decided to bring into Europe. So, if I look into the blockchain perspective, I need to have a trucking company to bring it to my facility to the port. The trucking company needs to have a system that connects to the blockchain. Because otherwise blockchain cannot start with him, so there is the trucking company, port handling company, and the country of origin as in the US. So, the port handling company needs to have a connection with my blockchain. Then the shipper has to have the system as well. And we have the port handling at the destination port that needs to have a system that	BC

		can connect to the blockchain. Then I have a trucking company that will fix it up. And then you will have me receiving it in the warehouse. So, in the warehouse we already have six systems being connected to the blockchain. At this point, you can imagine how we look into the rules of a blockchain. Not everybody in the supply chain can adapt to a blockchain. But then I would miss if one trucking company, for example, picking it up from the destination and bringing it to me; doesn't add his information to the blockchain. Then I would not have every information because I need the CMR – the shipping document- which he accepted to complete all documentation in the supply chain. So, there you see the biggest constraint of getting all the companies in one chain. It could be that a company like us can then say that they take the whole supply chain end-to-end and use everything they received and put it into the blockchain and then try to connect more parties into this blockchain. That could be an opportunity, but this is not the case yet.	
11	Researcher	Ok, this is a follow-up. Do you think that blockchain is applicable in every sector of the supply chain? For example, we have seen the blockchain in food traceability, logistics, etc. Do you think global supply chains overall; is blockchain really applicable to each of them?	
12	R3	I think blockchain could be applicable due to the fact that I'm always collecting information and adding information into the value chain of a product. And that could be starting from the factory to you at home; because from the factory I have a shipping document that is going to the port, then from the port, there is a container document that needs to be put on the boat. Also from an insurance perspective; these companies need to have the document so they are adding on all kinds of information like a chain of blocks. The only thing is once you have all the information adding up everybody needs to have the possibility to add his information to the chain. That is the biggest issue. Will Blockchain work in the supply chain? I absolutely have no doubt about it! I think infrastructure and the way how to implement it and the knowledge available in our global IT department, for example, is not at that level that we can use it already. But the philosophy itself as it sounds as what the definition says, "the chain of blocks" – "blockchain"- that is specifically what's happening in the supply chain.	BC

13	Researcher	Another follow-up here. According to your perspective, which industries will likely benefit most from the supply chain use cases of blockchain technology, and why?	
14	R3	Industries from a logistics supply chain perspective, right? Then I think one of the major industries in this regard would be the high-tech industry. Again, we are coming back to speed! Because once you produce - as an example - an electrical material that has a gadget; I need to put it into the market within one month because otherwise, my competitor might offer something new. So, there is speed to market which is the biggest issue to make good money! Because margins in the high-tech business are based upon speed to market. I think they would really benefit from this. Also, I think the food industry… Again, what you want to know in the common future or even you see it right now with the Coronavirus is where does food come from, what has been done with the food, is it directly coming from the farmer or is it already that infected? Is there specific stuff being put on the food? I don't know, as a consumer, I would like to know this in the future. I don't buy anything in the supermarket anymore because I am a little bit suspicious about what happened with the food and why it is cheap, is it good for my body, is it good for my health, etc. With blockchain, once you buy any food, you have all the information available because it's already been put in the blockchain. So, you can easily have the transparency to show that. Also, in the health care business…Especially now with the Coronavirus, no one knows where everything is in the supply chain. Nobody knows if there are respirators, oxygen machines, etc. That will in the future also be important due to the fact they will need this information, especially in the epidemic world pursuing this where you will have customization on health care services. We all need different types of healthcare. Once you'll combine someone's information with the information that is in the supply chain, but you can only find it in a way as in the blockchain because it's an easy and secure way of fetching information. Not all information but the required to make a comparison with the data of my body and from a health care perspective, it will be an interesting case for the companies using blockchain. Because there is security as an important part of being able to combine customization of healthcare and privacy data like my health and my body.	OF

15	Researcher	Before we get into the correlations between blockchain characteristics and aspects of sustainability, can we talk about types of blockchain in the technical perspective: public blockchains versus private blockchains. How do you compare these two in terms of adaptability, capabilities, technical competencies, privacy issues, etc.?	
16	R3	Well, if you look at public blockchains, I don't think that will work in the coming 10 years. Why? As a very simple example, our industry has been telling each other for the last 25 years that when you share information and work together, you will have a lot of money because you can optimize shipments, do good forecasts, even with building good customer and supplier relationships. That still doesn't fly. Companies are still not working together because they don't trust each other! Blockchain says you can trust our philosophy and infrastructure because it's secure. This is true but there is a basic rule that people do not trust the open source area, especially with a company perspective. So, the adaptation of really trusting the public blockchain will not fly for the following 10 years. I think the next generation will probably adopt more and more of this and it will take a minimum of 10 years, that's my foresight. Private blockchains, on the other hand, I think they are easier to adopt because there is a purpose for companies like Heineken, Shell, or whatever, to say that they have a lot of volume as manufacturing companies and once you want to business with them you will need to adapt to the blockchain which they use. That will help you to get paid faster, they will have speed in the market, and they have specific requirements (i.e., use of blockchain) to work together as business partners. They would say that they know it will take a lot of investment from the other parties' side, maybe a half a million or whatever, but those parties can earn it back with a 10-year contract which the controlling company gives them. And then those parties would be eligible for taking access into the private blockchain. So, I think it is the main difference that the public blockchain will take another 10 years to be adopted while the private versions are already being adopted in some companies. And it will take faster to move forward because the objective of a private blockchain is to add value to a specific supply chain.	OF
17	Researcher	What kind of supply chains are we talking about here?	
18	R3	Well, every product has a different supply chain. That makes it difficult. You cannot have a company supply	BC

		chain that will fulfill everything. You will have a product supply chain because even a pen needs certification. But this pen is made of plastic and rubber. So, my inbound plastic in this area is different because I have 4 suppliers in an inbound raw material side so I can have 1 supplier to select amongst them. I think we should really look into the product supply chain once we are thinking about the private blockchains because that's the only way that would work. Or you would say I can use the transportation services and warehouse services only, for example, shipment A will always be suited for specific contract requirements, so will the warehousing process for that specific shipment, and the information I exchange between parties can be used for different products. Then I would have a service blockchain. That is what people are trying to do, creating a service blockchain. This is what Gartner is telling about, that is why it is failing most of the time by now. Because if you are doing a service blockchain, you will miss the difference shared over every product. Because every supply chain is different, every document is different. Every destination is different. Every speed to market is different. That makes it crazy!	
19	Researcher	What are the potential blockchain use cases for green and sustainable supply chains?	
20	R3	Well, as I mentioned before, speed is very important within a blockchain, and speed can only be achieved by having the right information as soon as possible. The way we do business in logistics is, we have lead times and that needs once I get an order in. I need to ship something and that needs to be there the next day or day after. The only thing is that if I would have three days to bring the shipment to you, I can wait another day to consolidate shipments that are in the same area where you live. So, once I go into the next day's delivery, and it takes a long time before I get the right information, I need to send a package to you in Sweden somewhere. If I can wait another day because I have more time, I can maybe send in all three of you a package, because you don't send in the order at the same time but you can take the next day. That means that I can send the bigger package into your area, which is sustainable because I use one shipment for three packages. So, the same for blockchain is that once the information is available earlier than what we have right now; we have consolidation optimization possibilities within the supply	BC, A-En

		chain and there you can reach an absolutely big sustainable advantage. And I am just purely talking about the logistics perspective. From a blockchain perspective, you can even have more environmental possibilities because what you also see is that the lead time of production and distribution also determines the way of purchasing raw materials. So, it could mean that raw materials that are close by or on a ship already and not being sold, or whatever, are not available to the market because people don't know these raw materials on the market. Maybe they buy the raw material in Brazil, instead of the raw material being on a ship in Spain. These kinds of grey areas which we don't know now, I believe, will be fulfilled through bigger blockchains which will be available once you have this infrastructure in place.	
21	Researcher	How can we correlate decentralization as an impact wise with environmental concerns of a supply chain?	
22	R3	Well, all the data is in database architecture and I now only use the data I need for moving goods from A to B. My customer does not allow me or does not see the advantages of getting other data that they have into the supply chain. Because they don't see the value of it right now and they don't trust me with the data. Because once they send in the data they all need to do extra work or then they need to send all the information and then they send silos of data to me and that is what they don't want to do. I think within a decentralized database infrastructure, you are able to say these two parts which I get from my sales data, that part I want to share. And then they share it with me, and I can make decisions on energy conservation or I can start with recycling because I know something about the material, etc. which I would have not known in the past. But they didn't know what to share with me. I think the blockchain's decentralized database and the security aspect is something by which they can freely share small parts of information to me that will impact the way I see this business right. I think that will make a difference.	BC-D, A-En, BC-SI
23	Researcher	On a three-point scale like low-medium-high, what would you say about the correlation of this decentralized database architecture with the environmental concerns?	
24	R3	I think it's highly related because right now I don't have the information to make the right decisions on this part.	BC-D, A-En

		Once I will have it, I am not sure which one is the right ones depending on what type of information is available at the outside of a table, but now I'm just driving a car to go to my grandfather, for example, I know I need to go to my grandfather and I go by my car. But once I do not know I can go to my grandfather by bus with twenty people, I would not take a bus for that. I think that the option of the blockchain will help us in sharing small parts of information that companies now do not want to share because they are frightened to share it or because it takes a lot of effort for them to share it through the current infrastructure.	
25	Researcher	How do you see the correlation between immutability and the environmental concerns of a supply chain?	
26	R3	Since you cannot change data because this is what you mean by immutability, not changing the data… That will I think has a medium impact due to the fact that companies that are currently willing to change the data do not comply with recycling, waste management, or green if you get what I am saying. What you kept as data, you need to act on all of them because you cannot change it in reporting or whatever.	BC-I, A-En
27	Researcher	Next, we have transparency.	
28	R3	I think it has a huge impact. Once the transparency is in the supply chain, everybody can see and even share what I will do in terms of energy conservation, recycling, waste management, etc. in a way that I need to report attached to it.	BC-T, A-En
29	Researcher	We have security and integrity of data so how do you see the impact of these characteristics on supply chains?	
30	R3	More or less in a decentralized data, I think there is a link there. People are willing to share parts of the data which they will not do now. Well, I can take the right decisions to come to this sustainable decision. So that would have a big impact.	BC-SI, A-En
31	Researcher	Can we correlate the aspect of what we call the integrity of data with energy conservation directly?	
32	R3	Yes, because once I would have the integrity of the data or what I need to provide or report back into the	BC-SI, A-En

		blockchain, it can help to make reliable decisions. And that is the key! Because what you now have is the integrity of the data once I still manage the data, I can never be 100% sure about the accuracy of data. Because it is maybe company X in company Y that gives me data with 100% accuracy whereas company B in company C gives it with 90% accuracy, but probably they are all reporting the same. That doesn't change the fact that data can get lost in translation! I think blockchain will help us to have this translation in a more accurate form.	
33	Researcher	Next, we have smart executions. I think it is done through smart contracts as we all know but could you just elaborate a bit more on this one so that we can comprehend better its technical groundwork?	
34	R3	. For example, from the supply chain perspective, let's say you will have pallet X and you need to repack the pallet X into specific parcels, there you have vast packaging material. You will get paid once you show the certificate of putting it into another group in certain areas, then your smart contract will pay 10 euros automatically within one second once you do it. Because that's a part of what you need to report. So, the smart contract can help you in executing the activities in this case, meaning what you request from a supply. And that will of course automatically be an important part because one of the main factors for companies is that they need to get paid in a very fast way forward. Investments are being done with the payback period, the payback period is cross-examined like thinking is there a way to set it like half a year. But they also take into account the payment term of 60 days, for example. So there's once you use smart contract and the smart contract is designed in a way that this is a topic that is part of smart contracts and people are faced to one day with this part of smart contract and the people are automatically paid in a single day with the use of smart contracts. So, companies like us will need to find the right services to comply with smart contracts so that we can make money from them. That will have a huge impact on having all these services by companies like us.	
35	Researcher	How would you scale it when it comes to the evaluation of the correlation between smart executions and	

		environmental concerns? On a 3-point scale of low-medium-high?	
36	R3	High.	BC-SE, A-En
37	Researcher	Just a quick follow-up question at this point. In smart contracts is there any kind of trust issue within the supply chain?	
38	R3	No, I think from the standpoint of smart contracts I would not say that because then you already have adopted the blockchain philosophy, which means you trust the philosophy. So I think what you have is designing a contract and using a smart contract. I think there was no trust issue anymore. I think a big trust issue is adopting the blockchain philosophy itself!	
39	Researcher	This last term here is a bit latent because by attributing versatility characteristics to the blockchain, we are referring to the evolution of blockchain. To be clear, as far as we know, Blockchain 1.0 stands for the introduction of Bitcoin in financial markets, Blockchain 2.0 refers to the use of smart contracts, whereas Blockchain 3.0 and 4.0 is more like the industrial use cases of blockchain with its integration with artificial intelligence elements. So that's the aspect by which we call blockchain as a versatile technology. Considering this perspective, how can the versatility of blockchain technology impact the environmental concerns of a supply chain? What would you say about that?	
40	R3	There are a lot of developments on these technologies, like with artificial intelligence, machine learning on how all of those will help us get smarter through the workplace in energy conservation, recycling activities, etc.	
41	Researcher	I think we were talking about the versatility aspect?	
42	R3	Yes. So I think a lot of technologies help us in having more effort into these topics. And if blockchain technology is going into a version 3.0 where artificial intelligence and machine learning will help us, where it will absolutely impact the year, the way how energy conservation, etc. will be influenced.	BC-V, A-En

43	Researcher	OK, so can we say, like high impact or medium impact?	
44	R3	Yes, I would say high absolutely.	BC-V, A-En
45	Researchers	So I think we can move on to economical concerns. I think it might make better sense when it comes to financial concerns of the supply chain. You know, we can just keep track of the same logic over here as well. You know, we have decentralization, immutability transparency, etc., etc. So we can start with decentralization.	
46	R3	I would love to do that. I will go point by point maybe if that's ok?	
47	Researcher	Sure, it will be better.	
48	R3	So I think from an economical answer in the supply chain, I think that what I said is that there is a way how margins can be influenced, meaning the spirit to market is very important to markets which are already indicated and also having the availability of part of this decentralized database will help us. Also, the uptime, in this case, is very important because sometimes we will see connection issues with the supply of the customer, sometimes we lose connections but with a decentralized database, I think you have 100% uptime so you don't have losses of using the system, I guess. So that was a big impact for acting, so there is a high link there. Immutability, I think it's low, it's due to the fact that you cannot change anything if it's already given, so once it's a given in data, there are ways that you and I have specific pricing towards something because you're going to that it should not be changed, because if you have a different order, you should create a different order and not change the current order. Sometimes in the supply chain, you see, let's say I have an order of three ballots. And before I put it into the truck, the customer calls you and asks to add Q, another product, because I was presented with a document that has an economical value, that shipment price would become higher and we get more market. I think in the blockchain, we will need to create a new shape for that order. And I still can do it, of course. But it has a low economic impact. It's just in a new shape.	BC-D, BC-I, BC-T, A-Ec

		Transparency will have a huge impact because the bigger the gray area, the more money I can make.	
49	Researcher	That's even self-explanatory.	
50	R3	Good. I think that has a huge impact on the concerns within the supply chain. Because I think a lot of customers from our side do not really know what's happening. I know what's happening. And once they say we have three days, I will give it three days but if I have an extra day, I can optimize my operation, for example. So transparency will have a huge impact. That's what I believe. Security, integrity of data, depends on how the trust in the blockchain is being dealt with, because most people do not trust the blockchain philosophy, then the security and integrity of the data doesn't matter anymore. So I think this would have a low impact. And why, we are again coming back to the public and private blockchains. For the public part, it's even, I think, not existing because there are few people who can adapt to the public way of what I said. I don't think it will happen from across to ten years. For a private blockchain, I think it's part of the contract. So the one who is initiating the private blockchain, that companies should ensure the security and integrity of the data because they started it up. So maybe I should say it like this, "shit in and shit out". And I think that then again, it's stated low, because if data is good, then it's good service but the payment is still the same and if the data is bad, I will build a good service but of bad payment, so the shipment will be probably wrong. But I can still rely on the data because it gathers pieces of what I needed to do.	BC-T, BC-SI, A-Ec
51	Researcher	Yes, but just one follow up. Isn't it a problem when it comes to the perspective of managing lead times to ship products? Because if you just miss a lead time, especially for customers like from the upper segment, maybe you can just, you know, put yourself on the downside of advantage with the lead times, because if you can't manage lead times, if it just goes in the wrong way to satisfy the customer need or the customer request, may be the integrity of data can be effective from that perspective. I'm just asking and I'm really curious about your perspective.	

52	R3	I think that's a good addition. I agree with you. Then I would say there is a medium impact. I would change my opinion, that's a good one, that's true. But if "shit in shit out", it still has an economical concern too.	BC-SI, A-Ec
53	Researcher	And next, we have smart executions?	
54	R3	Yes, so I think that will have a huge impact. Why? Smart Contracts will ensure that you can do the service and get paid within the instance. So normally once we have a payment term, for example, of 60 days, we calculate interest. We discuss that's a financial risk. And once you do not have that anymore from smart execution contracts, that one is a big impact, because that's a lot of money when you talk about billions globally. Also the way of negotiating. What do you think of us negotiating every time on a shipment or whatever it might influence the department? So, this will have a huge impact because this is not only on the activity itself, but also on my overhead.	BC-SE, A-Ec
55	Researcher	I'm sorry, what did you say in the last part of the sentence?	
56	R3	Overhead. Because I meet lots of people for purchasing and administration delays.	
57	Researcher	Exactly. And we have the versatility of blockchain technology?	
58	R3	Yes, I think from what I said, that if these new technologies are being embraced by blockchain, that will have a huge impact. I have the feeling that trust in machine learning and artificial intelligence can easily be adapted to blockchain technology, which is strange.	BC-V, A-Ec
59	Researcher	That was what I was about to ask because most of the literature has discussed the integration of blockchain technology with IoT. So when it comes to that, I think this versatility aspect is not an independent aspect. I think it's totally related to the transparency and traceability as well right?	

60	R3	Yeah, absolutely and once people have a competitive advantage, selling products with IoT and they make good money on it, then they need the technology. That's a different thing in adapting to a new technology and saying, ok, how can we use this, instead of we have another technology, which is a huge success, but I can only make it a bigger success once I use blockchain. Then it is automatically adopted. So I think this will have a huge impact because. Once companies make money with another technology, then it's automatically done.	BC-V, A-Ec
61	Researcher	How would you rate it on a 3-point scale?	
62	R3	High.	BC-V, A-Ec
63	Researcher	For the impact of versatility on economical concerns, right?	
64	R3	Yes, definitely.	
65	Researcher	Ok, and so the last pillar of sustainability here is social concerns, as you would appreciate. So we can just go on to that part.	
66	R3	Yeah, social concerns. And that's more or less social concerns of a society or of a company?	
67	Researcher	Let me explain that a little deeper. It's more of organizational concerns because we wonder about the correlation between blockchain technology use cases with the organizational concerns, organizational aspects. It can be about inter-organizational activities or intra-organizational activities. But we think there might be certain aspects to discuss about?	
68	R3	Let me give you an example of this. I have a lot of connections with our customers and we have a huge global IT department, including nearly 1600 people. They all work not only on connections but also on sharing information, etc., preventing me from using Zoom, for example! There's a lot of issues once systems are done. The uptime of a decentralized database	BC-D, BC-I, A-So

		architecture can mean that there are lesser frustrations between operations and the IT department, due to the fact this blockchain's decentralized database is always variable. I think from that point of view, also with connections and not being able to go through active pre-service going down and not receiving EDI messages, I think it has a medium impact, but for some people, it will have a huge impact. So that will decrease the frustration on both intra-organizational or interdepartmental activities. So I would say a medium impact. When it comes to immutability, for that I would also tell it has a medium impact, due to the fact that we have a lot of discussions with customers or the data which they sent to us, so they sent in orders, etc., or whatever, and the executed services. So once I do billing, I do activity-based costing most of the time. So I need to explain the causes that create the total cost of a shipment and there needs to be a cause regarding this. I have a lot of discussions because due to the fact that what I've said before, they send in an order of two pallets and a half an hour before they call me to ask if I can add up to that. But if I do not administer that, I lose my activities regarding these two pallets. If they don't administer that when they call me, then I would say no, you were asking me to send two pallets instead of four. So I would exclude a lot of discussions between my customer service department and the supply chain department of my company, and that's all about intra-organizational activities in this case. So that will help me a lot and I would say the impact of immutability is medium because, from an interdepartmental perspective, we all look at the same system. So they should have the same information.	
69	Researcher	How about transparency?	
70	R3	I think transparency will have a low impact and the reason is because there are a lot of systems that give us transparency already, but these are more or less practical. So I got products to ship, I can go into tracking the trace of the ship, so I will know where it is. I see which purchase orders are right up there. So I need a lot of work to get the transparency, but the transparency is there. So from a social perspective, I know it has a low impact, to my perspective.	BC-T, A-So

71	Researcher	How about security, integrity of data?	
72	R3	For security and integrity of data, I think coming back to my intercompany perspective from invoicing and customer services. Once we have the same data, it doesn't be much of a discussion anymore because we're talking about the same thing.	BC-SI, A-So
73	Researcher	How about smart contracts?	
74	R3	For smart contracts, I think there would be a huge impact. We will have less inter-human interaction from purchasing with salespeople, with customer service, with supply chain people, because most of the things are automatically executed once an order is being fulfilled. The only thing is that once you are designing a smart contract, you will have different kinds of engineers and purchasing people and salespeople, so that has a big impact by leading to less contact. And once there is conflict, we need different capabilities from people working now in normal fields. It's the other way of selling your product.	BC-SE, A-So, OF
75	Researcher	How about versatility?	
76	R3	I think that embracing new technologies like IoT, machine learning, these people will also need other people with other capabilities. So, that's a big issue with companies because what you normally have is logistics engineers, salespeople, customer service people, whereas it is hard for us to find really tactical people. However, that may also be in a need of two things. This is more like the first real cross-section which we are in as a company and as a market at all. But do I need people with more capabilities that can manage any kind of technologies together, or do I need a system that manages different technologies within the data perspective? So, I need more people with lots of technical capabilities. I think this has a huge impact, like how are these innovations evolving and how will that have an impact on our organization, not only from an organization perspective like our company on its own but also my interaction with other companies. Because once I am talking about IoT and how the impact is on their product, integrating IoT in their product, me registering	BC-V, A-So, CR-AWC

		this product once it enters my warehouse or once I deliver it, these are all part of a very different type of discussion than what I talk about. I mean, okay I received an incoming delivery, but is it euro pallet or block pallet? It's a totally different perspective. So there would be a huge impact on organizations I could tell.	
77	Researcher	Before we talk about the last part. This is just a follow-up question, just a general concern about blockchain technology in the aspect of sustainable supply chains. For example, environmental, social and the economical aspects that we talked about, we would like to ask your overall opinion by asking how you would rate the impact of blockchain on environmental, economic and social concerns in an impact scale of low, medium, high, in general?	
78	R3	I think the environmental impact would be high. I think from an economical perspective, it would be medium, and lastly, the social impact would also be medium, nonetheless with the potential of being very high! For the social aspect of sustainable supply chains, it more or less depends on how the public and the private blockchains are being adapted. Because once the public blockchain is embraced, if within 10 years, I think absolutely the social impact will be huge.	A-En, A-Ec, A- So, OF
79	Researcher	One more follow up. You know, we already passed through the blockchain characteristics and all of their correlations with the three aspects of sustainable supply chains. So is there any other aspect of sustainable supply chain management or blockchain characteristics that you would like to draw attention to?	
80	R3	Well, I think the integration of the civil and public sector is a topic of discussion here. The civil sector is looking at economic parts and sustainability. But in the public sector, I think they are a critical part of the supply chain. For example, in the Netherlands tax authorities are thinking about the adoption of blockchain technology. They say that it could be interesting, relying on the idea that they will always be able to catch the right information to do a tax declaration, etc., which will work on the net. But if Belgium, for example, if their tax authorities say this is nothing for them, then it will totally	OF

		stop because then blockchain for the associated companies is not relevant anymore. Well, I think that that's an important part of the blockchain research, meaning you really need to look at the public sector because that's a really important issue that can make or break blockchain technology.	
81	Researcher	That's going to take a lot of regulations, I mean conformity to law, governance standards?	
82	R3	Yes, not only practical would we like to use it, but absolutely legislation, etc. That's huge.	CR-LC
83	Researcher	So at that point we can move onto the potential challenges and risks with the adoption of blockchain technology. We have a list here but you might want to make some additions after all. But first, we can discuss what we initially have here. The first challenge that we identified is the immaturity of blockchain, how would you evaluate the impact of this on the adoption of blockchain technology?	
84	R3	I think this would be high because this will make the reliability of blockchain an important competitive advantage towards the existing infrastructures so that it would be high.	CR-IM
85	Researcher	And then we have lack of awareness and lack of technical competence?	
86	R3	That is also high because we saw it in our company, there are a few people that are aware that have some technical competencies and these are in global IT for example. But for them, it's not easy to convince the upper management to invest in further research on a large scale in this technology. So, the people who are working on this are good, people have awareness, they have technical competence, higher management can make it difficult due to lack of awareness, so yes its high, I would tell.	CR-AWC
87	Researcher	So you are saying that there should be an agile management mindset with the upper management, right?	

88	R3	Yes, exactly.	
89	Researcher	So, the third aspect is organizational collaboration. How do you call the impact of this on the adoption of blockchain?	
90	R3	That could be medium because that could help. For example, in our organization, we look to IoT together with global IT and a project of 3D printing if blockchain could be interesting for printing. We saw, of course, that there are large files that can be shared by blockchain, but with the blockchain database, it could be fetched and that discussion made the higher management more aware. So it could help you in creating awareness that something happens because 3D printing is something that they understand and attract so much attention from the upper management. And once I integrate with this discussion, then the collaboration helps us interact. So it could have an intermediate impact, not high, but a medium impact.	CR-OC
91	Researcher	Okay, great. So next we have change management.	
92	R3	That is low because the awareness and technical competence in an agile high management organization would be enough to have change management working for implementing. So implementing will only be a certain part of the organization. Yes, that will have an impact. Once implemented and that could be a specific department, but in the essence there is a low impact.	
93	Researcher	Actually, we were just trying to explain the change management process of the whole supply chain network, including the stakeholders from different sites. So when it comes to inter-organizational processes, yes, we are all totally on the same page. Maybe the second aspect, which is the awareness of upper management will be insufficient to cover everything because change management is definitely included on this one as well. But when you think about the whole supply chain network, including suppliers, retailers, stakeholders, how would you scale it?	
94	R3	Then it will be high because then change management will be the driver from the owner of the private	CR-CM

		blockchain. For example, Heineken could say, okay guys if you want to keep having business with me in my supply chain, you will have to adapt to a blockchain setup. So it's more or less the issue of change management demanded by the owner of the private blockchain, which will have a huge impact on me adopting this technology because I want to keep my business with Heineken, for example.	
95	Researcher	I have one other follow-up, just a short question. Before this session, we have a kind of perspective through the literature and through the other sessions that some people think that the biggest challenge with this blockchain technology is the data ownership. So who will be the data owner? Who will own the data? Who will run the system? Who will just get the management of the system? So what do you think about this as a challenge?	
96	R3	I agree that data ownership is a challenge because it comes back to trust. It's always like money makes the world go round. So, for example, Heineken can say that they will have their private blockchain, they will own the data, and then when I would say, yes, but I don't want this then I think that they could take another logistics company for their services. And then my boss would say: "Yes, but I still want to have the business" And I would say: "Yes, sure but Heineken will be the owner of the data." And yet again, money makes the world go round. Are we losing the business or are we taking the business? If we are taking the business, we should adopt a private blockchain, where Heineken would be the owner of the data so that will not be a huge issue. Actually, that is the key issue why the public blockchain will not be for real in the coming ten years because who will be the owner of the data? You have seen it now with Facebook, people are distrusting Facebook because they see how they use their data. They are the owner of the data so may companies be free to use my data?	OF
97	Researcher	You're talking about this filter bubbling thing, right?	
98	R3	Yes, that's one thing.	

99	Researcher	So we have two more challenges in the list. One of them is cost and functionality. What do you think about that regarding blockchain?	
100	R3	I think that's low because we see cost and functionality back in our IT systems as well. It could be per order line or for data interchange or whatever, so we are used to that. So I don't think that we'll have a huge impact on adopting or maybe but that's a low impact because I do not see any issues. But that could possibly have a high impact because we already know the cost and functionality of a system used so it depends on how you would see it! As we know, cost and functionality are already within our IT system as something which we have taken into account to have a high impact on me adopting this technology or we already are known with the cost or functionality of this system. So there is a low impact, though I am not sure how you see this answer.	CR-CF
101	Researcher	I have a question, I just want to ask: Do you think that sharing this information through blockchain is going to be a disadvantage to retailers? Maybe the customers when they have access to the information they can get to their supplier directly themselves and source for the material, the product?	
102	R3	Yes, that's what I say. It's about who is designing the availability of data. That is more or less how you want to create a user interface of a blockchain. I agree with you in this regard. For example, I'm a supplier to a retailer and I sell Coca-Cola or I sell cola. Coca-Cola also has and I see what Coca-Cola is selling, I can adjust my price so there is a distrust of not only on price, but even on volumes. For example, if I know the volume of one hundred thousand bottles of Cola of Coca-Cola and I have two hundred thousand bottles of my Cola, then I know I'm the bigger party so I can adjust my negotiation, whatever. So that's a critical thing, that this data is really secure.	
103	Researcher	So just back to the cost and functionality, the thing is a lot of people say that since it has a decentralization nature, blockchain technology takes a lot of investment through the adoption process as compared to centralized systems. But nevertheless, blockchain technology can put up some advantages when just the technology itself	

		improves the efficiency all over the place. So, when you just compare these two things, how would you scale the impact of cost and functionality on the adoption of blockchain technology?	
104	R3	Then it would be high, because it always depends on the business case. So if I have a good business case, then the costs and functionality concerns will be fulfilled and they will be approved.	CR-CF
105	Researcher	So I think it's all about the investment plan itself. It's all about the return on investment maybe?	
106	R3	No, you have a business case to build upon two items, which is the investment case and the operational effect. It has an operational cost and same things and then you have a total business case of three years or five years or whatever. Both cases are compared in a business case.	OF
107	Researcher	So the last subject matter was legal and compliance. How would you scale it?	
108	R3	I think it has a medium impact, because what we can do as a company is to rule out liabilities, and that's the main issue. Because we have standard liabilities in the logistics market. Once we put them into smart contracts, for example, that is for us, legal and compliance is absolutely not an issue.	CR-LC
109	Researcher	But since we are talking about your company as an example in this case, can we just look into that with an overall approach? As you would appreciate, there are many many kinds of strict laws and legal regulations associated with maritime transportation and international trade. So if one just wants to adopt this blockchain technology to handle the operations in sea transportation, is it still a medium effect that we can attribute to legal and compliance?	
110	R3	Yes, it’s medium indeed, I think there are strict rules, but once you set up a blockchain, you can integrate these rules and the advantage would be instead, once you have some kind of a chain starting and if it doesn't comply	CR-LC

		with the rules that we are already setting in, the blockchain automatically stops. So I think once I explained this to our lawyers and our compliance, the only thing they would want to know is like, how can we be sure that the jurisdiction and the applicable law will be used. I think that the blockchain will be easy with smart contacts to get that in the right direction.	
111	Researcher	If there are any other challenges or risks coming to mind that you can suggest to us to think of, we will appreciate it. But before that, one another question. In the absence of blockchain technology, are there any other technologies that can replace it for the sake of sustainable supply chain management?	
112	R3	Yes, of course, because you have the ERP of the customer, which is important because that will send us the specific data at a specific time, which is what I explained before… I need time to make the right decisions to consolidate and to make shipments, but also a need for more materials, which I have. Then I have TMS (i.e., transport management system), which really helps me in optimizing the routing of my shipments. And again, that helps us in saving time and also saving miles or kilometers. And we also have algorithms in our WMS. These algorithms will do the routing within our warehouses using logistics equipment, paving the way for using less trucks, for example. And the lesser distances I make within the warehouse, the lesser loading work for this equipment. That is important for us on an operational level so that the technologies and the system we use for sustainability. Of course, we have reporting systems but that's not helping us in that case, just to report what we do.	
113	Researcher	So the last question again, is there any other challenge or risk that you would like to point out?	
114	R3	No. I already gave you what I see with all the discussions I had from the past with all kinds of companies, but also governments. Again, you should take into account the public sector because they will be the key to the success, because once they adopt and implement this technology, companies will automatically follow because they will be able to see that they can make money. You can only	OF

		comply with the total chain. So once I only invest in something that ends up at the tax authorities and I still need to do a lot of work, that is not interesting. So I would really suggest to you, if you put those points into consideration, I think you will have a huge part of what is the mission for the blockchain.	
115	Researcher	Yeah that's a really good tip, we already noted it. So what do you think about our theoretical framework? Our interview guide. Is it kind of inclusive or do you see any other aspects that we need to consider furthermore?	
116	R3	I think it is inclusive of what you're trying to do here is to have the functionalities of blockchain being discussed there. Like you cannot change data, it is secure, it has a decentralized database, which gives you a specific functionality and uptime. These are all the important parts for supply chain management. And of course, you can add more on this.	BC, A
117	Researcher	Would you like us to send a copy of this study before it's published?	
118	R3	Yes, please. I would really love that, great!	
119	Researcher	Would it work for you if we get back to for anything to be clarified or if any other question arises, like through e-mails or anything else?	
120	R3	Yeah through email. Just send me anything, I will be at your service!.	
121	Researcher	Thank you so much, R3. We're appreciated for your generosity.	
122	R3	You too! Wish you the best for sending up this research and I hope it gets a good grade and then you can go start working in the real world!	
123	Researcher	Thanks a lot. We're grateful for this opportunity. Bye!	

124	R3	No worries… Bye!	

Appendix 7: Interview Transcript – R4

Company: Anonymous

Interviewee: R4

Job title: Director - Senior Blockchain Market Specialist

Interview Type: Zoom Video Call

Duration: 53:15

Date and time: 23th of April, 2020

(A-En) - Environmental Aspect of SSCM - Green

(A-Ec) - Economic Aspect of SSCM - Yellow

(A-So) - Social Aspect of SSCM - Blue

(OF) - Other Findings – Red

Line	Person	Text	Category
1	Researcher	Can we just start by asking what prior experience you have with blockchain, sustainable supply chain management or sustainability agenda?	
2	R4	I have been involved in the blockchain for around 6 years. Usually in Bitcoin. I am an engineer, also a lawyer. I have worked in consulting, worked for the Central Bank as a regulator, worked in payment services. Very interested in when I first started to hear about bitcoin. It is an interesting technology, the way it brings together stores of valued payment and ledger. First step was to buy some bitcoin which I did. It was a very surprise when the price was getting up, making some money on that and then using that to buy some bitcoin miners. So, mining bitcoin was probably about 3 months, until it got to the point that it was just economically not viable. Because the energy cost in price has just been stacked up. And, the bitcoin miners are quite dangerous, given the amount of heat that they have been generating. So, I	

		moved into my own business where I set up a business to help people understand how bitcoin works. So, both the cryptography, the economics, and the application to business problems. I've looked at about 150 blockchain problems, blockchain projects and I've supported probably about 10, and then delivered about 5 of those, among these one is a listed coin and the second is an app which is on iTunes and Android. And these other engagements along the way are sort of consulting type engaging where it helped me set up blockchain type companies.	
3	Researcher	Do you have any prior experience regarding supply chain management?	
4	R4	I've worked in consulting so I understand supply chain from rules, commodities, energy all the way through to gigs and services as it works through the supply chain, whereof the provenance issues and handoff between suppliers created conceptual design frameworks for those and we have some opportunities with the customers that'd be excelled to sell anything.	
5	Researcher	Ok, in this regard such a prior experience seems to make you a perfect fit to conduct an interview with for the sake of our study. So, let us ask how can the use of blockchain technology transform supply chains, as compared to the prevalent ERP systems, meaning what makes the blockchain architecture attractive to supply chains?	
6	R4	The first response to that is each entity within the supply chain has its own ERP or multiple ERPs, because it is as simple as just having one ERP to manage inventory. From the field and all the way through to point of sale, each of those separately glanced pieces have got their own ERPs in general ledgers. Then which is separating them is our firewalls. Trying to link tiers through those differences in supply chains, through those firewalls, so I can see where my pen has come from. Because this pen has come from oil, a barrel of oil; and, it is possible if I set the supply chain properly to be able to see all of the oil that made this pen. There is a little bit of metal in there, just on the tip and there is this stuff in here, don't know where the ink comes from,	BC, BC-T

		but the pen basically comes from oil. If I try to link the supply chain through the separate ERPs, technically it becomes very very difficult. If I take bitcoin, I can take any Bitcoin and I can see all the way through the supply chain where the Bitcoin has come from, all the bits of Bitcoins have been assembled to create the Bitcoin I've perceived. What blockchain allows you to do is that lots of people who don't trust each other, who can write in a single trusted ledger in such a way that everybody can read and write and update in a way that can be trusted so it starts with the field or it starts with a barrel of oil which runs all the way through to points of sale, so that when I take receipt of the pen I have, a little code which opens up a little address that allows me to see all of the manufacturing steps that have happened with this pen all the way back to barrel of oil. Is it interesting in manufacturing pens? Not really. Is it interesting when it comes to diamonds, gold – Yes! Is it interesting with things like tobacco? Absolutely. And then where it starts to get our interest in business cases since I pay for all the ERPs, you remember, the cost of this pen is the function of the firewalls and all of the ERP cost… So to say, I am only using blockchain types so I'm actually using one ERP that is shared, so actually I don't need all those multiple ERPs. So, this is kind of a tipping point in the application where the more people we have writing to this, the less the future ERPs we need. So, the business case becomes very apparent, I mean if we can take a lot of cost down so the cost associated with the manufacturing cost reduces. Does that make sense?	
7	Researcher	Yes, totally. Does the blockchain universe rely upon more adaptable rules than other supply chain technologies? As far as we know, right now all the prevalent conventional supply chains are built-in and complex systems, it seems really hard to change anything throughout the all supply chain network. So, when you think about that perspective, would you say that blockchain has more adaptable rules than the prevalent ERP systems?	

8	R4	I think the flexibility of existing ERPs is very constrained because there is a lot of technical governance that sits around each of those steps in the supply chain. And it is both technical governance and legal compliance contractually. So, the supply chains themselves are very inflexible both technically, commercially, contractually. The outcome is a product that the consumer can trust, or the consumer can eat or the services that consumers can trust and make use of. So, provided the configurability and the flexibility delivered is a product of equivalent safety then we should not be too bothered. Because the commercial constraints would be the same. We want products and services that are safe and secure for the consumer. Blockchain may off the flexibility but actually it is only getting it off the flexibility to the extent, as it is within the parameters that are required by the consumer. I can make it free for everybody. But actually, that might kill people. So, we have got to be quite tight in the way we define those parameters that govern the blockchain.	BC
9	Researcher	What do you think about the potential blockchain use cases for green and sustainable supply chain practices?	
10	R4	When it comes to greening supply chains, the term I would use ESG – Environmental, Societal, Governance, because that is slightly broader. And we have got things like the circular economy, and I would say CSR- Corporate Social Responsibility. I think the headline is really; what is the damage done to the environment? What is the benefit to the environment in terms of the activities? What are the societal issues associated with anybody involved in the supply chain? Are they using child labor, for example? Are they getting paid properly? Are they working in adequate conditions? So, if you think about; where this has come from to the sustainability perspective and how it is being brought together in a way that is ethical and proper, those are the parameters that need to be tracked. I think… the sort of capturing those locally; I mean you can take child laboring in tobacco, for example, what you have got to do is you've got to attach a record of where that child labor was used in that field in tobacco to the	A-En, A-So, OF

		tobacco leaves themselves, right? First, this is a technical problem, not a blockchain problem necessarily. But it is when you start passing it through the supply chain, it does become a blockchain opportunity. Because the images associated with a fact, it was no child labor associated with the harvest you have had with the tobacco leaves and you can pass it through in different layers of the supply chain. When you pick up a cigarette you can look on the side of the pocket and you can open an address; which actually gives you the different tiers in the supply chain takes you all the way back to the child labor. So, blockchain does offer a solution, but you have got to be clear about the parameters that you want to catch up, which leads you to the point of origin.	
11	Researcher	According to your perspective, which industries will likely benefit most from the supply chain use cases of blockchain technology, and why?	
12	R4	Well, I say that is a good and very big question because there are lots of different sets out there. I think about the backbone of the economy on a certain page if you would like? So, the economy starts with raw materials, energy, and IP. So, what we see here now is that we are using laptops, paper, pens but actually all goes back to oil, gas, trees, coal, whatever. I mean it goes back to metals, some raw materials, some sort of materials anyone got from the ground, and then it all goes back to knowhow and IP. When we map all of that forward, we get to the exclusive rights, we get to the votes of registration, we get to courts-type service, which of those industries will benefit the most, I think that is a question of risk! So, to what extent can you use blockchain to mitigate risk, and to what extent to use blockchain to reduce the risk of consumer harm at the point of consumption. And then is also a pricing piece, I mean to what extent the use of blockchain implements efficiencies into the supply chain, which makes the delivery of the goods and services cheaper than what it was previously. I do not know if we can use blockchain for many things, like sneakers, confectionary. What we would do if there was child labor involved in the coco beans, okay, we would do if there was an issue of the fake sugar products that was being put in the …. I mean you need a risk based and cost based approach. I think that is a pretty big	BC, A-Ec, OF

		issue to think of… I mean I cannot give you a straight answer, though to be a gut feel, I think it is probably pharmaceuticals, and fake products, maybe the baby milk sector… I think in the medium term, it is about addressing consumer products that causes damage to the individual. I mean, you've picked on something quite specific, whether it relates to the supply chain provenance, or such like, I think the rather interesting use case is something like identity and money, for example, thresholds and agreements engaging with. That is how it sounds more of scope of this discussion.	
13	Researcher	Perhaps we can just talk a little about the technical aspects of blockchains: Public and private blockchains. What do you infer from the distinction between public blockchain and private blockchain?	
14	R4	Public block chain doesn't have a firewall. So, it relies on cryptography. Because if you take bitcoin for example; anybody can join a bitcoin mining network, anybody can become a node, for a thousand of miners roughly - 14000 nodes roughly. But what it relies on is the extensive cryptography required to participate and the energy you have got to bring to the protocol. And they force you into the place that it is better for you to cooperate with protocol than it is for you to act maliciously. Because the payoff of one versus the other is greater if you collaborate than if you act maliciously. Bitcoin is probably the only protocol that is exposed to 7 billion people every day that potentially can try to hack it. So, it means it does not need that level of cryptography associated with it. What's interesting is that as soon as we start to erect parameters in the form of technical firewalls around these blockchain protocols; the requirement for the cryptography diminishes, because what we are doing is we are actually moving where bitcoin has got a highly distributed trust layer but no firewall, as soon as we stop gathering up bits of that trust and putting it behind the firewall then actually the cryptography we need reduces. So, it is that balance between private – with firewall and public -with no firewall! So as long as we can operate with trusted actors that means the requirement for the cryptography reduces because we are already relying on some of the firewall capability - which also means, if you take the case of bitcoin for example, we don't need all of that energy as a sort of	OF

		a disincentive to act maliciously versus act in the good faith.	
15	Researcher	To our understanding from here, for organizations the biggest distinction between public and private blockchain seems to be the matter of discussion on security, which is based on trust level, because isn't it the current situation that public blockchains are relatively in the process of evolution to be implemented into various networks, whereas private blockchains are more available to be deployed in a list of networks within the areas other than core finance, such as supply chain networks?	
16	R4	I think the interesting headline of observation I would make is we may discover the only useful blockchain in a public sense is Bitcoin. I think bitcoin is brilliant, okay? You see, it is probably the only thing among many things with which you want to bring together 7 billion people, unless you want to make a global Facebook type of networking.	OF
17	Researcher	Then how do you see the future of blockchain technology through the supply chain networks? Because we have seen a recent report from Gartner, predicting nearly 90% of blockchain-based supply chain initiatives will fail in years to come due to lack of suitable use cases. What would you say about that?	
18	R4	I think I would say a couple of things about this point. The technology organizations in those participant entities are not incented to cooperate, right? And the reason I say that is because the CIO is running let's say 5 general ledgers, he's got 10000 people working for him. His budget is maybe three hundred million dollars. He is in one of two places – he even understands how Blockchain works or he doesn't understand how Blockchain works. But if he doesn't understand he is not really interested; if he does understand, he realises what he can do. He or she is not going to say like, you know what, it's a truck load of hassle to say: "I'm going to start collaborating with people down the supply chain and up the supply chain… I'll tell you what we'll do, let's get rid of our Oracle / SAP supply chains stuff, which is really safe and secure, and nothing goes down, cause if something goes down, I am going to get	

		fired. So, let's all start writing to a shared ledger so that we all could have governance of" … That is never going to happen! Now, McKinsey has this term "coopetition", which is basically around to achieve an outcome which is superior… I think, I'll go into a risk-based approach, or you know you try to put out the fire basically… when people come to an acute problem and say: "We've got this problem and we are trying everything but it's really complex so how can we solve it?" – and then someone replies: "Oh yes, we've got this edge solution over here called Blockchain, it will do exactly what you need"… I mean you are not going to change the world by saying you are going to change the world. What you have to do is to set fire to little things on the corner and just see how they take hold!	
19	Researcher	Maybe, we can move on to blockchain characteristics and their correlations to the aspects of the supply chain management. We divided this track into 3 parts: Environmental concerns; Social concerns; and Economical concerns of Sustainable Supply Chains. So first we have environmental concerns. We have just listed 6 different blockchain characteristics as a summary: decentralization; immutability; transparency; security and integrity of data; smart executions and versatility. So, in that perspective, can we correlate these blockchain characteristics one by one with the environmental concerns of a supply chain like energy conservation, recycling, waste management and so forth? Let's start with the decentralization then. How do you see the correlation between decentralization and environmental concerns of a supply chain?	
20	R4	I don't necessarily follow the logic of this question. That's not an invitation to explain it to me. I think you are always better saying how does blockchain work; what things are being offered with blockchain to help me solve some of those problems. Just repeat it again, what were the problems that you're trying to address? Just three headings you've listed, doesn't it?	
21	Researcher	Yes, we have 3 pillars of sustainability, which are environmental, economic, and social concerns. Then we have 6 characteristics of blockchain technology that we listed, and we are just working on any	

		correlations between each of those pillars and BC characteristics by contrasting one by one.	
22	R4	So what I would do; I would assign equal proportions: because basically I'll take decentralization, immutability, transparency, integrity of data all of these I'm speaking of, they all needed to be in place to give you those 3 outcomes that you have been talking about. And smart executions, I'd say, I would put that as the smallest one amongst others. And what was the final one?	BC-D, BC-T, BC-SI, BC-SE, A-En, A-Ec, A-So
23	Researcher	Versatility. But versatility here stands for the evolution of Blockchain in more recent times, which people are sorting through versions such as Blockchain 1.0, 2.0, 3.0, and 4.0 recently.	
24	R4	I think I would say, I would allocate the first four (i.e., decentralization, immutability, transparency, security and integrity of data), 80% to %20 each, and for the final two, I would give them 10% to each.	BC-D, BC-I, BC-T, BC-SI, BC-SE, BC-V, A-En
25	Researcher	So, you mean decentralization, immutability, transparency, and integrity of data are more included and smart executions and versatility are not that much actually?	
26	R4	Actually, I would say, they are not more included. But I think all of those six things give you those three outcomes in the supply chain. In terms of the reliance upon them, those four characteristics are probably the most important to do with the equal priority. Then the last two, I mean smart executions are more like speed-related issues, and when it comes to versatility, it is directly about flexibility. But, when I don't have these two, and if I still got the first four, then they will give me those three things (i.e., environmental, economic, and social sustainability) that are important to me.	BC-D, BC-I, BC-T, BC-SI, A-En, A-Ec, A-So

27	Researcher	Let me elaborate my question a bit more because it is really important for our case. On a three-point scale like low-medium-high, how would you rate these characteristics one by one in correlation-wise?	
28	R4	I mean, for the first four I would say all of them have high impact, and then for the other two I would say low-to-medium.	BC-D, BC-I, BC-T, BC-SI, BC-SE, BC-V, A-En, A-So, A-Ec
29	Researcher	So, is this logic applicable to all of the aspects like environmental, social and economic, respectively or does it just change with respect to the aspect itself?	
30	R4	I'd say, the appropriate term here to say it's equal. They are all interconnected anyways you know.	
31	Researcher	And perhaps you can amplify your answer in the reasons why you would give it to them in this way?	
32	R4	Decentralization is about sharing. It is about lots of people being able to access data which has integrity. Because simply if I share some stuff, I would like to be able to trust the data. And that's why those two are more important. And when it comes to immutability and transparency, I would like to be able to share the data that I trust and that actually I do not want it to change. Because if it is changing, then I can't trust it right? I would like to be able to do that for lots of people who can read and write but do so in a way that we can trust them then we know it's all correct!	BC-D, BC-I, BC-T, BC-SI
33	Researcher	At this point, we can move onto economic concerns of sustainable supply chains and their correlations with blockchain characteristics that we listed above? Let's start with decentralization if it works...	
34	R4	So, when we talk about economics, I would say it is probably about efficiency. And then what we are doing is, I think it is possible that entities in the supply chain will have their own separate ERPs. It is	BC-SI, A-Ec

		more than possible that companies can have a single shared ERP that can flow all the way through the supply chain. So, instead of them all having their own single instances of ERP they can just have one big shared ledger, I mean they can use the Bitcoin ledger. Lots of efficiency there; it is also full of provenance from the sustainability perspective because you got anti-counterfeiting as well, so managing and preventing fake products in the supply chain. So, from an economic perspective you've got reduced cost through leveraging economies of scale, improved security, improved consumer safety, improved transparency, improved provenance of the end goods.	
35	Researcher	So, on a 3-point scale, what would you say about the extent of this correlation?	
36	R4	I would say high.	BC-D, A-Ec
37	Researcher	What about data immutability?	
38	R4	Probably medium.	
39	Researcher	So how would you elaborate your answer a bit more because data immutability probably is related to the immutable data nature itself within the blockchain network. So if you just process data into the blockchain I think there is no allowance to change it afterwards, it might be related to the effectiveness or efficiency of the process itself. We are just trying to understand the impact of it.	
40	R4	For me, immutability sounds like a prerequisite since immutability itself does not deliver any value. What immutability allows you to do is to decentralize and share. I mean you can share it to pretty much anybody, but you can be comfortable that they're not going to make any changes to it that haven't been approved by the network mechanism. Immutability itself doesn't add any value. It is a precondition to give you the ability to create a decentralized sharing framework.	BC-I, BC-D, A-Ec
41	Researcher	Okay, next we have transparency again. That might be the one that has the highest impact on the economic concerns, right?	

42	R4	Yes, true as I have explained it through the first section.	BC-T, A-Ec
43	Researcher	So, the next one is security and integrity of data. What would say about the correlation of it with the economic concerns of a supply chain?	
44	R4	I would say high. Because again that is an outcome. But again, that is a precondition to be able to share the data because if you haven't got security then we all would get very worried. But starting with immutability and decentralization which allow you to share, your outcome is a high degree of security which builds on those previous two.	BC-SI, A-Ec
45	Researcher	Next, we have smart executions which are done by smart contracts. So, it just stimulates the automation as we know, so what would you say about the correlation of smart executions with the economical concerns of sustainable supply chains?	
46	R4	So, it is friction, it's friction in common, so it is being able to reduce the frictional costs associated with establishing contracts in a first instance, which introduces frictional cost. You've got the frictional cost of payments infrastructure procuring infrastructure. Because actually if you do your smart contract properly, you don't need procurement infrastructure. And then there is the third dimension to this in that… Because if people are getting paid on time that means you don't have any cost of funding. What happens is that the supplier knows they're not going to be paid for 90 days but they're carrying the cost through loans that they have their own draft to take out of the bank. Everybody is passing on this funding cost. And the only people that have benefits are actually the banks ultimately. They would be paying people simultaneously then actually they're getting the money upfront when the goods and services are delivered; and I think there is a final incentive in there because actually if you want to get paid, you make sure the goods are specified because if they get rejected; then you're not going to get paid. So, I think it is raising the standard in terms of meeting a specification of the delivered goods.	BC-SE. A-Ec
47	Researcher	So, on a three-point scale like low-medium-high?	

48	R4	High.	BC-SE. A-Ec
49	Researcher	And lastly, we have versatility. Please recall that by saying versatility we are just referring to the evolution of blockchain technology through the test of time. Regarding this Blockchain 3.0 and 4.0 seem to be more included in this discussion since these two stand for the industrial use cases of blockchain theoretically. What would you say about the versatile nature of blockchain technology and its correlation with economic concerns of sustainable supply chains?	
50	R4	In terms of versatility, I think for me it is still a far away, it is a long way from eBay or Amazon or Windows type experiences. And for me, if you really add economical value it is got to be as easy as anybody can use it. So, eBay, Amazon, a Facebook type experience that anybody can use… And I would say its current economic value is probably low; and that's not because it hasn't got potential because it has got lots of potential. The issue is regulatory but also its integration and also its maturity. Because regulatory is given, integration is what actually I think ultimately that goes to maturity which is effectively you've got permissioned and not permissioned blockchains… Actually, everything goes back to Bitcoin ultimately, you've got Ethereum which is instead of the DOS if you like, so if Bitcoin is machine code; Ethereum is DOS. But what's not yet seen is basic and then Windows and then actually eBay. So we're still many many steps away. I think the level of impact would be probably low.	BC-V, A-Ec, CR-LC, CR-IM
51	Researcher	So next we have social concerns as the last pillar of sustainability in a supply chain. Again, we have 6 features of BC technology, so let's start with decentralization. So, what do you think about the correlation between social concerns and blockchain characteristics? And, by saying social concerns we are just referring to the organizational concerns, including inter-organizational and intra-organizational concerns.	
52	R4	Forgive me but what do you mean by social concerns?	

53	Researcher	Actually, we are just trying to extract some kind of correlation between the use of decentralized database architecture with the organizational concerns of a sustainable supply chain, including maybe organizational collaboration, information sharing through the organization, those kinds of things…	
54	R4	Conceptually, the organization doesn't understand the opportunity presented by decentralization. Because organizations are weirdly, by definition, centralized. So, the concept of decentralized framework is very opposite to the fact that organizations are centralized things. So, sharing across lots of entities is not something they do with their centralized records. And the reason they do that is because people in charge ultimately worry about getting fired. Because it feels like if I'm responsible for that piece of technology there, that's mine. But if I share it across 50 people then I lose control of it. That means I lose control. So, if anything happens, I get fired; and by the way my control also diminishes, because I own 100% of that normally but if it is decentralized, I own 50% of it. So, I think interestingly that is part of the reason why certain people want to get traction around blockchain in centralized organizations, because they don't see the value of the decentralized support frameworks.	BC-D, A-So
55	Researcher	On a three-point scale what would you say, low medium high?	
56	R4	It is difficult to grade it. The fact which inhibits the adoption of decentralized architectures is the centralized nature of the organization, if you see what I mean, which is high…	BC-D, A-So
57	Researcher	Next, we have data immutability?	
58	R4	I think it flows in the same sort of way. Because immutability gives you a precondition for decentralization. The organization does not get the decentralization since the last thing they want is immutability. They always want the ability to go in and change what they have screwed up.	BC-I, A-So
59	Researcher	So, you are saying there might be an impact in the negative way maybe, right? And is it because people in the workplace need to align with the new system in this regard.	

60	R4	Right. Immutability is the last thing they want because they want to be able to have mutability that can bring in flexibility. So immutability removes any kind of flexibility.	BC-I, A-So
61	Researcher	Next, we have transparency.	
62	R4	I think people need that, that is a big positive that comes from this. I don't think anybody would disagree with that.	BC-T, A-So
63	Researcher	When it comes to immutability, it sounds like a thing with pros and cons with respect to your reflections. Our understanding is that data cannot be changed after it is processed through the network, but the thing is you can just modify the previous data by adding some kind of new records into the blockchain. So, the data is immutable but it is also updateable. When it comes to information sharing throughout an organizational network, don't you see any correlation between the immutable nature of data and organizational concerns?	
64	R4	The reason why you have immutability so you can share the ledger with lots of people. Bitcoin is the best. It is the universal global bank in many ways. You get a high probability of getting rewarded if you collaborate than if you're trying to attack it. But that is because of its setup in that way to make sure that it makes it very difficult to attack. That causes a global protocol.	BC-I
65	Researcher	The forth one was security and integrity of data again. What would you say about the correlation of it with the organizational concerns?	
66	R4	That is a real positive. I think that is a real and solid point. We believe in decentralization as an enabler as a facilitator for value creation.	BC-SI, BC-D, A-So
67	Researcher	So, is there a high impact?	
68	R4	Yes.	BC-SI, A-So
69	Researcher	So, next we have smart executions.	

70	R4	Again, absolutely. Lots of value in that; you can actually do that in isolation, you don't need shared ledgers to do that. Because actually you can create separate smart contract frameworks that can sit outside of the organization everybody subscribes to. So, I think that got lots of value.	BC-SE, A-So
71	Researcher	And the last one, versatility?	
72	R4	I would say that would probably cause problems because actually I want control on our flexibility. But once we're all subscribed to this, it makes it very difficult to change it because I have a one 50th vote in the whole protocol again. Culturally, organizations would have control themselves, they don't want to put up control to lead the system to a big democracy.	BC-V, A-So
73	Researcher	So, we are done with Track 2. Is there any other aspect of SSCM or Blockchain that you would like to draw attention to?	
74	R4	No, I think we covered everything with provenance, anti-counterfeiting, we talked about friction from payments and contracts, transparency… Yes, I think that pretty much covers it.	BC, OF
75	Researcher	So what do you think about our theoretical framework by now? Do you think that it just covers everything when it comes to blockchain features and the aspects of sustainable supply chain management?	
76	R4	I believe it's got everything. I am going to make it simple as much as I can. The star point is having the ability for lots of people who don't trust each other to write to a single shared ledger. Once you establish that without any trusted authority, a lot of things fly from it. It is like we are going to give you this because it gives you the following benefits. So, it is distinguishing between the solution and the benefits that flow from that. For me, immutability is a future but not a benefit. What I would say is the distinction between features and benefits if you like. I think it has been very clear about what is the solution, what is our feature and what are the benefits that flow from that? And then what is the response of the organization to those benefits and features. That's where you want to be clear about.	BC, BC-I

77	Researcher	Now, Track 3 is all about challenges and risks with the adoption of blockchain technology. We've just summarized 6 challenges and risks through the literature review. The list starts with immaturity of blockchain with which we are just referring to cybersecurity attacks, throughput, latency, etc. In this regard, how does immaturity of blockchain impact the adoption of this technology? Regarding the extent of it, how would you rate it on a 3-point scale like low, medium, high?	
78	R4	I think, theoretically, it is not the reason of being immature. But blockchain's application in an enterprise concept, that is where we need to work on, that is where it is immature. However, the principles of Bitcoin are well-understood. To my knowledge Bitcoin is not being hacked; what gets hacked are the wallets in the exchanges. Bitcoin is a protocol that is not being hacked. So, theoretical maturity is there and the real case maturity in the concept of Bitcoin is provable. But it is taking the blockchain ID and it is applying to enterprises that is where the thinking is locked a little bit, so we gotta expand more on that.	CR-IM
79	Researcher	So, what would be your rate regarding this?	
80	R4	I would say medium. I don't think it is high or low.	CR-IM
81	Researcher	So, the second one is lack of awareness and lack of technical competence throughout the organizations when it comes to the adoption of blockchain technology. So how does it impact?	
82	R4	Well, it is definitely high, very broad.	CR-AWC
83	Researcher	I think it is clear but would you like to go into detail with your answer?	
84	R4	I think it is self-explanatory. I think the mistake has been managed in such inefficient ways that people tend to apply blockchain to point problems. So, that will take a bit of the process and suddenly they discover that it is not adding any value. But that might be a completely wrong use case for it.	CR-AWC

85	Researcher	So, the third challenge we refer to here is lack of organizational collaboration. How do you see the impact of organizational collaboration on the adoption of BC technology?	
86	R4	I think it depends. When you say organizational collaboration, do you mean internal or cross organizations?	
87	Researcher	Both, actually.	
88	R4	To be honest, I would say high for both of them because we need to collaborate across the organizations, but also across organizations, generally.	CR-OC
89	Researcher	And the fourth challenge here is change management. As we go through the literature we see that change management is an issue in any kind of technology adoption. But when it comes to blockchain technology specifically, how do you see the impact of it as a challenge through the adoption of BC technology?	
90	R4	It needs to be as easy to use as Amazon or eBay. The problem at the moment is just not the technology itself. Yes, it is not mature enough, but it is packaging for organizations. It is like a banking experience, okay? I can turn up and say here are all the bits of systems that you have to use to experience a bank type experience so I can say, look here is a bank… You want your money, you can see your money… But at the moment what we still have is just lots of bits of systems that need to be glued together and they haven't been packaged up in a way that you can just use blockchain as a silo in a simple manner to facilitate your business.	CR-CM
91	Researcher	And the next challenge is cost and functionality. By saying functionality we are just trying to talk about efficiency and effectiveness combined. As we reviewed the literature, we have seen that investment costs are a bit high regarding the adoption of BC technology. So, we have merged these two aspects in a single question by asking how does cost and functionality impact the deployment of blockchain.	

92	R4	Significantly, I could tell… Because it costs two ways; one is the challenge you have because you have a conversation like we got this blockchain stuff, which is really good, by which you can add value and then we will just spend 25 million on SAP or Oracle or ERP. So first off, of course you gain a sort of regular update anyway. But secondly, because of the maturity in the lack of integration, it is quite costly to get into the organization and actually it can stop where it is applied in a real sense, which ultimately comes back to the packaging. And when you need very mature offerings so that you take to the organization to say look it is ready to go, then it has packed up for being used but somebody has got to pay for that, right? So, you're going back to the investment case. And we have already done this blockchain thing, but we haven't seen any value from it yet. So we'll somehow get through that loop and I think it is the material. You have got to be turned up with a very simple business case that people understand from day one to get it going.	CR-CF, OF
93	Researcher	So what kind of a scale do you think of, like low medium high?	
94	R4	High. It is gonna be high.	CR-CF
95	Researcher	And lastly, we have legal and compliance. I think it is pretty much the issue when it comes to the deployment of any kind of technology, but specifically for blockchain technology, what is the extent of the challenge when it comes to legal and compliance?	
96	R4	I think it is probably medium. I think from a compliance perspective, and when I say compliance it is actually cybersecurity issues, it's going all the way to a CISO, either he or she has to be comfortable with that. From a legal perspective, that's due diligence in terms of that we need to be comfortable with these people, we can do business with them. And actually having a conversation with blue chip organizations that raise the chances because they are credible and they got the right legal entities. They pay the taxes, known and ensured. So, I think it is important but they are all fixable problems.	CR-LC
97	Researcher	Okay, we are done with Track 3. Any other challenges or risks you can suggest to us to think of?	

98	R4	I think people need to use it, right? But people should understand it. The biggest issue we have is people don't understand it. It is a weird technology to understand and you got to spend time on it.	CR-AWC
99	Researcher	In that case, are you just saying that the lack of competence and lack of awareness might be the biggest problem?	
100	R4	Definitely.	CR-AWC
101	Researcher	Before we end the session, would it work for you if we get back to you for anything to be clarified? Through emails maybe?	
102	R4	Sure.	
103	Researcher	Thanks for participating in our study, really appreciated.	
104	R4	It was a pleasure for me.	
105	Researcher	Would you like us to send a copy of our study before it's published?	
106	R4	Yes, please. That would be good. Alright guys, thank you.	
107	Researcher	Thank you, bye.	

Appendix 8: Interview Transcript – R5

Company: PwC

Interviewee: R5

Job title: Director of Digital Trust – Strategic IT Management

Interview Type: Skype Audio Call

Duration: 1:15:26

Date and time: 27th of April, 2020

(A-En) - Environmental Aspect of SSCM - Green

(A-Ec) - Economic Aspect of SSCM - Yellow

(A-So) - Social Aspect of SSCM - Blue

(OF) - Other Findings – Red

Line	Person	Text	Category
1	Researcher	Are we allowed to use the title of your company? Or would you prefer it to be anonymous?	
2	R5	It is fine if you use my title.	
3	Researcher	Our first question is what prior experience do you have regarding blockchain technology, supply chain management, and sustainability agenda?	
4	R5	Generally speaking, my first contact with this concept, which was introduced by the firm, was 4 years ago. Additionally, 3 years ago, I participated in a study by some of your fellow students, I guess... they were writing an article related to these concepts. From a more professional point of view, my involvement in blockchain in connection with the supply chain is more of a global perspective since we worked with some of the top practitioners regarding blockchain, but from a Swedish perspective in general, clients and markets are	BC

		not that mature yet. Most of my experience with blockchain so far is related to the bank business, performing, training, and education in this area. From the discussion point of view, it can be added that many of the clients have many issues going on in terms of blockchain; however, implementing blockchain involves getting control over the existing processes in data, and I would say most of the companies I've worked with have a journey to do in that area.	
5	Researcher	To be more specific, could you please elaborate on your practical experience in supply chain management, or ERP implementation experience through supply chain network, if you have?	
6	R5	Sure, I have a lot of practical experience in supply chain management from more of a requirements and business process design point of view, and of course, that includes auditing such ERP implementation projects. Currently, I experience that many companies integrate their supply chains to the suppliers' actual production processes. But I would say my prior experience is quite low-tech, so to speak, that is, it is more of integration, not so much blockchain yet. However, there are a lot of pre-studies performed and they are all in the process of progression.	
7	Researcher	How can the use of blockchain technology transform supply chains as compared to prevalent ERP systems? Our aim of asking this question is to enhance understanding of what makes blockchain architecture attractive to supply chains?	
8	R5	In such a case, the trust will increase in the process; the roles and responsibilities are blockchain-driven, sort to speak. It is possible to incorporate resources and control them over time as well. Especially in terms of trust, blockchain technology promotes the extension of transparency. But my experience shows that although blockchain technology offers a lot of great opportunities, it is also associated with many new risks, which is not the case with the setup that most of the companies have today, just to balance it…	BC
9	Researcher	Does the blockchain universe rely on more adaptable rules than other supply chain technologies? If this is the	

		case, what are those rules? The purpose of addressing this issue is, nowadays, it seems that conventional supply chains are built-in and complex systems, which are very hard to replicate or replace with other technologies. In this regard, as a disruptive technology, what would you say about the adaptability of blockchain technology to traditional supply chain networks?	
10	R5	Well, my answer is "Yes". Since, the technology itself is more transparent, which makes it easier to have an open-source look. Just a side note: I do not totally agree with the idea that supply chains are complex; a lot of companies have quite optimized and screen-lined supply chain processes established in today's technology.	BC
11	Researcher	How do you see the future of blockchain technology through the established supply chain networks then?	
12	R5	As you said, the technology is disruptive. Since the journey has newly started, the maturity in some branches or industries is quite low. The progress will take time. For example, I work with a couple of game companies implementing blockchain technology, but it is on a very small scale, but in general, tech companies are more mature and more agile. The great benefit for industrial companies with high reliance on supply chains will be more efficiency and effectiveness generated from this new technology. Nonetheless, still, there is a gap to fill to be able to implement this; the existing data in processes need to be controlled. In this regard, it is similar to AI, which is a great technology, but pre-conditions and the platform itself are not mature enough to implement or to adapt this to existing processes and governance structures as well.	BC, CR, CR-AWS,
13	Researcher	Could we move onto Green and Sustainable Chain Practices? What kind of potential blockchain use cases do you think are applicable to greening and sustainability of supply chain practices in general?	
14	R5	I guess you guys are aware of what H&M has been doing through its supply chain technology, by which at least you can get to know certain sources associated with some of the clothes they sell at the store. There is IKEA as well, which PwC works with – that have a similar setup –. It is more manual as of now, but they	A

		aim at being able to trace back the region of every piece used on certain furniture, for example. Currently, the market is demanding in this regard, meaning using yearly reports is not sufficient to demonstrate sustainability performance, instead, it is every consumer's decision to judge on, so you need to be able to demonstrate your sustainability performance stringently and transparently. At least I have seen this trend in the Swedish companies so far. It is market-driven. I mean, of course, most companies want to do it but it is the demand from the market that drives this at a higher pace moving forward I would say. Besides that, there are couples of industrial companies supplying products to both public and private markets. Another one would be orbital systems, creating this incredible shower by which we use the water. In this case, the product itself must be sustainable, it is more of a question of branding as for Tesla, which can be a good example for it… I mean eventually, the market will require if the batteries are constructed and produced sustainably. It is about how the market turned back to the product. In this case, I would not exclude any industry really, but still, there would be a couple of examples, where the consumer goods would be initial ones to consider in this respect because they would be affected in the fastest way.	
15	Researcher	Follow-up question: according to your perspective, which industries will likely benefit most supply chain uses of blockchain technology? Why?	
16	R5	In my opinion, from the sustainability aspect, firstly, it is the food industry. Secondly, the retail industry can be illustrated in general. The reason that I ordered in this way is: the maturity in these industries is a bit higher than general production industries, such as healthcare, rubber, or chemical industries. My rationale here is, compared to business-to-business companies, they are more market-driven with end-consumers having higher levels of awareness. Since health and defense industries have a high reliance on traceability, they can be added into this categorization; however, it is more about quality assurance rather than the sustainability aspect.	
17	Researcher	How do you compare public blockchains with private blockchains regarding technical aspects? Background to the question: private blockchains seem to be more established and common as PoC through various	

		industries, comparing them with public blockchains. What would you tell about the differences between them and their use cases?	
18	R5	I have only been involved in private blockchains, to be more specific, it is the banking industry. Despite private blockchains are still blockchain technology, they are quite structured, and more adaptable and more simple from the tech aspect – not many blocks in each chain. My experience covers the conduct of second opinions and reviews in the PwC Act, auditing firm and consultancy firm, but not any implementation of blockchain. It is more of a classic control approach to ensure that access and change management, as well as the environment itself, are managed in a controlled way, and the development is stringent and followed by some use cases and test cases. In terms of management – standards, governance, and establishing policies – blockchains are quite similar to how many other technologies shall be managed. How to apply blockchain would be different, but the management of blockchain and many other technologies is alike to me in that sense.	BC, OF
19	Researcher	Could you please elaborate a bit more on your answer related to that blockchain has more adaptable rules than other supply chain technologies?	
20	R5	Yes, blockchain has more adaptable rules than other supply chain technologies. There are a couple of benefits in the roles and responsibilities and in the interface that blockchain enables, which makes it possible to apply not general but let's say more specific rules. Again, transparency contributes to that which I think is the baseline for it.	BC
21	Researcher	As you know with Track 2 in our interview guide, three pillars of sustainable chain management have been provided: environmental, economic, and social (organizational) concerns. We have just summarized 6 mainstream characteristics of blockchain technology: decentralization, immutability, transparency, the integrity of data, smart executions, and versatility. The first question is about the correlation between these 6 characters of blockchain and environmental concerns of supply chains, such as energy conservation, recycling, resource management, or any other kind of green activities. Starting with decentralization, how can blockchain's decentralized database architecture impact	

		the environmental concerns of a supply chain? What would be your reasoning in this regard?	
22	R5	I am not sure if the decentralized database architecture itself would impact the environmental concerns of a supply chain. I think there are other elements in this pillar that have more impact. I cannot really tell how decentralization would impact and why. I see no correlation.	BC-D, A-En
23	Researcher	How can data immutability impact the environmental concerns of the supply chain? Are they correlated?	
24	R5	Since the consumer would ask for a way of tracing the product or service and it will be forced by the market, the correlation would be high.	BC-I, A-En
25	Researcher	How can transparency impact the environmental concerns of the supply chain? Are they correlated?	
26	R5	I think transparency is at the core of this technology and it's one of the greatest benefits with the adoption of this technology. I would say there is a high correlation, and higher transparency potentially has a high contribution to environmental concerns.	BC-T, A-En
27	Researcher	How can the security or integrity of data impact the environmental concerns of the supply chain? Why?	
28	R5	As I said before, one contribution of the blockchain would be trust because it is signed off by multiple counterparties, I think, the integrity would be impacted in a good way. The impact is medium I would say. For an additional note: for me, the integrity of data is different from the security aspect. Security is a much broader topic. Integrity does not add up to security; to put it broadly, you may have high standards of integrity of data, but it may not be secure. I would correlate the integrity of data to environmental concerns rather than security. Because integrity is controlled and assured by multiple sources built up by the blockchain; that is, there are multiple reviews of the processing activities that would contribute to a higher quality. From my perspective, security is broader and includes harder measures.	BC, BC-SI, A-En, OF

29	Researcher	How can the smart executions conducted by smart contracts impact the environmental concerns of the supply chain? Why?	
30	R5	It is about monitoring more effectively, by that it is possible to be more agile, which contributes to decision-making on sustainable supply chain management from an environmental perspective. I could tell it provides proactivity rather than reactivity, and I would say there is a medium correlation.	BC-SE, A-En
31	Researcher	This last term here is a bit latent because by attributing versatility characteristics to Blockchain, we are referring to the evolution of blockchain. To be clear, as far as we know, Blockchain 1.0 stands for the introduction of Bitcoin in financial markets, Blockchain 2.0 refers to the use of smart contracts, whereas Blockchain 3.0 and 4.0 are more like the industrial use cases of blockchain with its integration with artificial intelligence elements. So that's the aspect by which we call blockchain as a versatile technology. Considering this perspective, how can the versatility of blockchain technology impact the environmental concerns of a supply chain. Additionally, I will ask you to have comments on the level of correlation between them, considering the potential industrial use cases by the integration of these technologies.	
32	R5	Blockchain's adaptability, its transparency, some of its built-in functionality or capabilities within the technology enable versatility. In my understanding, the answer resides in the question: it is in the technology itself. I have been working on a project for industrial companies working with operational technology, which is similar to IoT. They basically place sensors on the production lines and connect them to the ERP system. By doing that, they are kind of putting together the blockchain, but not in the perfect sense. There are some bits and pieces that enable you to trace all the way back from the supply chain to the consumer perspective. I assume we can expect a high correlation between the versatility of blockchain technology and supply chains' environmental concerns.	BC, BC-V, A-En,
33	Researcher	Regarding the economical aspect of supply chain management, do you think that there is a correlation between the blockchain's decentralized database architecture and economical concerns of SCM? If there is, what would be your justification?	

34	R5	My personal opinion is, there is a low correlation.	BC-D, A-Ec
35	Researcher	What would be your response to the rate of correlation between immutability and economic concerns of supply chain management? To be a background for this question, as we go through the literature, there seem to be certain concerns among stakeholders that the decentralized database architecture poses high investment costs, specifically regarding the initial costs. However, it is predicted that through the sharing of information, the collaboration between supply chain partners and blockchain network stakeholders, which is essentially offered by the decentralized database architecture, investment costs can be recovered in the long run. Even investors can get profit from the network in the course of time. In that sense, the immutability of data seems to enhance the security aspect of transactions. From an economic point of view, do you think that they are of high essence in order to mitigate the risk of revenue and profit losses, to strengthen the level of customer retention, and to eliminate inefficiencies, operational wastes, etc.?	
36	R5	Based on this explanation, I would say there is a high correlation, acknowledging the fact that on average nearly 80% of incumbents in a given company do not trust their own data. At this point decision-making processes will potentially benefit from the higher quality and integrity of data, considering trust built-in with the use of blockchain technology and it will have an impact on the economical concerns of SCM.	BC-I, A-Ec
37	Researcher	How would you evaluate the possible correlation between transparency and economic concerns?	
38	R5	Again, I would say transparency is one of the major things with the adoption of BC technology.	BC-T, A-Ec
39	Researcher	Now we have a follow-up question: Transparency enables customers or clients to trace data and has higher levels of control upon suppliers and retailers by reaching out to any information about a certain product or service all the way up to the origin, right? So, regarding the economic stability through a supply chain network solely, would you consider this aspect of	

		transparency on the downside, I mean not for customers but the other stakeholders?	
40	R5	No, I would say transparency does not pose any disadvantage in this regard. There can be certain cases that might specifically lead to that idea, but in general, I would say the weight of opportunities is much more preponderant.	BC-T, A-Ec
41	Researcher	So you are saying that you don't agree with my point that transparency can be a downside of advantage for certain stakeholders through the blockchain network, right?	
42	R5	Not in general, as I said, in specific cases, of course, but the benefits overwhelm that.	
43	Researcher	So, maybe we can just move on to the integrity of data or security. How does security or integrity of data impact the economic concerns of a supply chain and why?	
44	R5	Well again, trust the data, the process, and the data would be at a higher quality standard and therefore that would impact again the market or whoever gains access to the blockchain itself or the consolidated transactions.	BC-SI, A-Ec
45	Researcher	So how would you rate it on a three-point scale?	
46	R5	Medium, that is more based on from what I see. I mean, at least financial data are today to a quite high extent, trustable. It's available, the integrity is quite high and there is control over data and transactions that are quite good, at least from a financial point of view. Not rock the world, so to speak.	BC-SI, A-Ec
47	Researcher	Do you mean precautions or some kind of qualities regarding the integrity of data are already established through the prevalent technologies?	

48	R5	Correct.	
49	Researcher	So next, we have smart executions. How would you correlate it with economic concerns?	
50	R5	I mean, it's more efficient and proactive I would say. And so it will contribute in that sense to probably a high extent, depending on what they're working with today, of course, and the maturity of the supply chain process you have in place. I think that's one piece that will contribute an impact to a high extent.	BC-SE, A-Ec
51	Researcher	So last but not the least, we have versatility?	
52	R5	Yes, I think that would be similar for economical concerns as for the environmental concerns.	BC-V, A-Ec
53	Researcher	So would you rate its low, medium, high?	
54	R5	Medium.	BC-V, A-Ec
55	Researcher	Would you like to elaborate on your answer a bit more? When you talk about economical concerns of a supply chain, profitability, revenue generation, kind of cost reduction projects or whatever… When you think about the integration capability of blockchain with some kind of different technologies, how can this adaptability or versatility aspect impact the economical concerns in this regard?	
56	R5	Yes, I think again, since the technology itself is very dynamic, it will enable, as you said for example, more proper cash management, of course. And again, more trusted solutions can be added to this technology but it's not that different from today, I mean, the economical area in general, its maturity is a bit higher than the environmental aspect has, I would say.	BC-V, A-Ec

57	Researcher	So, the next group of concerns is social concerns, and by saying social concerns, we are implying the organizational concerns. It can be intra-organizational concerns or inter-organizational concerns. So when you think about these six characteristics once again, we can just go by one by one and how can blockchain's decentralized database architecture influence the organizational concerns of a supply chain? I mean, it can be like the relationships between different organizations or it can be just about any kind of relationships within the organization.	
58	R5	I might be misusing the word trust, but I think that contributes to the point where the ownership of data is always a question. And when you have a setup like this, it will be shared to a larger extent and that will contribute in a good way with trust. On the other hand, you might experience what that's like, it might be harder to change a certain supply chain setup when you are too decentralized, so to speak. I'm not finding the word that it sounds like a bit of a lockdown.	BC-D, A-So
59	Researcher	I get your point. You know, there seems to be pros and cons with this decentralized database architecture. So how would you scale it on a three-point scale?	
60	R5	I would say medium.	BC-D, A-So
61	Researcher	And next, we have data immutability. What would you say about its impact on the organizational concerns of a sustainable supply chain and why?	
62	R5	I am having trouble with this immutability thing. It's hard to tell how that relates because that's not a characteristic that only goes for blockchain. So I would say low.	BC-I, A-So
63	Researcher	So you see no correlation?	
64	R5	No, not really.	

65	Researcher	Next, we have transparency?	
66	R5	gain, the super power of blockchain, I would say… That goes for organizational, both internal and external as well. By having for example let's say, co-hosted transaction flow, you will contribute with data and by consolidating data, you will get the information and that will potentially support both counterparties or if they are more than two. So high impact.A	BC-T, A-So
67	Researcher	And we have security and integrity of data. What would you say about the impact of this aspect on the organizational concerns?	
68	R5	Again, security and integrity of data will contribute to higher trust in the transaction, the data itself. And by that make more precise and correct decisions. So that goes for both internal and external.	BC-SI, A-So
69	Researcher	So next, we have smart executions, as you know?	
70	R5	Yes, smart executions from an organizational perspective, I think it's more covered in the economical and environmental and I think to a lower extent from a social concern. But with the similar rationale.	BC-SE, A-So
71	Researcher	What kind of similar rationale are you referring to?	
72	R5	By that I mean proactive again, and yes, it is dynamic as for versatility.	
73	Researcher	Now we have versatility, do you see any kind of correlation with organizational concerns of supply chains?	

74	R5	Well, I think from an organizational point of view, there are areas that have not been, I mean, fully… Let's say I have not elaborated too much on this aspect from a blockchain point of view, from my understanding and experience. So, I think there can be great potential. But I haven't heard of any studies on that specific topic.	BC-V, A-So
75	Researcher	So how would you scale it in this regard?	
76	R5	Then it's really hard to scale but maybe low…	BC-V, A-So
77	Researcher	No correlation?	
78	R5	Yes.	
79	Researcher	So, regarding this track, are there any other aspects of sustainable supply chain management or blockchain characteristics that you would like to mention?	
80	R5	I would say that it will also contribute to or enable more precise and structured governance. More bottom-up approach instead of traditional top-down governance approach, which is the most common within the supply chain. So, I think that it will highly impact the governance approach to this area or process.	BC, OF
81	Researcher	So can we move onto challenges and risks, the last part?	
82	R5	Sure!	
83	Researcher	We just listed six different challenges and risks. We have the immaturity of blockchain as we go through the literature, we see some kind of cybersecurity openings, I mean some kind of immature characteristics of blockchain such as throughput and latency problems, data processing problems. The second one is the lack of awareness and technical competence, and organization collaboration and change management, cost and functionality, and lastly, legal and compliance. So, we have six challenges and risks in this part. If we just start	

		with the immaturity of blockchain, how does it impact the adoption of this technology regarding its benefits, how would you rate on a 3-point scale?	
84	R5	I would say low. I think the challenge is more like the second one, lack of awareness and understanding. I do not find the technology itself that immature; I think that one is low. The second one is high, lack of understanding, and lack of technical competence, so to say. And for the third one, does organizational collaboration impact the adoption? Yes, I think that is one threshold if we can call it like this. That needs to be managed and have a huge impact because each and every line manager protects their own processes and part of the process. So, I think organizational collaboration, just to walk through the supply chain processes end to end, would contribute to higher awareness and by that understanding the benefits of the technology. So, high impact.	CR-IM, CR-AWC,CR-OC
85	Researcher	The fourth one is change management? What would you say for the impact of this?	
86	R5	I would say low. As I said before, change management is supporting or surrounding any technology. At least from a technical point of view, it would have a low impact. On the other side, from more of a transformation point of view, its impact would be high, but in that case, you need to consider the organizational learning and training part as well. If we keep change management as for technology itself, I will say low.	CR-CM
87	Researcher	Could you explain a bit more that you would address the impact of it as low when we think about the technological context?	
88	R5	Sure. Well, management over any technology shall be robust and there is a good experience in history I would say within IT that manages new technologies and processes supporting that. The process is quite iterative and agile, so I do not see that as an obstacle for blockchain.	CR-CM

89	Researcher	Is it right to interchange the words change management and top management in this regard, like the impact of top management on blockchain technology, can it be a challenge also? Like, how does top management impact the adoption of blockchain?	
90	R5	If I understood you correctly, yes! I think there is a challenge that top management is not aware of and do not understand, then we have the gaps as barriers between organizational divisions or parts within the supply chain, for example.	OF
91	Researcher	Because I think the understanding of top management in blockchain can change their organizational strategy, correct?	
92	R5	Yes, it is correct.	
93	Researcher	And how will you rate it, impact-wise?	
94	R5	I would say there is a high impact of upper management involvement or dedication for adopting such a technology.	OF
95	Researcher	So next, we have cost and functionality, how do cost and functionality affect the adoption of blockchain technology?	
96	R5	Well, if looking at cost and functionality from the perspective of challenges and risks, I would say low. I mean, you were describing the return on investment, etc. So, I do not see the cost as an obstacle and functionality-wise, that is one of the contributions that come with this technology, especially for the supply chain. It is an opportunity, not a challenge, from my point of view.	CR-CF
97	Researcher	So, lastly we have legal and compliance as a challenge or risk.	

98	R5	Definitely, a high impact. Especially looking at the compliance and the policy and the instructions for… I mean some areas are not updated, and it is hard to demonstrate that you adhere to such unknown technology to most people. I think there is a challenge to have third-party assurance over your blockchain technology.	CR-LC
99	Researcher	So, is there any other challenge or risk that you can suggest to us to consider in this respect?	
100	R5	I think one risk is that the business model itself may not be adjusted appropriately based on the blockchain technology, meaning you will govern an exterior company based on obsolete preconditions. I think that is an important piece that you need to align your BC initiatives to the business model itself. I think that is a common risk in all transformations, especially in blockchain, involving technologies that the management do not always fully understand the alignment with their business model.	OF
101	Researcher	Just to understand this correctly, are you referring to the fact that established business models are not easy to adjust to the requirements of blockchain technology and some kind of upper management people or incumbents are not fully aware of that fact, are you addressing these issues?	
102	R5	No, not really. More of taking that aspect into consideration when dealing with BC technology initiatives to incorporate that to the business model more. I do not see the lack of alignment of the setting to the business model as an obstacle, it is just an aspect to consider, that is just a challenge to align that to the business case needs a lot of work.	OF
103	Researcher	So, it would be effort taking, time-consuming, it requires upper management dedication, I mean are you just referring to these aspects when it comes to business model transformation?	

104	R5	Yes, correct.	
105	Researcher	I think we are about to close. We have one or maybe two more questions. Is there anything else you want to add before ending the interview? I mean challenges, risks, benefits, any kind of aspects which we just went through by now.	
106	R5	No, not really. I think the most clients I meet are starting this as a pilot project with only a piece of for example, supply chain process. So, I think that is a good way of making a PoC and then extending it. That can be added.	OF
107	Researcher	So, maybe I can just come up with a follow-up question because you were saying that this kind of pilot projects add up to some kind of PoC with blockchain technology and literature is full of information regarding this. But according to certain reports from some research and advisory companies, and I will share one from Gartner in this case, nearly 85 percent of supply chain implementation projects on blockchain technology adoption have failed or are likely to fail in the short term. So, how would you make evaluations of that? What is the root cause of this problem with the adoption of blockchain technology through the supply chain networks?	
108	R5	Well, underestimation of costs and lack of resources... As most of the IT projects in general and that goes for BC projects as well. I am not surprised over that number. So, either you are building some kind of project assurance methodology approving the feasibility and realization of any projects. But especially when it comes to technical projects, they are shadowed by some third party or such, else you need more management attention.	BC, OF
109	Researcher	Got you! So, would it work for you if we get back to you for anything that we want to clarify or if any other question arises, maybe through emails?	

110	R5	Yes, sure… You can do that.	
111	Researcher	Would it be okay for you, if we send the final draft of our work to you before publication?	
112	R5	Yes, please do! Could be interesting, and I hope I have contributed in some sense to your thesis?	
113	Researcher	Thank you for taking the time to participate in our study. We hope this session will be really serviceable for us. Goodbye.	
114	R5	Thank you. Bye.	

Appendix 9: Interview Transcript – R6

Company: Deloitte Digital Nordic

Interviewee: R6

Job title: Director, Lead of Blockchain Operations

Interview Type: Zoom Audio Call

Duration: 1:31:05

Date and time: 28th of April, 2020

(A-En) - Environmental Aspect of SSCM - Green

(A-Ec) - Economic Aspect of SSCM - Yellow

(A-So) - Social Aspect of SSCM - Blue

(OF) - Other Findings – Red

Line	Person	Text	Category
1	Researcher	Sir, are we allowed to use your company title, or would you prefer it to be anonymous?	
2	R6	That's fine. You can use my company title.	
3	Researcher	So maybe we can start by asking what prior experience do you have with blockchain, sustainable supply chain management, or sustainability agenda?	
4	R6	I have been working with blockchain in Deloitte for four to five years now, I believe it was back in 2016 when I first started to deal with subjects falling into this area. The concept of Blockchain was trending upwards by that time and we also introduced a couple of products into some of our clients having the ability to do a car transaction, utilizing Bitcoin, and so on. That was more or less the offset and then I have been leading up our blockchain practice in Denmark and also in part of our global leadership in Deloitte on Blockchain and we have done multiple projects out of Denmark, but also I had some of	

		my people working with blockchain projects around the globe. So, at this point, we are twelve people in Denmark working fully allocated to blockchain only and we have maybe an additional 10 people working on and off, not exclusively with blockchain. They worked out of Danish parties, more than 20 projects, ranging from advisory and strategic envisioning down to proof concept, pilots, and production-ready supply blockchain applications as well. So that is across various industries but what we see right now is a lot of activity within supply chain, logistics, and transportation. We also have people working inside all major initiatives within the supply chain and transportation.	
5	Researcher	Did you have a chance to take a glance at or go through with our interview guide before this session?	
6	R6	I didn't have a chance to look through it carefully, perhaps it will be better for you to steer it to tell me what you need to know and we can extract the best out of this session.	
7	Researcher	Great! The structured part of our interview guide starts with asking the following question: "How can the use of blockchain technology transform supply chains as compared to the prevalent ERP systems?" I mean, what makes the blockchain architecture attractive to supply chains? We are asking this question because conventional supply chains are widely considered as complex and built-in systems. Deploying blockchain technology in supply chain networks, how do you describe the transformative nature of blockchain technology for supply chain mechanisms?	
8	R6	If I look at what is happening within supply chains, that is pretty much default and that has been the case throughout all of the built-in systems, a multi-stakeholder network of moving things across. I mean, one company doesn't have the power or authority to move everything from an agency or manufacture down to the end consumer, meaning that the entire chain of making products, including packaging, shipping, selling, and distributing them, is something where everyone is relying on others to take a part of the entire supply chain. So, it's a multi-stakeholder game, and what we have seen with the digitalization so far - and ERP is part of that journey - has been out trying to advocate for their software within just each and every single participant in the supply chain. So, if you have Maersk, they have	BC, BC-T, BC-SE, A-Ec, A-So, OF

		SAP, then you might have some others that have SAP or Oracle, and then you have small man transportation maybe. Every ERP solution is sold into one company and one company only. What makes the compelling case for blockchain technology, especially within the supply chain, is that the real value with supply chain lies in things moving across all the different actors in the supply chain and thereby also all the data moving across all the different ERP solutions. So, my impression of what makes real value is actually what happens in the transaction between companies, whereas ERP solution predominately tries to capture how to control everything that happens within the company. So, the ability to have this flow through different ERP solutions really makes sense. And essentially what it's all about is the ability to make sure that whatever person A is seeing is the same that person B is seeing and all the way through the end destination, meaning that if we in the offset just have a shared view of what is actually happening across all the different stakeholders in the supply chain, then that is a massive improvement. And then you could have the second layer, where we want to establish trust and remove intermediaries, do additional financing on top of that, or remove all the types of risk. And there we also have a lot of compelling cases where the underlying asset is, if we can make sure that the records across all the different transactions happening into the silos is in sync with a golden truth where we can use the blockchain, we can also start using smart contracts and on top of that, doing financing, payments, smart contracting, facilitating a lot of the trust issues in the second or third phase of a supply chain-blockchain sort of transformation. So, in this aspect, I would say that blockchain holds the potential of doing the most disruption we've seen within the supply chain since the container was invented. It's really something unique. However, it's also a huge network of existing businesses, processes, and systems. The transformation and getting the volume of its offerings will be a battle that will go on for quite a number of years. Being expected to have the ability to save a lot of money, so it's efficiency gain that calls for that this will happen. And, of course, there is a need for a lot of infrastructures to take place and so on. But it's one of the industries where we see a lot of activities and also consortiums building up trying to address this. That’s the overall reason why we really believe in this. If I'm to explicitly say why blockchain, or maybe I would prefer to use the concept “Distributed ledgers” rather than “Blockchain” because I don't know if	

		you have that distinction, but the blockchain is just one way of creating a distributed ledger. However, what we see right now is that there are distributed ledgers not using blockchain that would have a better fit, especially within the supply chain, simply due to performance and also in terms of creating data finality, etc. But anyway, what makes distributed ledger technologies attractive to this is to be able to have data immutability and we can have complete participants rule enforcement. The ability to have smart contracting could come into play. And we also see a really big potential in creating zero-knowledge proof to eliminate distrust within the supply chain. And fourthly, we also see the idea of creating at no cost digital twin to combat counterfeit, etc. that will allow us to do something that is yet to be seen unprecedented in trying to make a transition from supply chain to what we call demand chain. So, the supply chain is pushing products out to demand, whereas if products could actually find customer demand instead of the other way around. That would be something quite interesting. But that is something that we will see maybe in five to eight years out on the horizon. So, all of this builds on top of having the trustless, immutable data record, and the immutable logic execution through smart contracts. And then also with zero-knowledge proof, there is the ability to share information without sharing data. I think that is from a technical blockchain architectural point of view, why it makes really good sense into the supply chain.	
9	Researcher	Got it! Does the blockchain universe rely upon more adaptable rules than other supply chain technologies? If so, what are those rules?	
10	R6	What you mean about adaptable rules, could you elaborate a bit on that?	
11	Researcher	Sure. When we think about the prevailing supply chain mechanisms, they seem to be built-in and complex systems with their own conventional rules working but blockchain has its own universe with its capabilities. At this point, as we see some reports from different consultancy companies, for example, a report from Gartner lately shows that nearly 85 percent of blockchain technology implementation projects through supply chain networks have failed or will possibly fail in the short term.	

		From this perspective, is blockchain really adaptable to built-in supply chain networks?	
12	R6	Okay got it! From a technological point of view, you can do a lot of stuff with blockchain. It has, for the moment at least, the flexibility and maneuverability to be applied to a supply chain scenario, without limitation in terms of performance, etc. Of course, there are configurations but as we see it right now, the technical issues are not what is slowing down or making blockchain projects fail within supply chains. From our point of view and experience, the critical issue here is to distinguish between building a minimum viable solution and building out the ecosystem with standardization in operation. A minimum viable solution is just getting something up and running that people can understand. And sometimes, especially when people are really happy about the technology, they focus only on getting something up and running. They go: "We need TradeLens. We are already in production and we've got cargo smart. We'll build the blockchain of the future.", so and so forth. They only focus on promises with great technology. But on the other hand, that's the minimal viable product. That's the easy part. What is actually difficult, especially when you are in blockchain projects that call for a supply chain, is how do you build a minimal viable ecosystem. That is, you would not be the only one using this solution. I mean, if you're the only one having a smartphone, you really have something that wasn't that smart. In other words, if you couldn't use it to call anyone else or there wasn't anyone else providing content for it, it will actually lose the value. So, I mean, the ability to have participation in a network is really essential. So, building out the ecosystem, that's the difficult part. That is the one slowing down progress because it's not driven out of technology. Instead, it's driven out of governance and policy and how you are creating this. And normally when you look at joining these consortiums within supply chains… Let's just take the example of Maersk and IBM TradeLens… I mean, they initiated this but they have had a really difficult time getting their competitors to join because they don't want to support something that can bring value to the shareholders of Maersk. Then someone else will do a competing initiative and have developed something that involves quite a bit of participant, and then Cosco is doing their CargoSmart, etc. So then you will have networks trying to battle out against each other, trying to make the more attractive solution. I think that's really the tricky part because if we need to have something	BC, CR, CR-LC, CR-OC, OF

		that makes sense, we need all people to opt-in through the same tank of solution. Again coming back to the first question, where this needs to be something that can move across multiple silos and multiple ERP solutions. And if that's the case, you need people to opt-in on the same rules. So, if you need to have a blockchain solution, it will require that we agree on some data standards, that we agree on a way to communicate with each other. We also need to agree on the rules of how we do and conduct information exchange and how we conduct business. That means you need this process and rules standardization, and this is the tricky part. And if you look into the supply chain particularly, the level of standardization also just on some of the core aspects of moving things across isn't really that firm. I think that's sort of a reason why we've seen project failures, this is not just within the supply chain, but a lot of blockchain projects within financial service industries, insurance, and that's why others are trying to create consortium because this is something that would benefit everyone having more efficiency in the offset. On the other hand, we also need to build a model where we can collaborate and not just hand over money to some of our competitors. And that makes the consortium play the crucial one and the difficult one. From the technical part, there is an overflow of focus on saying: "Does it work? Can we make it work from a technical point of view?". But in every single blockchain project, the difficult part lies within establishing an ecosystem and creating an incentive model that allows people to join in, even though they are competitors. And then it solves what we normally call a wicked problem. So it's not just my problem, it's also someone else's problem and that someone else might be someone who I actually compete with on a regular basis. So how do we do that, especially without maybe having a government trying to enforce standardization of rules of adoption? Besides, when you look at the supply chain, I mean, it might be fine that Sweden is doing something and then Denmark is just doing something different than that, whereas the European Union is doing something else, also China is doing differently… I mean, we have things moving across borders and of course, these different sets of rules and regulations make it more difficult to make 100% sure that this will work, which I believe is the tricky part. So actually, it's not that we cannot make blockchain work within the area of the supply chain but its more on how we can actually make sure that supply chain gets optimized so that everyone can benefit from this. And I think that what	

		we do see is a lot of fractions. I mean, especially within shipping, but also land transportation. And we also have governmental initiatives, I mean, the Chinese Belt and Road Initiative and you've got the Dubai Silk Road Initiative and something is coming up within the European Union. And there are also discussions on how to do something for improving trade efficiency with the US. So, I think it's a matter of adapting it into the business real-world, and not from the technical point of view.	
13	Researcher	According to your perspective, which industries will likely benefit most from the supply chain use cases of blockchain technology? And, why?	
14	R6	I think that in the first order of who would benefit, there would be all the efficiency benefits. I mean, just having a single reconciliation layer, making sure that whatever I see and what I have in custody is the same thing that you will take away as the next party in the supply chain. That kind of efficiency would primarily go through all the land transportation and shipping companies because they will be able to operate more efficiently. There are different ways to calculate efficiency, but I think on average what I've seen is that when it's fully implemented you can roughly reduce around 200 US dollars per container shipment in removing friction. And of course, that is to benefit them. There is also having a more seamless order flow of goods, which would allow for the ease of having trade import and export of trades, and that would allow for also some company use cases. There are also use cases saying if you have food or flowers or something that might have a limited lifespan, having the ability to have that flow through you also could eliminate some of the waste of product. I mean, I don't know the exact numbers, but there is a huge amount of products deteriorating due to the fact that they cannot get through customs or something like that. You're missing out on paper since you don't have the entire chain of information ready. This is the first level and then the second level will be insurance, trade, and finance on top of that and I think thirdly, we will see manufacturers having the ability to combat counterfeit and also going through some more optimized way of thinking supply chains. The fourth phase is where I think the zero-knowledge proof will come into play. That would essentially have the idea that we can read out malicious actors within the supply chain and make sure that we could increase the trust in the global supply chain. I think	BC, A-En, OF

		that would call for immediate, significant something. But it's also extremely difficult and we are far away from having something like that to be put into place.	
15	Researcher	We already talked about it a little, but how do you see the future of blockchain technology through the supply chain networks? It might be different in the short term, or in the long run but do you see a bright future for blockchain technology to be implemented in the supply chain networks, let's say in the next five years?	
16	R6	When we look at the number of initiatives going on, then it's really positive. I think what we will see is a sort of consolidation. So, some of these initiatives will have a difficult time in managing their blockchain projects. And again, I think what we will see is not due to technical difficulties but due to how to attract and get more people onto the network. That's the tricky part. I mean just to address an analogy, Facebook came along, Google tried to launch that Google Plus, which I believe was eight years ago, and even though they were Google, they were not successful. So, it really requires something to think of how you construct something where you can make sure that you have mass adoption within the industry and doing something like that. So, I do see this playing out quite nicely. And we also see the rise of some standardization, nonprofit collaboration within the industry, making sure to provide the data standards, the process standards, the IoT standards. One of the recent initiatives is DCSA, so it is the Digital Container Shipping Association. It is something that has been established two years ago and it's now an organization running out of the Netherlands, but on a global scale. I think this kind of initiative will also help in adopting blockchain. So, on one hand, we will see a consolidation of some of the initiatives. We will see not-for-profit standardization organs trying to provide standards and collaboration within industries. I think, thirdly, we will also see a lot of work being put into interoperability because we will not just have one blockchain or one distributed ledger for all supply chains. We see a future where we will have multiple of them. We will have something within shipping, land transportation, customs clearing ports, etc. We will see something maybe coming out of the European Union and something in China, etc. And if we need to make all these blockchains work together, we need to make them interoperable. And I think that's the reason why blockchain interoperability at	OF

		this point is where many people are trying to look into, the effort of making it possible to take unique information from one ledger and making sure that you can represent that on another ledger without creating copies or having redundant data or trust on a third party to do that as a swap of information. So, we've seen the same within payments and what we see now is an ability to do this, not with something that holds value, but something that we would call arbitrary data. So, the ability to make sure that the more blockchains can work interoperable with each other, that is one of the key essential components. The technology at this point is not in place to make blockchain interoperable at the level that we would like it to be, but of course, once we have that in place, that would call for making it easier to say: "If Asia wants to adopt one ruleset, so we can do something different in Europe, and the US can do something thirdly. But we also just need to come into consideration when we then do changes across." How do we do that? And that will make it easier. At least that is our projection on what we'll have. I think if you need to look into some more aspects of this. Besides all of the above, we have done some work on the Fourth Industrial Revolution focusing on a blockchain and supply chain together with the World Economic Forum and we have an entire toolkit that will be released on how to build blockchain with different chapters, which will also showcase the difficult parts of this. We have released a lot of different papers until now, but I think the entire tool kit will be widely accessible within a couple of weeks.	
17	Researcher	Thanks for sharing the latest, we'll definitely look into your publications regarding this. What are the potential blockchain use cases for green and sustainable supply chain practices? From our literature review, we identified several mechanisms supporting energy conservation, recycling, waste management, etc. In this perspective, what potential use cases coming to mind for greening supply chains through blockchain applications?	
18	R6	Multiple people are trying to address how this could be put into play. Sometimes it seems like people are trying to autofit different things together because sustainability has been a real buzz, just like blockchain. We have also seen the concerns of energy consumption while using blockchain and nodes etc. I think it's really not a concern anymore due to the fact that it was the Bitcoin network and then we see different energy consumption models if	BC, A-En,

		we move away from bitcoin and look into other ledgers. That's really not the case. I know the EU has launched a part of the APSIS platform that can take a sort of green blockchain initiative looking at sustainable use cases for this. There are use cases seeing something to eliminate friction in energy trading, allowing that to make it easier to utilize overcapacity in one end down to another end. However, you alternate to move energy around and blockchain can only help during the transaction and make that easy. We have also seen it is really not that applicable in the Nordics. But in the US and all the areas of the world, we've seen on an entity perspective, you have a smart contract and the ability to have prosumers, meaning they are not just consumers but also producers that produce something from scratch under a roof and you can also buy and sell depending on what you need and if you can do those transactions efficiently that could call for smarter and more resilient grids. I've been in a lot of discussions, but it is also highly complex. I haven't seen many cases on a large scale regarding that case. When it comes to recycling and waste management, especially within transportation and logistics, having a frictionless and hands-off supply chain can help make that the products will arrive at the right time, and of course, the products are also not swapped or counterfeited that they have been preserved at the right temperature if it is medicine, food, or something like that. So, there can be a lot of positive environmental sides. I don't have the exact number, but I know that right now we are shipping around quite the number of containers that are more or less filled with nothing or only half full. If it was easier to maybe book and have some sort of automation, smart contracting, booking thing, that could also allow if it is a product that can actually wait until the container is full, it would be cheaper and you could use less to ship it. These kinds of concerns could come into play. But I also see other issues that are non-blockchain related but maybe have a benefit for greening supply chains, regarding environmental concerns, etc. But of course, there are use cases, its efficiency, and there is also a green angle towards that.	

19	Researcher	Can we just talk a little bit about the distinctions between public blockchain and private blockchain? As we see, private blockchains are more of established cases through the networks right now, whereas public blockchains seem to be a bit immature as compared to the private blockchains in terms of being used through non-financial areas.	
20	R6	Yes, I think like any other technology, you need to select what is best for the use case, for what you want to achieve. Then you should select the best technology to solve that problem, so it starts with the problem, not with the blockchain itself. There are compelling use cases for using public ledgers, as is the case with private or permissioned blockchains. Besides, there are compelling use cases where you combine the two into a hybrid model. I think what we will see is the fact that it's easier to start with a permissioned blockchain since then you know the participants and can also have some sort of controller who can actually see what, where, how, and how long. On the other hand, if you want to do value exchange and swap of value, you will probably move into an open, public ledger. Again, it might also be that you would do a combination of these combinations. I mean, some of the projects that we are running have started as a permissioned blockchain and now for a different use case, they also utilized a public blockchain. So, it's really not something like one is better than the other. It is a matter of how great it fits into what you are trying to solve.	OF
21	Researcher	So, when you say the third form of blockchain, which is the combination of these two, are you referring to consortium blockchains?	
22	R6	Not really. For example, with the Ethereum Network, you have the Ethereum Enterprise Edition and also the Public Ethereum Network. The same goes for their hashgraph. So, they actually have the ability to do something public and something private. So there are multiple differences, though I can't remember all of them. You also see, for example, that IBM and Hyperledger have made an announcement of doing an ordering service together with their hashgraph. So, it is having the ability to run everything that you would do within your Hyperledger node in a private network. And then if you need to prove something across different participants, you can do that by an ordering service utilizing a new hashgraph ordering	OF

		mechanism on the public blockchain. So, I also believe we will see a lot of work being put into the interoperability piece where if I need to swap something from my business system Hyperledger down to a Corda system, on the other hand, it could actually be a great fit to have a public ledger where both business systems trust the integrity of the public ledger, but only as of the lowest level of information being shared there, but enough to make sure that the data has been exchanged between the two ledgers and we have a created copy. These kinds of scenarios, I think we will see a lot of hybrid activities with a bunch of things.	
23	Researcher	So, there's a certain distinction between hybrid blockchains, and the consortium blockchain, right?	
24	R6	Yes, I mean consortium blockchains in my opinion, you can build a consortium that's sort of a social construct of who is going together. Of course, you can also say that some of these foundations are consortiums. So, R3 has Corda, which can be used for this purpose. But I think you need to distinguish between what is the organization behind it and then the platform.	
25	Researcher	So, this is the end of Track 1. The next track is related to the blockchain characteristics and the aspects of sustainable supply chains. When it comes to sustainable supply chain management, we just divided it into three different sections like environmental concerns, economic concerns, and social concerns, and by saying social, we are just referring to the intra-organizational and inter-organizational concerns. As we go through the literature, there are many different characteristics of blockchain, but we just summarized the six of them to make it inclusive as much as we could. These are decentralization, data immutability, transparency, security and integrity of data, smart executions, and versatility. And we will explain what we are trying to imply by “versatility”. But these are the six aspects that we consolidated up to this point. So, the first part of our guide is more like the environmental concerns of sustainable supply chains. So, maybe we can just start by looking into those BC characteristics and their correlation with environmental concerns and try to address the level of correlations on a three-point scale, like low, medium, high at the end, with some brief explanations for each of them if that works for you. The first one is	

		decentralization. So how can blockchain's decentralized database architecture impact the environmental concerns of a supply chain like energy conservation, recycling, waste management, etc.? And why? Is there a certain correlation that you can infer?	
26	R6	I think there might be a lot of things that may be ongoing that I don't know, but I think the first one is sort of the same as I said earlier. If you think of the ability to have prosumers, by that you can produce energy and also calculate and distribute it, and some of these areas are where you have extremely centralized entities doing something today. At this point, the ability to decentralize that, make it more inclusive, and maybe more resilient can really make sense. But I think you could say blockchain infrastructure could help support and make that easy. But it requires a lot of other stuff on top of that. I mean, the entire energy, for example, the entire network of how you distribute energy needs to be turned the other way around. And I know from Denmark, it's really difficult for all the people having some of the rough times to actually sell something. So, it ends up being something that we do to make that prosumer happy. But in reality, we really are not selling anything because it all gets into waste. After all, we are not able to handle back and forth at a good level. There are a lot of things that need to be considered other than blockchain. If we are to look into that decentralization specifically, it's not just a database and information flow. If you have a physical flow of something, you also need to look into how that works and how do you change that in a better way. I think that would most likely be more difficult than just trying to make a distribution of a distributed node infrastructure and smart contracting layer.	BC-D, A-En
27	Researcher	So, on a three-point scale, like low, medium, high, how would you attribute it when it comes to the correlation between decentralization and environmental concerns of a supply chain?	
28	R6	I would say low.	BC-D, A-En
29	Researcher	How about data immutability in this regard?	

30	R6	I think that makes more sense. I mean that would be high.	BC-I, A-En
31	Researcher	Could you just briefly explain why you think that way?	
32	R6	I think that since it's extremely difficult to actually have transparency throughout a multi-stakeholder supply chain, just having a single source of the truth, even though it's very basic, can actually eliminate a lot of inefficiencies, including also the checks and balances where they can move across the border or whatever. And if someone has said that they have done this, they cannot just change it to their own benefit. So, you don't need to rely on people that might have an incentive to try to cheat you. Once it's there, it will stay there. And I think that this makes it really simple. This is where we would see it having a huge impact. So I say high.	BC-I, A-En
33	Researcher	The third one is transparency in this respect. What would you say about it regarding its correlation with the environmental concerns of a supply chain?	
34	R6	I think transparency is a bit more tricky than data immutability. We are not able to change something that happened in the blockchain because of data immutability, thereby we can trust it. Transparency stands for having the ability to see any change in the blockchain. And of course, that may have a huge impact on the negative side. We also have an issue that if we share everything, that makes it extremely difficult to run a business and it also prohibits sometimes the collaboration through updating on this. So, I would put it in the middle. It has pros and cons. And I also think that's the reason why we think of zero-knowledge proof. I don't know if you're familiar with zero-knowledge proof. So essentially, if we were to do a trade, I would ask the seller if he has enough money to buy what I'm trying to sell him before I actually ship the goods. And instead of revealing how much money he really has in his bank account, we would have in between us a protocol saying of this transaction, I need to make sure that you're not lying to me and saying that you have the money that you can use all over the transaction. And so that will then go into your data and saying, let's create a perfect proof that is sealed and based on the data he will come back to me and say, this is ok and you have the money. I don't know how much money you have, but I'm good. Thereby, I consent to this one. And I think that is	BC-T, A-En,

		something in the legacy where we used to send copies of data in order to prove that you can trust me, then show me all the data. Instead of what we need to start asking is you don't need to show me the data, but just show me proof that you're not lying to me in terms of what we're trying to achieve together. So, I think at the level that we are right now, it would be true when we see zero-knowledge proof being put into full production level. This would be free. It will have a huge impact.	
35	Researcher	So you're saying transparency would have a huge correlation in this regard?	
36	R6	Yes.	BC-T, A-En
37	Researcher	So next, we have security and integrity of data. How would you correlate it to environmental concerns?	
38	R6	I think that security and the integrity of data are two different things. But I would say that the ability to make sure that the data is the data that we need and it's sort of validated, also has a positive impact, sort of the same as we've seen with the immutability. So, one thing is that you cannot change the data, but you also need it. You have the data which is the right data and security together with integrity of data are the things that you cannot compromise. So, in many aspects, I will give this high.	BC-SI, A-En
39	Researcher	The fifth one is smart executions. How would you correlate it with the environmental concerns?	
40	R6	Of course, that can also have a high impact. I think the ability to see what we gain with smart contracts is that we can close the gap between the delivery versus payment from near zero and eliminate the risk in between. But also, maybe we should put it in the medium because we also see smart contracting and doing this at large scale with the intent that we want to do. We still have some other risks and it's not that easy as we intend to do. And of course, it's removing friction. It has a huge impact. But short term, I would say medium, long term, it could be high by solving some more inefficiencies.	

41	Researcher	So the last one is versatility in this track. As we go through the literature, we see four different generations with the evolution of blockchain technology, starting with Blockchain 1.0 which stands for the introduction of Bitcoin as cryptocurrency, whereas Blockchain 2.0 refers to the use of smart contracts. Blockchain 3.0 and 4.0 are more into the use of blockchain technology for the sake of industrial use cases, with possible integration with other disruptive and emerging technologies, such as artificial intelligence, machine learning, deep learning, IoT, etc. So when we think about this perspective of blockchain technology as a versatile technology, so how can we correlate it with the environmental concerns?	
42	R6	I think it has a high impact. Of course, you can always discuss AI, machine learning, etc. I mean, a really fine AI-machine learning is not that interesting because they essentially just need data attributed to something better compared to if they didn't have data. But what blockchain can do is, of course, improve the quality of trusted, secure and validated data and thereby can also improve whatever you are using it for at the later part from an AI perspective. What you see on the IoT side is a more compelling fit into the blockchain. Essentially what blockchain is all about is to make sure that we know either who people are or what kind of machines they are. Every time we want to do a transaction on the blockchain, you need to know who is signing the transaction. So, I mean the cornerstone of more or less every blockchain solution is an identity key. And normally we think of identity in organizations or people. What we also will see in the future is the identity of machines, the identity of stuff and the ability to control that on a level that makes sense and also make sure that if I have an IoT sensor at my exhaust pipe on my car, I need to make sure that I haven't counterfeited with that to have it sent a piece of different information than what it's supposed to do. The ability to control the identity and integrity of this we can use blockchain to do something like that. And of course, that calls for this link between the physical and digital world that the link would be an IoT device and the identity of these would be on a blockchain. And if you are changing with your IoT device, it doesn't link up to the blockchain anymore and you cannot fulfill your applications. And thereby you are fought in pushing 3.0 or 4.0 issues or whatever it could be. So, I think that the link is extremely	BC-V, A-En

		interesting and also where we see a lot of activity happening so far.	
43	Researcher	So can we just keep track of the same logic for the other concerns, like economical concerns and social concerns? First, we have economical concerns. And can you just try to correlate those six blockchain characteristics with economical concerns of supply chain management? Of course, we are asking you to briefly explain your reasoning for each of them. Let's start with decentralization again.	
44	R6	I think that the correlation level between the decentralized database architecture and the economic concerns has the potential to be extremely high. I think that especially if you combine it into the ability to swap value and also the ability that if someone in the supply chain has done something in the right way and if you can tokenize that and provide that as a credit rating function, which is many people are looking at that could call for an inclusion level of doing something far more beneficial today. And on the other hand, we also see all the efficiency gains for the large players, so the decentralized power here actually fits quite well together.	BC-D, A-Ec
45	Researcher	Got it. Next, we have data immutability in this connection.	
46	R6	It's also high. I mean, again, if you can only do the same record once, you cannot change it to your benefit. I mean, that's sort of the cornerstone. Otherwise, it's difficult to trust it. So, you get the full audit trail out of the immutability pieces at that time.	BC-I, A-Ec
47	Researcher	What about transparency?	
48	R6	I would say again transparency would be on short term a medium because it can be a downside of blockchain in terms of making it problematic for certain applications, especially the ones regarding finance, but I think on the long term when you see zero-knowledge proof again comes more into play, then it will have a high impact.	BC-T, A-Ec

49	Researcher	The next one is the security and integrity of data. As you've already said, these are two separate things, but you can evaluate both of them separately or as a single factor, depending on how you wish.	
50	R6	Yes, but that's also high. I mean, you cannot trust an economical something if your data is compromised or if the data is not following, I mean if suddenly it's a different currency, maybe it's a different invoice… I mean, regarding these aspects, that's extremely high.	BC-SI, A-Ec
51	Researcher	What about smart executions?	
52	R6	It's high and for the same reasons as we talked about through the previous track.	BC-SE, A-Ec
53	Researcher	And versatility is the last one in this respect. How do you see the correlation of this characteristic with the economic concerns?	
54	R6	Also high. You see this going in, this would be the piece that could bring the supply chain together with trade, finance, down to IT level credit rating functions, etc. So, that's high.	BC-V, A-Ec
55	Researcher	So the last part in this Track 2 is about the potential correlations between BC characteristics and the social concerns of sustainable supply chains. And by saying social concerns, we are referring to the organizational concerns, regarding both intra-organizational and inter-organizational issues. The first one again decentralization. How can blockchain's decentralization database architecture impact the organizational concerns of a supply chain? And why? On a 3-point scale, how would you rate the impact of it?	
56	R6	I would rate it high. The ability to use a decentralized architecture to make sure that we get a neat view of what is flowing across different actors within the supply chain really holds on one hand, of course, security design, but it also holds the ability to create incentives between actors, not just to hold their own data but to optimize for their own perfect pool. But actually, it ultimately holds the supply chain optimization potential. And of course, it comes to different variances. Recall that we have	BC-D, A-So, OF

		mentioned the ability to create the zero-knowledge proof, as part of that I based on my data can prove to you I am not lying when I hand over the goods to you. And this proof could then be whatever would be shared across but the ability to do that decentralized instead of having a trusted agent, where actually allow that we could do more, we could do it faster, cheaper, and with the lower granularity within the supply chain. I think that really is one of the key points.	
57	Researcher	So, the next one is data immutability. What do you think about the potential impact of data immutability on the organizational concerns of a supply chain? Could you explain your reasoning beneath it?	
58	R6	Again, I see the potential being the end-to-end optimization of the supply chain. Of course, if you are someone within the supply chain that makes a lot of running out of maybe tweaking information to or information asymmetry into a benefit for yourself, this ability to not be able to cover your tracks, because you will have an immutable record, will provide a negative consequence for those in this kind of things. But the overall ambition is that you will actually have the real flow of information flow throughout. On the other hand, we also do see issues in regards to the imperfect world of sensors, for example. So right now, we have a trying where we are following a time-stamping into a ledger, the entire flow of work from Denmark to China and that includes the cooling temperatures from sensors. And some of the datasets that we are receiving from the sensors might come to a point where the sensors are doing calibration activities, so suddenly you got minus 200 degrees or plus 400 degrees, and that's just because the sensors are calibrating, it is not because that's the temperature of the container. But I mean when you start doing this immutable record layer, you might also get, not on purpose, but just out of practical use cases, some measurements that can lead to negative consequences. So, I think the immutability also comes with a price to pay in terms of having better data management, which is really crucial. Otherwise, whatever is on the blockchain can then stay on the blockchain. For example, this could also reveal transparency that could lead you to have your export right to a country revoked, simply due to the fact that traceability and immutability is something where you should start and then arguing whether that was actually the case amount that you cannot change it. So, it comes with	BC-I, A-So

		consequences, especially if you increase time and you are also time off what kind of the events you put on to a ledger. So, there is a lot of governance and data management, but you need to revolve around this. On the other hand, it is really one of the most critical components, having the ability that no one after they said so can change this to their own benefits at a later point.	
59	Researcher	So, how would you rate the impact of it on the organizational concerns on a 3-point scale?	
60	R6	It is high.	BC-I, A-So
61	Researcher	The third characteristic again is transparency. What would you say about the impact of transparency on social concerns?	
62	R6	I think that there are issues with transparency. Again, back to the point why we in the future believe that zero-knowledge proof actually is way better suited to create transparency because instead of exchanging or revealing data, you can reveal information so I only need to know enough and have a proof that you are not lying to me but I don't need to be the owner of your data. I think data is quite obviously something today that is an asset alongside everything else that is valuable so people try to trigger that to their own benefits and they should still have the ability to do so but on the other hand, we need to have a way of creating trust without revealing too much data. Whether that comes with zero-knowledge proof by creating data signed by a data proof or it comes by having permissioned blockchain, it will come in various shapes and types. But I think we will see this, on one hand, transparency is needed, and it is in demand. On the other hand, there is transparency that might not be best for business, you could also say so. It is sort of a two-way street and you need to give and take something, and also think that there is the market needs to adapt to a new reality where transparency is not what we have the most of right now. So, it is a changing paradigm and the practical implementation will come out of doing some restrictions or some smart implementation of the solution that could lead to information sharing rather than data sharing. That's to me is the crucial point. But I would say the impact is right now medium and the reason why it is not high is that there are also some issues cracking it down.	BC-T, A-So

63	Researcher	So the next one is security and the integrity of data. What do you think about its potential impact on the social concerns of SSCM?	
64	R6	If the immutability is the ability to not to change the data, and the security is more of an ability that cannot be compromised, that's, of course, is also a very crucial part. But on the other hand, it also requires that you have a mass scale adoption. Otherwise, you will have a network that could easily be compromised. So, on the one hand, it is really great but on the other hand, you also need active participation and the distribution of your ledger. So, it is tricky but of course, it is one of the main characteristics. If you don't have that you could say why we are bothering to adopt it if it is compromised from the security point of view.	BC-SI, A-So
65	Researcher	So, on a 3-point scale, what would be your rating for the potential impact of it?	
66	R6	I would say medium. Again, there is a reason for not putting it on high. When we look at security concerns around Blockchain, the reality is that most ledgers would most likely not fulfill globally accepted security standards and norms. It might be just a high level of security. I think there are some tradeoffs to be made here that can be difficult, so the impact is medium.	BC-SI, A-So
67	Researcher	Got it. So the fifth one is smart executions which are done by smart contracts. What would you say about its potential impact on social concerns, such as workflow, information flow, etc.?	
68	R6	That is mainly on the high-end. The removal of intermediaries, and also the ability to execute based on data instead of people inspecting and checking and doing manual processes, it really could automate and make a better flow of the supply chain. So, it is high.	BC-SE, A-So
69	Researcher	So the last one was versatility. Maybe we need to recall it to explain why we are calling it versatility. It is all about the evolution of blockchain technology from the invention all the way up to the time we are in, including Blockchain 1.0, 2.0, 3.0, and 4.0. What would say about the potential impact of the versatile nature of blockchain technology on the social concerns of SSCM?	
70	R6	It is high, and I think it is the difficult part because normally blockchain provides an information	BC-V, A-So, OF

		infrastructure for organizing a digital supply chain that really hasn't happened before. But it is not like having had the digitalization of supply chains, just hasn't had their own dedicated information infrastructure. That's the reason why it will reshape the entire flow of the supply chain. But on the other hand, it is also the reason why this will happen slower than many people would think. Since you've already put investments into place in organizing it more into the digitalization of individual silos within the supply chain, now suddenly you need everyone to contribute to a new infrastructure that could make it better and faster for everyone. That kind of transition is difficult. It would be way more easier if it was sort of a greenfield where no one was doing anything like this. That's also what we have seen with social media and these kinds of things, where we haven't had anything in place before, then it is always super easy to come with a new piece of technology that will just enable something instead of transforming something. So, in nature, it is different by default and in our opinion, it is way better but the main struggle is getting the transition from the legacy way of thinking, the legacy way of doing into a new and better infrastructure but we see the exact same within the payment and payment rounds and distributed ledgers. Everyone who has a dedicated digital infrastructure available that is working and doing whatever it needs to do on a trusted and secure and fast level, they are not that eager to explore the options of ledgers but on the other hand, you will have some problems coming in and now almost every central banks around the globe are looking into the testing of distributed ledgers. They could have easily done so through the last 5 or 6 years but they didn't do so. I think that's just a matter of saying: "When you need to do a transformation that goes slower but since it is something completely different, it will take over at some point in time.". We could have come with the same example of electrical cars and so on, which has changed the entire industry in a night. Getting people to transform into something new is just a way slower process than establishing something that doesn't exist. This is sort of the same story with ledgers in the supply chain.	
71	Researcher	So, you would rate its impact high, right?	
72	R6	Yes, definitely.	BC-V, A-So

73	Researcher	Before we get into the last track of our interview guide, is there any other aspect of SSCM or blockchain characteristics that you would like to draw attention to?	
74	R6	I think I have already mentioned it, but that would be the zero-knowledge proof. It has existed for the last 20 or 25 years. But now we have a timing where it is actually doable from the computational point of view. It really makes sense within what already has been introduced with distributed ledgers and cryptography. So, I really think that even though it is not mainstream there yet, zero-knowledge proof actually holds the potential to unlock some of the major concerns of people joining the blockchain consortia. They are asking: "Should we relieve all data? Should we hand in the minimized data? Can we protect our own assets? Can we make sure that we are doing nothing more than one which is in the best interest of everyone?" In these kinds of all collaborative and competitive questions, the zero-knowledge proof seems to be one of the key solutions for providing that into transparency and mitigating some of the issues. So, that is by far what I think within the next 3 to 4 years would be one of the hottest topics.	OF
75	Researcher	So, the last track is all about challenges and risks with the adoption of BC technology. After going through the literature, we listed six challenges and risks associated with blockchain technology. These are (i) immaturity of BC technology, which includes cybersecurity attacks, throughput, the amount of data that blockchains are capable to process, latency, etc.; (ii) lack of awareness and technical competence; (iii) organizational collaboration; (iv) change management; (v) cost and functionality, whereby functionality stands for the combined set of efficiency and effectiveness; and (vi) legal and compliance. If we start with the immaturity of BC technology, how does it impact the adoption of BC technology? And regarding the extent of it, how would you rate it on a 3-point scale?	
76	R6	I would say medium. I think we see the technology is moving extremely fast, actually way faster than people's idea of what is possible and what is not possible. So, a lot of people have addressed this as one of the major roadblocks, which I guess is something that you will find in the literature. But in reality, what we have seen of performance testing and maturity assessments that we	CR-IM

		have done on ledgers, it is actually not the technology holding the deployment of blockchain technology back. It is way more something else. I would also expect that the ability for this technology to deliver on its promise and the pace of where the technology is moving is way faster than how the ability to apply this to industry problems. So, I am not that concerned about the immaturity of these ledgers at this point. We also see large scale deployments in production already. So, it is not like it is not there. And recently this week I had a call with someone from a very global large company and some of their architects said they have put much money on blockchain but it seems like it is going nowhere the discussion we had then were sort of whether they should for the third time within 12 years do a modernization of their ERP solution. My simple question back then was how much money have you put into an ERP solution. Why are you still for the third time in need of doing a modernization of that kind of infrastructure which is just within your organization? All in all, I would rate it medium because there are still issues to be solved. But it is primarily not the technology slowing things down, it is more our ability to apply.	
77	Researcher	So, the second one is the lack of awareness and technical competence. How would you rate its impact on the adoption of BC technology as a challenge?	
78	R6	Right now, it is high. There are people embracing this, but there are definitely more people thinking of this as a bad thing. It is simply because they don't have sufficient awareness and skillset to compete in this. You can also see how blockchain skills are one of the most critical and in-demand skill sets at all in the technical market as of this year. So, there we say this one has a high impact.	CR-AWS
79	Researcher	So, the third one is organizational collaboration. What do you think about its practical impact on the adoption of BC technology?	
80	R6	I would say this high and the reason is that this is actually one of the biggest issues for adopting blockchain. There are a lot of people trying to prove the technology just by creating a POC (i.e., PoC) within a lab or an innovation office. And it will lead to nowhere! Essentially blockchain is a strategic C-level and CEO's decision to make because it involves how we connect with the stakeholders, like suppliers, vendors, customers, and how we exchange information, how we capitalize on this data, and how we	CR-OC, OF

		create completely new market models. So, it is a strategic point of view and a transformational journey that will take some time. That's the reason why you need to see upper management involvement. This makes it tricky and I think this is what is slowing the adoption down. But we can just see that when you've got a C-level person involved, that seize the potential since that is where you get the attraction. So, it is quite simple… If you have a blockchain project that is not supported by the C-level, the chance of success is just very low. If you've got their support, provenance, and commitment, then you are in good shape. That's the biggest point!	
81	Researcher	And the fourth one here is change management. As we see through the literature, this is something that affects any kind of disruptive technology adoption, not just regarding blockchain technology. What would you say about its impact as a challenge? And let me put a note on this one. We are asking you to consider the upper management involvement as attached to this one when you evaluate the potential impact of it.	
82	R6	Yes, in my opinion, the interpretation of change management within the blockchain includes a tricky part which pushes me to see its impact as high, that is, for every business where you do something today and where you need to redo it in a completely different way you've got a new way of thinking that makes it extremely difficult. For example, most of the time I say to our auditors that they don't need to audit on transactions and/or check balances because it is all completed and automated by themselves when the transaction is initiated. That's something they don't understand because they have been doing so for the last 2000 years! That has been how they have been auditing all along. Reshaping that into a new way of thinking is difficult. I mean, if you have high learning with your environments when entering in something new and also the ability to use it, that makes it difficult so I would also rate this one as high.	CR-CM
83	Researcher	So, the fifth one is cost and functionality here. By saying cost, we are just trying to address investment costs, project management costs, overheads, etc. And by pointing out functionality, we aim to include effectiveness and efficiency under this term as an aspect here. So, what would you say about the impact of cost and functionality on the adoption of BC technology?	

84	R6	I would think that cost is not much of a big deal, instead, it is more on the benefits side that if you are to construct a blockchain, you need scale and people to join, and the benefit is not just for you on your own but also some of your competitors and collaborators. That makes it tricky to create the benefit side and of course, that also has an impact on the cost side who should bear the burden of that kind of investment since the benefit is scattered around. And on the other hand, also the functionality is also tied into the network part of the technology. So, I mean you'll get very limited functionality out of a really good blockchain solution if you have no one participating in it. I mean, you might have the best solution in the world but now we come out of participation. I will just give you a very simple example of this. I mean, go to cryptocribs.com it is a peer to peer network computing with Airbnb, so you can settle in crypto or field currency and everything is up and running through the platform. I think in Copenhagen there are two apartments that you can rent so it is rather competitive to have Airbnb, even though it might be better or cheaper or whatever. We don't have the scale and the functionality that actually comes out of active participation and that's the crucial part.	CR-CF
85	Researcher	So, how would you rate its impact?	
86	R6	Medium.	CR-CF
87	Researcher	So the last one is legal and compliance. How would you rate its impact on this?	
88	R6	I think that legal and compliance always come late to the party. So, of course, it is slowing something down. People always want clarity on regulation upfront, which will never happen with any technology. But that will always be slow but of course, it is slowing things down and it also requires people to show attention to it. So, I would say it is medium that's the reason why. It will come along if the technology is good enough. So, it will be like that.	CR-LC
89	Researcher	So one follow-up question, just real quick. Some respondents who we conducted interviews with were talking about data ownership and scalability as challenges with the adoption of this technology. What would you say about those two aspects? Are these aspects really posing risks to have this technology in place accurately?	

90	R6	Regarding scalability, yes, people had addressed throughput as an issue, but these people are not testing this out in practical terms. I mean you can redesign or design a use case. There are a lot of use cases we are seeing that don't require throughput that we cannot enable with the ledger so far. So, in my opinion, a lot of excuses and several people not being on top of what is actually possible or designing it in the right way. Data ownership is of course tricky. There are some regulation parts to it. But it is also one of the reasons why I think the ability to have that kind of zero-knowledge proof where you should not reveal all your data but you should prove to others based on your data that you are not lying and you can be trustworthy without having an intermediary to do so. That can resolve some of these issues. But of course, there are things within the data privacy and the right to be forgotten, etc. where legislation needs to follow the ability to do so but we will not see changes in that until we have larger deployments and that will take some years before reaching that point but it will come. I mean look again at Facebook, etc. data privacy was not an upfront concern but something that came afterward. And we will see sort of the same transition there I believe.	OF
91	Researcher	Yes, but regarding the data ownership, the concerns are more revolving around the question that says who will be the data owner of this blockchain network.	
92	R6	Yes, but let's think if it is an open public ledger. Who should actually own it? Who should control it? Who should govern it? Who should take corrective measures if something goes wrong? That's easy if you have an organization to do so. You have jurisdiction, you have someone that you can blame or you could put to responsibility. Of course, this is an issue if we're looking at something that is cross bordered global trade or information or asset exchange. But I think we do see the first sort of announcement of people trying to figure out a way to create a governance that is not biased of just being a single source of one company. I mean, if you should have a look at some of the ones that we think do this the best way. Our look to their hashgraph, they have created sort of a council, so they have different companies joining in the network as council members and these council members are trustworthy organizations from different regions of the world and different industries and all of them are the one deciding on what to do with the network if there is need to do corrective measures so it is sort of setting that we can entitle as presentative democracy	

		phased out of organizations. And they need to participate, they need to do the routing, they can only be there for a limited number of years, and then there is a rotation principle. So you see some of these democratic organizational models being put into play for these global information platforms, sort of the same way that we have on the World Trade Organization that you can elect for people into a nomination then they'll be elected at the point of they would do that for a couple of years then you have a rotation principle to make sure that you can fence off different interests. And we will see the same thing on the ledger's side, that's for sure. But it is still something in the shaping because we are not quite there yet but we see the initial steps of that I think you should look into the democracy literature if you want to have an idea. What they are supposedly doing right now is that most of these organizations and foundations are something that looks like what we had in Ancient Greece in democracy. And I think that will continue, it is only evolution depending on what are the issues and benefits of it.	
93	Researcher	Got it. So, is there any other challenge or risk that you would like to draw our attention to?	
94	R6	No, I think it is fine.	
95	Researcher	One last question. What do you think about our theoretical framework? Do you think that we are covering every or most of the aspects of blockchain and also regarding the sustainability of supply chain management? Are we missing a certain thing which we really need to focus on furthermore?	
96	R6	I think it is fine. I mean, you are entering into the core aspects. Every aspect is something that no one can comprehend so I think what you really just need to do is try to keep to one focus and that's fine for now. There are things outside of your scope but you shouldn't increase your scope. If you want to sharpen it, maybe you will need to narrow it down even further. But that's depending on what you want to achieve. But you shouldn't expand it by any means at all. You have more than enough, in my opinion, just stick with that.	
97	Researcher	Yes, actually we have been trying to address the question of how does the adoption of blockchain technology affect the sustainability aspect of supply chain management. That's why we constructed this kind of an extended interview guide but thanks for your advice, it really adds	

		value to our way of thinking. I think we rested our case. Many thanks for participating in our study, that was a really instructive session all over.	
98	R6	You're welcome. Thank you.	
99	Researcher	Have a good day. Bye.	
100	R6	You too. Bye.	

Appendix 10: Interview Transcript – R7

Company: EY

Interviewee: R7

Job title: Manager - Digital Supply Chain & Blockchain

Interview Type: Zoom Video Call

Duration: 1:44:47

Date and time: 28th of April, 2020

(A-En) - Environmental Aspect of SSCM - Green

(A-Ec) - Economic Aspect of SSCM - Yellow

(A-So) - Social Aspect of SSCM - Blue

(OF) - Other Findings – Red

Line	Person	Text	Category
1	Researcher	Before we start, are we allowed to use your company name, or would you prefer it to be anonymous?	
2	R7	You can share my company name. Let's just say for the record, they are all my views, not EY's views.	
3	Researcher	Definitely, we will put a note on that matter. Ok then, we can start by talking a little bit about your prior experience and background.	
4	R7	I've been in 4 years on the team; I am a founding member of the team. I've traveled all over the world helping hire people in Asia, Europe, and India. I've worked on a number of client engagement proposals, crafting use cases for these clients that actually building software. We'll talk about what EY has built, we'll get to the PowerPoint I sent you in a moment.	

5	Researcher	What prior experience do you have with sustainability or supply chain management?	
6	R7	So, in my first two years in EY, I've spent this part at SAP practice. SAP is one of EY's largest businesses. And a lot of that is working with fortune 500 companies to integrate their supply chains on new SAP implementations. So, in my first two years, I've spent time working through EY with General Motors, Procter and Gamble, Duracell, Berkshire Hathaway, large companies on SAP implementations, a large piece of which was supply chain-related. Now I'm currently undergoing a transition to China Blockchain Team or rather the China Supply Chain Team; digital supply chains are what they call it. So, at EY we see blockchain as being a key future of supply chain. We are making a big bet on it as a technology. We will go into the specifics but that's why I'm going to be sitting in the supply chain team even though my focus is blockchain.	
7	Researcher	So, we already walked through the presentation slides that you sent us. But we can maybe spare 10 minutes to walk it through again all together if you have certain things to share with us. We've already extracted some questions regarding it, but before that maybe you might want to share an overall evaluation on your Blockchain Summit that you conducted within the last week.	
8	R7	Sure… Actually, I don't have any need to go through the slides. I want to do what's best for you. If you guys just want to go through the questions, I want to be valuable to you. Please let me know what would be valuable. My only thought of bringing up the slides is that they provide concrete examples of what EY has worked on that may make it easier to address your questions.	
9	Researcher	Exactly, maybe we can just make use of those as secondary data after all because they seem to be full of information about public, private, and consortium blockchains, together with some real-life use cases. So, I think that will work a treat.	

10	R7	So, perhaps as we go through your questions, I may pull up the slides just to talk about concretely, you know, here is how we can visualize this, that kind of thing.	
11	Researcher	Great! I have seen a list of companies that you have already been engaged with. Are you now capable to practically and fully implement the EY operations chain or EY blockchain analyzer through customer projects?	
12	R7	Yes, absolutely. Those are the 2 sides of the coin of EY is offering. We have an advisory offering, which is us building things for our clients that are on EY OpsChain. That is a full end-to-end supply chain management solution on Blockchain. It is essentially middleware that will sit between enterprise ERPs like SAP, Oracle that kind of things; it is designed to sit between that and the Blockchain as the infrastructure. So, it is going to directly plug into SAP and the client ideally will not have any indication that what they are doing is changing. If we are implementing a Blockchain supply chain solution, the end-user will still enter everything in SAP as normal and our solution will work to integrate the two, so that's OpsChain. And then Blockchain Analyzer is the other side; that's for assurance and visualization of the data. So EY, as an audit company, needs to be able to sign off on our client's work when they start transacting value on the Blockchain. So as soon as they start running supply chain and transacting of an inventory on the Blockchain; EY needs to be able to visualize that data and sign off on it. So, that is where the analyzer comes into play.	BC
13	Researcher	So, we have also encountered something called EY OpsChain Tesseract, which seems to be an integrated mobility platform. I think it can deal with a car using service. I wonder how it handles the payment process, is it through tokens or are transactions being converted into real currencies at the end of that process?	
14	R7	So, correct. OpsChain is the name of the full platform. Tesseract is one module within it. All of the modules have been built over time with a specific client. A client comes to us and says they	

		want to build this… So Tesseract is the piece for asset management. The goal and the vision for Tesseract is when cars are self-driving, right? Wouldn't it be perfect when no one is buying cars anymore? How do GMs and Toyota's of the world make their money? The vision is perhaps to manage a self-driving fleet of cars on a Blockchain. It's going to be like Uber without a centralized party. That is the vision for Tesseract. That one may be a bit ahead of its time but essentially it is for managing assets in a decentralized manner, so you can do that with electric vehicles, smart grids, for example. We've deployed it for farm equipment in Australia. So anytime you have a high-value asset that no one wants to take responsibility for owning, you can actually fractionalize it and own it in a distributed fashion.	
15	Researcher	As we go through the literature, as compared to private blockchains, public blockchains seem to be relatively immature in terms of being adopted by various industries. Regarding public blockchains solely, how does your tool ensure the security concerns in this regard?	
16	R7	Yes, that was the original problem that we faced, that is, all of our competition wants private blockchains, in China especially. The original conversations we had were ''we only want a private blockchain.'' There was some limited work that was done on the public version, for things where privacy wasn't an issue, like tracing wine bottles, that kind of thing. That was done on Ethereum public because it wasn't that big of a deal to have individual bottle traceability on a public blockchain where everybody could see it. That is the big problem; historically, was that public blockchains don't have privacy. Anyway, we at EY, in conjunction with other people in the market, have a partnership with Consensus going right now. But we have also done a lot of the heavy lifting ourselves. We are building the capability to privately transact on public Ethereum. We are building something called Zero-Knowledge Proofs. All sorts of protocols to use to bring privacy to the public main net. Our bet for this is that it is going to be more secure, public blockchains are more secure and they're not controlled by any one party. So, when you use a public blockchain like Hyperledger,	OF

		for example, IBM, even if they're not in the network, they build Hyperledger. With a private blockchain there is a chance for one party to gain undue influence over the network, which is something that no clients of EY, no enterprise would ever want to enter into. This works fine in the short term when Walmart says: "Would you like to join our blockchain?" Because when Walmart asks; they are not really asking; they are saying if you want to conduct with us you must join our blockchain project. That works fine for now but the goal on a public blockchain is for it to be easy for any enterprise to join, reduce the barrier to entry in and reduce the chance for having competitors to take the whole market.	
17	Researcher	Who is going to be the data owner then? Who is going to take over the data governance in public blockchains?	
18	R7	You would maintain control of your own data. But on public Ethereum, it would be the Public Ethereum Community. It would be the Enterprise Ethereum Alliance. It would be the Ethereum Foundation, right? It would be an open-source, that's the vision.	
19	Researcher	When it comes to private blockchains, is it going to cause a problem of data ownership or data governance?	
20	R7	Let me think about that for a moment. I am not too familiar technically with how private blockchains' data governance works.	
21	Researcher	One last question may be, about the Summit. In the slides, we've seen some kind of different terms like PoC for public blockchains, PoS for consensus blockchains, PoW, for public blockchains again. If we want to scrutinize those terms, how would you evaluate those terms like comparisons among them?	
22	R7	PoC is unrelated to the other two. PoC is a stage of a project. So at EY when we were building or in IT when you are conducting an IT project, especially for new technology, you start in what's called PoC, which is where they often refer to it as a conference room pilot, where you're just building the	

		minimum viable product to determine if something is a good idea. So, before General Electric moves all of their HR to a blockchain for their entire global company; they're going to want to build it on one or two machines in an office and determine that the transaction still works. So, the way of this works is starting with PoC; then the next stage is pilot, the pilot is where you add limited external parties so that you add one of two key partners to the solution to test if that works well. And then the next big stage after the pilot is put on production. That's where you're actually using the system for the system of record, where you actually replace the current transaction with the new piece of technology. PoW, PoS are the consensus mechanisms on the blockchain. That's the way that the negotiation takes place to determine which transactions are valid and determined by the blockchain, by the protocol. So, bitcoin is PoW; that's why people were buying all the specialized mining nodes and setting them up in their Tesla's, plugged into the electric grid to most efficiently power their rigs, which is enormously energy inefficient and it was a big problem. Ethereum is migrating from PoW to PoS. PoS is a determination that you are a valid member of the network based on how much crypto you own, how much stake you have in that network. The moral of the story is, depending on the protocol is the way that the consensus is achieved. PoW, PoS, there are others as well as, proof of authority, a whole bunch of others.	
23	Researcher	We also wonder what would you say about whether we are going to see more public blockchain implementations in the supply chain networks than private blockchains?	
24	R7	So, EY says yes. Our competition says maybe; maybe not. IBM is building Hyperledger which is private, and they have done a really good job of selling it so far is PoC then pilot. I mean if you look at any blockchain news is China; it is all private. Because that's the way that Chinese Regulation is particularly attuned to private blockchains. Limited work has been done on public blockchains. There are a few production implementations, which EY has done that I can talk about. And you might be	

		able to find some more if you google. But our view is that in the very near future, there are going to be more projects on public blockchains because of the increases in privacy.	
25	Researcher	So, maybe we can just jump to our overall evaluation questions. The first questions is how can the use of blockchain technology transform supply chains, as compared to the prevalent ERP systems? By asking that, we mean what makes the blockchain architecture attractive to supply chain networks? What would you say about that?	
26	R7	I can say many things about that. So basically, the value of blockchain in a supply chain is creating visibility between parties that currently do not have any visibility. Let me share my screen with you. So, I mentioned that EY does a lot of work in SAP. In today's world, when you perform supply chain operations in an enterprise, the product leaves my warehouse it goes to your logistics company, it goes from your logistics company to a retailer. It passes through many different enterprises. In today's world, it happens all in different IT systems. So, the inventory goes from my SAP into your SAP instance via EDI, electronic data interchange, so its point-to-point. As soon as the inventory leaves my system and it enters yours, I lose track of where it is. I'm not sure if you shift it to the retailer, I'm not sure if you put it in the basement and forgot about it, it is all point-to-point. So, what we envision with the blockchain is using it to share information. What if all of the supply chain parties could read and write, could have a shared ledger of all of the inventory in the network? So that is how we see the transformation of supply chains' visibility throughout.	BC
27	Researcher	The second question can be, does the blockchain universe rely upon more adaptable rules than other supply chain technologies do? If so, what are those rules? This question can be a bit latent, perhaps I need to explain it a little more. The thing is as we know, conventional supply chains are a bit complex and built-in systems, where any change can be really challenging to do because we are just talking about embedded and established systems. So, if we want to integrate blockchain technology into a	

		supply chain network, or if we want to replace it all over from top to toe, is it easily adaptable when it comes to blockchain technology? And one more thing, we've just seen various reports from different sources. One report from Gartner mentions that nearly 85% of blockchain implementation projects within the supply chain have failed or will fail in the near future. What would you say about that?	
28	R7	So, the key in our view is to integrate directly with the ERP. That is we see the best path forward because companies have invested billions of dollars in integrating ERPs. And they are comprehensive, great pieces of software within an organization. Companies are not going to throw away their ERPs just because of some hot new technology, it is not going to happen. So, all of the software that we build; directly integrates with the ERP to make a seamless transition. Basically, with blockchain, we are just trying to get rid of EDI. We are trying to use the blockchain as the infrastructure, but where most of the work actually already happens is going to stay the same. And I would have imagined that the reason many of the blockchain implementations in supply chain fail is for the reasons that are mentioned about private versus public, it is too expensive to onboard parties in a private blockchain. Everybody needs to build their own infrastructure, if every party in the network has to invest 40 to 50 thousand plus dollars to join a blockchain network it is never going to take off. For a successful blockchain implementation on the supply chain, for it to be successful, it needs to be easy to join, easy to maintain, easy to integrate with, cost-effective. So, we see public blockchains doing all that. Getting back to the slides, here is a six-point test that we put together to determine if blockchain has a potential solution for a business problem. Multiple parties, establishing trust, the more parties, and the more complex agreements are between people, that is where blockchains value really comes into play, with the smart contracts, automated logic, that kind of thing. Are we securing the ownership or management of a finite resource? Do all the parties need to work with shared, complex business logic? Does the process depend on an extended business network? Is there enough ROI? Then our test says blockchain is the right solution for you.	BC, OF

29	Researcher	One different question… According to your perspective, which industries are likely to benefit most from the supply chain use case of BC technology?	
30	R7	That's a good question. We are currently putting together our points of view for each sector. We have identified the supply chain as one of the key use cases overall. But to ask for a specific one that would be impacted further to that is hard. Power and utilities, oil and gas, life sciences, manufacturing in automotive, etc. I am not sure if any specific sectors within the supply chain are prioritized.	OF
31	Researcher	Actually, you've already mentioned that but in your opinion, how do you see the future of blockchain technology through the supply chain networks, in the short term, in the middle term, etc. Do you think it is really deployable, is it more than hype to be applied to supply chain networks in the midst term?	
32	R7	In this current moment, it is still in the PoC pilot stage. Companies in the market are testing it to see if it worked. Over the last two years we've done a lot of conversations, companies ask us in to explain what blockchain is. So, it is moved from explaining what blockchain is to… "Okay, I want to try it, let's do something in a very limited PoC way. Okay, this works, let's onboard some partners, make it a pilot, explore it a little further." ... Very limited production use cases… I mean you can look online and see that many of the things that you see published, very few of them are actually in production. So, the industry is still exploring this technology. So, it is hard to say… In the short term, everyone is still testing, but we are betting on the long-term viability with the public blockchain.	CR-IM
33	Researcher	Can we compare the technical aspects of public and private blockchains? As we see, there are certain distinctions. We've already walked through your slides, in which a lot of different explanations were presented and all of them look insightful, but can you just talk a little more about this aspect?	

34	R7	Sure… So, when you integrate with a public blockchain, I mean, when you interact with it, you are interacting with an application built upon it. So if you're running your supply chain on the public Ethereum Blockchain, you would set up a contract between me and you as the manufacturer or the logistics provider, the retailer, we would have a contract that we all interact with on the public Ethereum Blockchain that controls the flow of goods. So, when you receive the product on a certain date, you automatically transfer the money, you automatically pay the invoice. All of this is coded into the contract. In a private network, each person needs to be onboarded separately, everyone needs to build their own infrastructure, and everything needs to be custom created if that makes sense. So, public blockchains would be shared infrastructure, like the internet. And with private blockchains, all need to be built from scratch.	OF
35	Researcher	So, I think we are done with Track 1. Track 2 will be about blockchain characteristics and their correlations with the aspects of sustainable supply chain management. We divided this section into 3 parts, like environmental concerns, economic concerns, and social concerns of SCM. And by saying social concerns, we are referring to both intra-organizational and inter-organizational concerns. As we go through the literature, we have seen several different aspects of blockchain, but we've just summarized six different features of blockchain as a baseline as decentralization, data immutability, transparency, security and integrity of data, smart executions, and last but not least versatility, which will be elaborated furthermore in a bit. Overall, these are the six mainstream characteristics of this technology that we listed. In this track, we are going to start to look for correlations between these features and the environmental aspect of SSCM. To begin with, how can blockchain's decentralized database architecture impact the environmental concerns of a supply chain?	
36	R7	So, I was reading through these questions. My thought is that decentralization and immutability are less important than transparency, the integrity of data, and smart executions. Those are the three	BC-D, BC-I, BC-T, BC-SI, BC-SE, A-En

		big values that I see blockchain having in the supply chain. The rest is less impactful I guess.	
37	Researcher	Could you elaborate your answer a bit more, like explaining your basis for this conclusion?	
38	R7	Sure… Let's talk about examples that can be directly applicable to this discussion. Basically, for all of these companies, for Carrefour, The House of Roosevelt, Canadian Blood Services, Merck; all of these companies we created an inventory visibility application for them. So, Carrefour is sharing some of its products end-to-end from where they are created to the actual retailer. A customer can scan a QR code and determine that a product is real, that it is not expired, and so forth. This can be done for bottles of wines or Carrefour. Canadian Blood Services, they want to create visibility between all of the parties and their chain to more efficiently manage the flow of blood. Because it is a valuable resource. So these systems were designed to create visibility between all the parties and have product traceability. So, a user can scan a QR Code and determine certain things about that product. Those were the reasons that this product (i.e., inventory visibility application of EY) was created. So, if we address your question of decentralized database architecture, that is not one of the reasons that blockchain was implemented in this case. Blockchain wasn't selected because it is decentralized; it was selected because it solved the problem of transparency and traceability. Does that make sense?	BC, BC-D, BC-T
39	Researcher	Yes, it totally makes sense. But when it comes to the environmental concerns, energy conservation, recycling, waste management, any kind of greening activities, etc. you are saying decentralization and immutability have nothing to do with the environmental concerns of a supply chain, is that right?	

40	R7	Right. Up until this point, I would say it is even worse. Like if you talk about Bitcoin, if you talk about Ethereum with PoW, if you remember we talked about the consensus mechanism, how it burns an extraordinary amount of energy, I would say up until this point it has been poor for the environment. But we hope that will change in the very near future.	BC-D, A-En
41	Researcher	Is it because of the high computational power capacity and high levels of energy consumption that the technology requires, right?	
42	R7	Exactly. The way to transact on the blockchain historically has been doing the work, has been solving math problems, expending computing power. And that's been enormously energy inefficient.	BC-D, BC-I, A-En
43	Researcher	And the last one was versatility. It might be a bit latent, perhaps I need to go into a little detail with it. As we reviewed the literature, blockchain has four different versions in evolution through the test of time. The first one is Blockchain 1.0, which stands for the introduction of Bitcoin, Blockchain 2.0 refers to the use of smart contracts. Blockchain 3.0 stands for the potential of blockchain to be used in the industry and some industrial use cases. Blockchain 4.0 is more like the capability of blockchain to be integrated with some kind of other disruptive and ever-evolving technologies AI, machine learning, deep learning, augmented analytics, IoT, so on and so forth. So, that's why the literature calls this aspect of blockchain as versatility. Regarding this, how can versatility of blockchain impact the environmental concerns of a supply chain? Do you think they are correlated somehow?	
44	R7	I would say if you define it that way, we are currently migrating between 2.0 and 3.0.. Functionality is currently being built to enable enterprise usage. Privacy has been the limiting factor up until this point. When you talk about Ethereum, everyone talks about scalability. They say the scaling problem, that is how they refer to it, which is how do you increase the transaction throughput with decentralized architecture, but what people haven't talked about is privacy. The	BC-V, A-En, OF

		scaling should not be a problem with the methods that they are using. They're doing things like storing data OpsChain, and there was another word that they use, something like charting, where they split the data sets into different pieces and store them throughout the network. The scaling we don't see being a problem in the very near future. The privacy was the real limiting factor. I don't see versatility being a key metric for supply chains.	
45	Researcher	So, we got your point clearly, but on a 3-point scale like low-medium-high, how would you attribute the level of correlation with the environmental concerns if we do it one by one. Let us start with decentralization.	
46	R7	Low.	BC-D, A-En
47	Researcher	And with data immutability?	
48	R7	Medium.	BC-I, A-En
49	Researchers	Transparency?	
50	R7	High.	BC-T, A-En
51	Researcher	Security and the integrity of data?	
52	R7	High.	BC-SI, A-En
53	Researcher	Smart executions?	
54	R7	High.	BC-SE, A-En
55	Researcher	Versatility?	
56	R7	Low.	BC-V, A-En
57	R7	Let me think about that again for a second… Sustainable supply chains… So would one target of that being things like fair trade coffee, fair trade foods, responsible fishing, and farming, so if we want to talk about environmental concerns or that's	BC-I, A-En

		what I would call an environmental concern perhaps, I would say immutability is high because in those use cases immutability is key. The fact that when I create a product and I stamp it and I tokenize it on the blockchain and I ship it to the next person… The immutability between each party showing that each party received it and created some action upon it, that future is key for environmental supply chain use cases.	
58	Researcher	Okay, that makes more sense right now. So, in this case, are u going to stick to your answer with decentralization, or is it still low?	
59	R7	Yes, the same thing.	BC-D, A-En
60	Researcher	So, by following the same logic we can start looking for correlations between these BC characteristics and the economic concerns of a sustainable supply chain, like profit or revenue generation, cash flow management, etc.?	
61	R7	For decentralization, I would say low. For immutability, I think it is medium. For transparency, definitely, it is high to my perspective. Security and the integrity of data is the basis for the adoption of this technology I could tell, so it is high. And for smart executions, again I would say high. And the last one, versatility, again it is low as is the case with the environmental concerns.	BC-D, BC-I, BC-T, BC-SI, BC-SE, BC-V, A-Ec
62	Researcher	And could you just elaborate on your answers a bit more, like why are you thinking that way? Let's start with decentralization in this case.	
63	R7	I would say low because decentralization is mainly the way that this technology works. It does not in my eyes, provide any intrinsic value, just the fact that it is decentralized. I mean it makes it more secure, immune to hacking but these are not economic concerns.	BC-D, A-Ec
64	Researcher	How about data immutability?	
65	R7	I would say again it is not the highest, medium is a stretch. Immutability again is part of the way the technology functions in a decentralized way, it makes the system hard to hack because everyone	BC-I, A-Ec

		maintains a copy and the record builds upon itself. I do not see it as having a lot of economic value in and of itself.	
66	Researcher	But your initial response was there would be a medium impact by immutability, so are you going to stick with that answer on this one? Why are you saying medium then, why it is not low if there is no apparent correlation?	
67	R7	Yes, I am happy to talk through this, but I am not really sure why I said medium in the first place, perhaps low is a better answer.	BC-I, A-Ec
68	Researcher	So, maybe we need to just change it to low then. The next one is transparency. How would you amplify your reasoning regarding the potential impact of transparency on the economic concerns of SSCM?	
69	R7	This is the easy one. So, I work in the supply chain, the majority of EY's clients are concerned with their supply chain, how blockchain will help them manage their supply chains. The reason that our clients choose blockchain over any other competing services in the market is that it provides transparency between supply chain partners. That is where the money is, that is where the value is. That is why they would choose blockchain over something else. So, that is why transparency in my view has the highest possible value.	BC-T, A-Ec
70	Researcher	Could you just present one example regarding the economic concerns and its relationship with transparency and its use in practical manners?	
71	R7	Sure, so, we have done a number of implementations for production setups with major companies. Let's just take for example Schneider Logistics in the US, which is a major transportation logistics company and they ship packages around the US, and they interface with tons of third-party logistics companies, and the issue that they had was visibility in their supply chain. So, as soon as they had a package that left their SAP system, that left their facilities and went on to a third party logistics provider, then they lost sight of it, they could not tell if it was delivered or where it was. So, they used blockchain to connect these disparate ERPs and it provided high value because now they can	BC-T, A-Ec

		see end-to-end where a package is in the supply chain.	
72	Researcher	So, what about the security and integrity of data? What would you say about its potential impacts on the economic concerns of supply chains?	
73	R7	I think it goes hand in hand with transparency, it provides a guarantee that, as I said a package is where you say it is, a piece of inventory is where you say it is. The transparency is enabled by the integrity of data. Everyone is operating off of the same ledger and therefore, you can guarantee the integrity of that data. That is a high value.	BC-SI, A-Ec
74	Researcher	The fifth one is smart executions, what would you say about that?	
75	R7	High as well because one of blockchain's key values over competing products in the market is their ability to automate the logic between parties. Let me give you an example regarding this… For a major consumer product company, which is a global consumer company that you have probably heard of but I cannot say their name because they have not gone public with their, whatever… We built them a procurement system. So, procurement is one of the biggest processes that we see ripe for blockchain transformation because procurement is the way that most manufacturing companies interface with other companies. So, they had an issue managing hundreds of different suppliers that provide them goods, they integrated volume-based purchase agreements. So, this global product company has hundreds of contract manufacturers or ordering of negotiated purchase agreements that they negotiated. If a group has hit a certain amount of purchasing, then the price of the goods should go down, the price of the supply should go down. Are you following what that process looks like?	BC-SE, A-Ec
76	Researcher	Yes, we are.	
77	R7	So, in the original scenario, there is no way for them to keep track of how much is purchased because that is all information these contract manufacturers do not want to share among themselves. In the current environment, it is all in their internal ERPs. So, at the end of the month, or	BC-SE, A-Ec

		realistically, at the end of the quarter, this global company in the middle has to go back over every single purchase order to tally up all of the purchases to make sure that they hit their volume agreements, and then readjust prices. And realistically, that would never happen because you cannot go back and change purchase orders after the fact without causing all sorts of drama.	
78	Researcher	And of course, there is a purpose for the audit to keep track of every record backward, right? So, if you have smart executions automated through the system, that means the data would be immutably recorded into the blockchains. So, there is no point to have it on different ERPs to reach out to that. So, that is my understanding from your point.	
79	R7	Yes, but the value is that we took those booked purchase orders and digitized them into smart contracts. Now, the entire process takes place through a smart contract, the smart contract maintains the record of all the purchase orders, and it does all the executions automatically. So, enormous value there and it is entirely because of the smart execution function of the blockchain.	BC-SE, A-Ec
80	Researcher	And that is somehow correlated to economic concerns because it just eliminates the tremendous amount of workload or some kind of data loss, maybe?	
81	R7	Data loss, disagreements, hundreds of people, thousands of man-hours required in reconciling the data at the end of the quarter.	BC-SE, A-Ec
82	Researcher	Got it. The last one is versatility. Do you recall how we define versatility, or should I just recall once more?	
83	R7	I would like you to recall it.	
84	Researcher	The thing is as we go through the literature, we see the evolution of blockchain within time, starting from blockchain 1.0 and the way to blockchain 4.0. BC 1.0 stands for the introduction of bitcoin and BC 2.0 refers to the use of smart contracts, BC 3.0 is just the use of blockchain technology for industrial use cases and lastly, BC 4.0 is the possibility of the blockchain to be integrated with	

		some kind of different disruptive technologies like Artificial Intelligence, Machine Learning, Deep Learning or Augmented Analytics, etc. When we think about this evolution period of blockchain through the test of time, we are just calling it the versatile aspect or nature of blockchain technology. So, how do you correlate the versatile aspect of blockchain on the economic concerns of sustainable supply chains?	
85	R7	What are we now? We are in 2.0?	
86	Researcher	Your initial response was that we were in the middle of 2.0 and 3.0.	
87	R7	And your question about versatility is the fact that it can move through those phases?	
88	Researcher	Yes, and also considering the potential of Blockchain 4.0 which is the integration of this technology with the other upcoming or acclaimed disruptive technologies. We are calling it versatile since it seems to be integratable with IoT, Artificial Intelligence, etc. Just using Blockchain as the front-end technology on the top of everything, do you think that this aspect is correlated to the economic concerns somehow?	
89	R7	Let me think about that for a second. I and my team, I do not think I have seen anything to indicate AI and integration of IoT. I do not see the versatility of being a high economic value of blockchain, at least at this point.	BC-V, A-Ec
90	Researcher	Because of the immaturity of the technology itself or something else?	
91	R7	Yes, I do not think we are close enough to determine the impact of AI and blockchain together. It has not been done.	BC-V, A-Ec,
92	Researchers	Next, we have social concerns. And by saying social, we are referring to the organizational concerns, both intra-organizational and inter-organizational issues that can be taken into account when it comes to the social aspects of sustainability through the supply chains. Let's start with decentralization again.	

93	R7	If we can talk about this high level for a moment, I feel like what blockchains do in creating visibility and transparency between parties, a lot of what the goal is automation within and between enterprises. So, a transaction that currently happens via paper, an email, an excel, and phone calls, you can automate that logic between parties. What is the social concern of that? It gets rid of manual jobs, which is something that people do not want to talk about but that is realistically what is happening. And hopefully creating smoother communication in these processes because you are automating it, instead of email or phone call or an excel it just happens. So, with that in mind the social concerns I would say are better across the board because we are getting rid of a lot of the social interaction.	BC, A-So
94	Researchers	Then, what would you say about the level of correlation between decentralization and economic concerns?	
95	R7	Again, I don't see that being a key future. The decentralized database is a fact but not a motive to prefer this technology. Companies would not choose blockchain because it is decentralized. That is just how it works.	BC-D, A-So
96	Researchers	Yes, but when it comes to the use cases of blockchain by different stakeholders, isn't it a factor that affects the social aspect, like making the sharing of information transparent for each party? I mean when the clients have all the information about what's going on through the whole supply chain network, even any detail all the way up to the origin of a product, may that be a kind of a problem for the other stakeholders such as sets of suppliers, retailers, especially from the standpoint of financial competition in the market because clients can have higher flexibility to select and regulate whom to work with, which is okay but also this situation can boost the competition to a level of inequality by sweeping most of the players in the market, maybe…	
97	R7	Oh, I see what you are saying. I see it and I believe that makes a lot of sense. Not right now but in the future, the vision is there would be more competition we'll see. Facebooks, Googles,	BC-D, A-So

		Airbnbs, and Ubers of the world… They are monopolies. They can argue that they are not, but they are. Because their sole purpose for existence is managing user's data. They are the intermediary that makes the transaction happen. Airbnb is the largest hotel company in the world. They don't own any hotels. Uber is the largest taxi company; they don't own any taxis. Their sole function is to be an intermediary. We see blockchain creating distributed systems; you can create these business processes, without the intermediary who gains undue control over the network. Since we are talking about social impact, I now agree with you. So, the decentralized database is high for social impact, for the reasons I've just said.	
98	Researchers	What about data immutability?	
99	R7	Medium.	BC-I, A-So
100	Researchers	Isn't it kind of thing that can be evaluated as both pros and cons. Data is immutable, that means data is traceable and you can track all the transactions on a time-stamped basis. On the other hand, you are going to keep any type of information in the chain even if the information is erroneous. Either way, the network would be full of redundant information, right? In this regard, would it be a trade-off?	
101	R7	So, that's why solution design at the beginning is really important. One of the things that EY is building, we are talking about privacy for which we build protocols called Baseline, which you can google. It is brand new. We just announced two weeks ago, which was the formal announcement. It allows private transactions on public Ethereum. But one of the key features is you're not actually storing any data on the blockchain itself. The protocol allows the transaction to happen. What you are writing to the blockchain is the proof that a transaction took place, instead of actually this inventory being sold to x person on x date. All you are doing is putting the proof on the blockchain. So, we envision a future where that is not a problem, where having too much data written to the blockchain is not a problem.	BC-I, A-So

102	Researchers	So, will scalability not be a problem sooner or later?	
103	R7	What I was just talking about was having sensitive extraneous data on the blockchain.	
104	Researchers	Yes, I mean the other thing is, we've just seen several comments on the problems with scalability and throughput. For instance, several scholars draw attention to the fact that VISA, for example, has the capability to handle the transactions at an incomparably higher pace, whereas blockchain has not that qualification. What would you say about that?	
105	R7	Many things to say about this. So private blockchains have primarily figured this out. You can have high throughput in a private blockchain because the consensus mechanism is more constrained. It is a lot easier to achieve consensus if it is just the four of us. If it is the four of us, plus Walmart in a blockchain, five parties, it is very easy for us to vote and determine if transactions are valid. Also, it is very easy to determine that they are valid because everybody is invited to the network, everyone is a trusted party. Where it gets complicated is with public blockchains like Bitcoin and Ethereum where you have unverified parties as part of the network. That's what causes the scalability transaction throughput issue, it is the scale of the network with the untrusted parties. So private blockchains have already been able to create high transaction throughput. Public blockchains we see being able to accommodate this in the near future for a number of reasons, technological improvements that they are working on, as we talked about earlier, with the charting and others. They have a whole plan for increasing transactions and also batching, which is putting more transactions into a single block. And then, things that EY is working on, I have just mentioned baseline, where you are not actually storing the data, but the proof. Another feature of that same protocol is batching of transactions. So, instead of doing one transaction at a time, creating the proof, writing the proof to the chain, originally that was every transaction had to go through it but now we batch them together, we can put up to between 40	BC-SE, OF

		and 50 transactions all through that same proof. So, you are doing 40 to 50 transactions at a time. Will it hit this level of throughput? Not right now. And we argue that it is not a problem because enterprises today take days to process a transaction. If I am shipping you a container, that involves invoices, then involves inventory transfer, it takes days to do things in today's enterprise environment. If you can automate it with a smart contract, and it takes 15 minutes, let's just say, to have a transaction execute, then it is still way faster than the current environment. So, what does it matter if it takes 15 minutes to write if you are removing 3 to 5 days of wait time? And also, VISA payments are not a good use case for blockchain. Everyone talks about as if blockchain is going to replace credit card companies, it is not because payments are simple. Going back to our criteria of what makes it to a good blockchain use case. Multiple parties and complex transactions… Credit cards are neither of those things. It is two parties with simple transactions and they already have an established mechanism that works. When CIOs decide to implement technology, it needs to be an order of magnitude more efficient for them to invest the time and take on the risk to implement an IT project and so payments just don't have that but other use cases do. When you are shaving days off of processes, that's where it is targeting.	
106	Researcher	So, let's talk about transparency. How would you rate the impact of transparency on the social concerns of sustainable supply chains?	
107	R7	High. So, you can say it is guaranteed that the fish is going to be caught in an ethical manner.	BC-T, A-So
108	Researcher	Next, we have security and integrity of data in this respect?	
109	R7	High. Because it is simple, you can prove that a certain product is legitimate, etc.	BC-SI, A-So
110	Researcher	And smart executions?	

111	R7	I would say medium here. I am not sure that smart executions have a direct impact on social implications, do you think the other way around? But if you want to say that it makes employees' lives easier by making their processes easier to facilitate, then surely the impact is high!	BC-SE, A-So
112	Researcher	And versatility, which is the last one here?	
113	R7	Low again.	BC-V, A-So
114	Researcher	So, before moving onto the last track, is there any other aspect of SSCM or blockchain characteristics that you would like to point out?	
115	R7	No, I don't think so. I think your guide covers it.	
116	Researcher	So, do you think that the blockchain characteristics we listed cover the essential features of blockchain?	
117	R7	Yes, as I mentioned before, transparency, data integrity, smart executions are the keys.	BC
118	Researcher	One last question before we go into Track 3. If we ask how would you rank the impacts by blockchain on the aspects of SSCM if we recall them again like environmental, economic, and social aspects, what could you say about this?	
119	R7	So, as a supply chain consultant, I have clients who are implementing these projects, so my goal is to save them money that's both my job and their job. That's all they care about. The primary thing is cost reduction, everything else is a bonus. So, number one is economic concerns because if it doesn't make any financial sense, it is not going to happen! I would say social and environmental are tied for second place. But at the end of the day, it really comes down to economics.	BC, A-En, A-Ec, A-So
120	Researcher	One follow-up question. In the absence of blockchain technology, are there any alternatives or a combination of other technologies that can replace blockchain technology in terms of delivering the same capabilities?	

121	R7	There is certainly a list of technologies that can solve some of these problems, but not all of them. Let me give you an example. A conversation that we have frequently is, if a company is already on Ariba, which is owned by SAP, it is the way that procurement is done. We are a big believer in blockchain for procurement, we see that as a big use case. If a client is already pre configured on Ariba or a similar procurement system, we are all of their procurement parties that are already integrated into one system. It is centralized but it gets the job done. We talked before about the value, meaning if it is not a super-high impact value, there is no integration of blockchain necessary. If you have a procurement system that works, you are not going to throw it out for a new technology. Another one is intercompany finance which is another big problem that enterprises face, it is a challenge of moving money between entities within a corporation. I'll give you an example. EY is a firm of firms. So, the US firm is a separate financial entity than the China firm, the UK firm, the Swedish firm, they are all separate financial entities. If we want to transfer money between parties, it has to actually go through banks, which takes 3 to 5 days. However, you can have an intercompany system, which is a centralized way to control payments within global organizations. The moral of the story is, if a company is already integrated into one of these systems, then you know, that could work.	OF
122	Researcher	So, the last part of our interview guide is about challenges and risks with the adoption of BC technology. Here we've listed six main challenges but there might be some more which you might want to add after all. The first one immaturity of BC, consisting of cybersecurity problems, throughput, latency, etc. What would you say about its impact as a challenge to the adoption of blockchain technology?	
123	R7	Just to reiterate, since we have already talked about it quite a bit. Historically, transaction throughput/scaling and privacy have been a part of the primary problem for adoption, and of course technical issues, but you can collect all of them under one title like immaturity of the technology itself. So, these are the core issues that create real	CR, OF

		barriers. It is too expensive to implement because of throughput and privacy. It is more costly to implement based on these issues.	
124	Researcher	How would you rate the immaturity of blockchain on the adoption of BC technology?	
125	R7	We are currently at medium impact with this one. The tools are currently being designed and implemented to make blockchains mature enough for implementation, but we are not there yet!	CR-IM
126	Researcher	What would be your standpoint on the second one, which is the lack of awareness and technical competence?	
127	R7	Not very high. Two years ago, I would have said awareness was a problem, but most people are familiar with what it is now, and they are familiar with its core problems, which are privacy and scaling. I would say low for its impact as a challenge, not a big problem as of now. When CIOs or supply chain officers ask us to meet with them, they are familiar with what blockchain is because they have read about it. Our market is educated on this topic.	CR, CR-AWC, OF
128	Researcher	So, the third one is organizational collaboration, and recall that upper management involvement is also attached to this. What would you say about this as a challenge?	
129		This is a really good question. Really good. One of the key problems in implementing a blockchain system is getting everybody to agree on the rules of the process. By implementing a blockchain process, you are sometimes removing power from somebody in the process. You are making it easier for everybody to transact. I would say organizational collaboration is a problem, but I would say its impact is medium because public blockchains have solved the problem of one party gaining too much power. That's one of the issues that enterprises face when they say: "Okay, this business process is definitely a fit for blockchain." But in a private blockchain, there would be a potential for one party to gain power, which is not something that we want to do. It has been a problem, but with public blockchains, we think it in the future would be less of a problem.	CR-OC

130	Researcher	So next, we have change management. What do you think about its impact?	
131	R7	Medium. Just because you have to get all the parties in a room to agree.	CR-CM
132	Researcher	And the fifth one is cost and functionality, which might be a little tricky because cost seems to be a natural part of it, however, by calculating ROI which was also included in your list of business requirements to implement blockchain if it is a rightful use case…	
133	R7	If we are talking strictly about technical implementation cost, it has been high, but it is decreasing significantly every year. It will decrease further with public blockchains. But the cost that you are saving by the automation of processes is high.	CR-CF
134	Researcher	What about functionality, meaning efficiency, and effectiveness as a combined key performance indicator?	
135	R7	The goal is for this to be low. That's why I said earlier, all of our solutions integrate with the SAP and other ERPs, the goal is for blockchain's functionality to be seamless for the end-users to continue doing their job, to continue entering the invoices. The bottom line is Blockchain is a back-end technology, so I would say low. But the impact of cost is now medium, but soon to be low. What confuses me is, are we comparing this with a standard IT implementation or another kind of IT implementation?	CR-CF
136	Researcher	Yes, we could interpret it that way because the literature shows us the challenges and risks like change management, immaturity, investment cost, etc. are kinds of problems that are in common when it comes to the adoption of almost all disruptive technologies.	
137	R7	Again, I would say medium because you still have to bill the integration with the ERP, although you are saving money. It is still something new, you still have to build integrations with current systems.	CR-CF
138	Researcher	So, you were saying medium for cost and functionality.	

139	R7	Yes, medium.	CR-CF
140	Researcher	So, the last one is legal and compliance, which seems to be significantly involved as a challenge according to the literature. But how do you attribute it?	
141	R7	It has been a wall, a blocker, especially in China. So, one of my jobs over the last year has been identifying what you are actually allowed to put on the blockchain in China. China has all sorts of data privacy rules. Certain data in a database cannot leave the country, it needs to be on servers, on-prem in China, that kind of thing. I'm sure you guys are relatively familiar with how crazy the censorship was. But this is a big problem for enterprises because most of them have IT in China so they have to figure out a way to overcome it. The legal and compliance has been a big problem to implement the technology because it hasn't been clear what they are allowed to transact/store in China or in other red box countries. So, it has been a high impact but as countries come around to the blockchain idea… For example, many banks are implementing CBDCs (i.e., Central Bank Digital Currencies), meaning a lot of the governments of the world are coming around the blockchain and issuing the regulation. So again, it has been high, but I would say we are moving toward medium, so to say.	CR-LC
142	Researcher	So, is there any other challenge or risk that you can suggest to us to think of?	
143	R7	An important point on the legal and compliance issue, blockchain will make legal and compliance easier. Once it is implemented, the data integrity, the automation of the transaction execution, these things will make legal and compliance easier because it is automated. You are removing humans and risk from the process.	BC, CR-LC
144	Researcher	We're nearly done but one quick question. Most of the respondents that we conducted this interview with were talking about data ownership and scalability as the utmost challenges to draw attention to when we talk about this blockchain	

		technology. Would you agree on that or do you have any further thoughts on this?	
145	R7	Okay. So, I disagree with those. First off, data ownership is the whole reason you chose blockchain because there is no centralized data owner at least in a public blockchain scenario. So, the other people you interviewed were probably talking about private blockchains where that is often an issue.	OF, CR
146	Researcher	Yes, the thing is you know they were mostly talking about private blockchains because public blockchains seem to be a bit immature to be used in the private sector for industrial use cases. Let's think that there is the main company and they have like three different suppliers, like tier one, tier two, tier three. So, there would be a central company and they would give some kind of business to those companies in order to extract some more capacity and they would be the one, in that scenario, having the data ownership. This is an interpretation of its use for private blockchains as you would appreciate, and we have already covered that. On the other hand, if someone wants to apply public blockchains on this medium, who will be the data owner in this case?	
147	R7	Okay, let me tell you a bit about the latest developments in public blockchains and this has come about in the last few months. EY recently released Baseline, it is a protocol for enabling private transactions on public Ethereum and one of the key components there is the concept of zero-knowledge proof. So, you are taking a proof that a transaction has happened, and you are putting it on the blockchain instead of actual transaction data.	OF
148	Researcher	Do you mean that this is the difference between sharing the information and sharing the data itself?	
149	R7	Exactly right! So, in the world that we see coming, in a very near future, there will be no private data on the blockchain, it will all be proofs of transactions taking place.	OF

150	Researcher	Does that build trust between stakeholders?	
151	R7	Yes, and then there is no data ownership issue. So, private or public, if you are putting private data on that chain, that is a security issue because who is to prove that a blockchain is 100 percent secure now or within a few years? I mean all of the systems in today's world have proven that they can be hacked, so any additional information that you put on the blockchain, private or public is an additional security risk. So, we envision not doing that, just putting proofs.	OF, CR
152	Researcher	And scalability, what do you think about that as a challenge?	
153	R7	So, as I told you earlier, scalability is rapidly becoming less of a problem, particularly because in order to do these proofs on public chains, you can actually batch transactions together. So, they are becoming faster and cheaper to perform. So, by scalability, if you include it within the transaction throughput, it is not much of a problem anymore, especially for EY's clients. That is in today's world, the business process that most companies use is about days. If you have to manually complete a contract, get signatures, get approvals, send it out, email it out, right? Any manual process is measured in days, if any part of that process can be automated by a smart contract, it does not matter if it takes 5 seconds like Visa or if it takes 15 minutes because you are still taking it from days to minutes. We do not see scalability as a bigger problem, the biggest problem we've seen is privacy which most people do not talk about. But that is what we'll see being solved in the very near future, through the use of zero-knowledge proof mechanism if we recall.	OF, CR
154	Researcher	With the public or private blockchain or both of them?	
155	R7	For private blockchain, you can enable privacy, but we see that happening on public blockchains in the very near future.	OF

156	Researcher	Got it. Do you think that our framework covers each and every challenge and risk associated with the adoption of BC technology? Is there any other aspect that you can recommend us to consider?	
157	R7	Yes, I can't think of anything you are missing.	
158	Researcher	Overall, what do you think about the inclusiveness of our framework and interview guide? Does it look right on the target or are we missing anything to your perspective?	
159	R7	I don't see anything that definitely you are missing. If I can ask what your thesis is, have you decided on that yet?	
160	Researcher	Yes, actually it is about the potential use of blockchain technology for the sake of a sustainable supply chain. But as we go through the literature it seems to us a bit lopsided in evaluation, meaning most studies are either talking about benefits and the utmost importance of some kind of use cases through various industries; or placing it on the top of the hype curve by emphasizing the dark shadow with challenges. But the thing is, our goal is to conduct this study double-sided, investigating benefits, together with challenges and risks at the same time. Maybe we can lay a little emphasis on the critical success factors for adopting blockchain in the correct way through the supply chain networks. That's why in the end, we are just trying to seek an answer to the question that is blockchain more than hype for sustainable supply chains? That's the point we are theoretically striving to reach out to.	

161	R7	I get it. I think this is important. I think in the next one to two years, we are going to have a solid answer for this. The reason I say that is because everybody is waking up to the fact this can be used in the production environment. Look at China. China is rolling out the largest network ever created. It is already in 100 cities. They are rolling out 40 more. The entire country of 1.5 billion people is going to be able to transact on a blockchain this year. If blockchains are now hype, if they have real value for the whole economy, we are going to find out within this year or two to three years in China. It is what happens in China but also the integration with the global ecosystem. The global ecosystem is more open and more amenable to public blockchains. And just one last thing… If we take a look at the slide where we talk about the use cases and the pillars of the EY OpsChain platform, I think one of the answers to your question is, it depends on the use case. First off, supply chains, with procurement and logistics is the backbone of economic issues. Companies are doing this for transparency and automation, which means they are doing it for economics. The second one is Traceability, which is more socially oriented because it is about customers verifying the legitimacy of a product. The third one is Tesseract Asset Management**,** which is all of them, including the sharing of an electric vehicle, this is environmental, social, and economic as well. Intercompany is about economic, social, but not really environmental at all! Fourth is Public Finance Manager**,** which is a big one, that is being used by governments right now. This year we are doing a project for the city of Toronto to track funds from the top of governments all the way down to the individual departments that handle money. You might know that corruption is a problem because leaders within governments acquire funds and use them on shady things. Governments are adopting blockchain for public finance to remove corruption. In this use case, it would be social and economic, more so than environmental. The fifth one is Contract Manager, which is the Microsoft Royalty Case. In today's world, whenever you buy an Xbox game online or in the store, all of those purchases are reported to Microsoft. Microsoft takes all those purchases and	A-En, A-Ec, A-So, OF

		determines what contract that belongs to. If you buy a video game in Sweden today, and I buy it in New York on Black Friday or next month, it is a different price with a different contract that determines what all of the parties will get paid. So, the video game, the graphic designer, the audio engineer, the retail store… All of them need a percentage of that price triggered by a different contract. Anyway, Microsoft finds itself in the position of doing all the heavy lifting of maintaining all these paper contracts and paying everybody in the chain. So, we built Contract Manager for Microsoft, which created 99% less time needed to calculate rights and royalties owed and 40% less cost.	
162	Researcher	Is this a joint venture?	
163	R7	EY built this platform for Microsoft. We partnered with Microsoft to make sure that Azure was properly figured to support the system. For **Contract Manager**, this would be economic, social, but not really environmental. And then finally, **Tax Engine**… The same thing, this is about calculating taxes on all of these transactions. That would be economical and social, but not environmental. I hope that was helpful?	BC, A-En, A-Ec, A-So
164	Researcher	That was great! Is there anything else that you would like to add before ending the interview?	
165	R7	Not really.	
166	Researcher	Seriously, thanks a ton. Your generosity and collaboration on this one are gratefully appreciated. The session was full of fruitful information that we can make use of we could tell. Would it work for you if we get back to you for anything to be clarified or if any other question arises, through mails maybe?	
167	R7	Sure… Let me know if you need anything I can help anymore.	
168	Researcher	Thanks. And would you like us to send a copy of our study before it is published?	

169	R7	Not for review, I don’t think so, but I would like to read it. Good luck to you guys.	
170	Researcher	Thanks a lot indeed. Bye.	

Appendix 11: Interview Transcript – R8

Company: Empirica

Interviewee: R8

Job title: CEO, Blockchain Lead – Consultancy to Arla Foods

Interview Type: Zoom Audio Call

Duration: 1:56:13

Date and time: 30th of April, 2020

(A-En) - Environmental Aspect of SSCM - Green

(A-Ec) - Economic Aspect of SSCM - Yellow

(A-So) - Social Aspect of SSCM - Blue

(OF) - Other Findings – Red

Line	Person	Text	Category
1	Researcher	Are we allowed to use your company title, or you would prefer it to be anonymous?	
2	R8	You can use my company title. Not a problem.	
3	Researcher	Great. Maybe we can start by asking what prior experience do you have in blockchain, supply chain management, or sustainability agenda?	
4	R8	In the traditional world, I have more than twenty years of experience as a consultant. I have worked across cases involving the use of more traditional ERPs at different supply chain and asset management solutions. For example, I was there for the Sydney Olympics, when they designed a solution for the Olympic village that had a sort of supply chain solution of how they would manage supplies for the athletes. It was a custom solution, not the traditional STM (i.e., software transactional memory) system. For sustainability, my experience mostly covered client work as a consultant or as a contributor to the	

		projecting. Sustainability being on the rise, this experience is being more reasoned. There have been projects with Nokia mobile phones, known for sustainability actions, and later with the food industry about some sustainability practices, which are not often even communicated outside the company. For blockchains, I have had a lot of different works, mostly I can tell on what the blockchains are really good for, and that's, of course, the fintech side of things… Also, we have been developing our own products for using blockchains for supply chain management. This is something that we have done domestically in Finland, but also outside of Finland. The greatest demand is in the USA and Indonesia. I have a company providing some food industry and blockchain implementation projects with consultancy services.	
5	Researcher	How can the use of blockchain technology transform supply chains as compared to prevalent ERP systems? In other words, what makes the blockchain architecture attractive to supply chains? The reason for asking this question is: conventional supply chains seem to be more complex and built-in systems through the existing networks. If we want to employ blockchain technology through supply chain networks, how do you compare the transformative nature of blockchain technology within the supply chain?	
6	R8	There are a lot of different views and misconceptions about that topic. I see blockchain technology as a foundational technology, that is, it is not a solution, but it is an enabler for you to build something on the top of it to achieve something better than what we have today. So the ERP systems have been around quite some time, and they are mostly built around some way or the old way of doing things. Depending on the size of the company, it is mostly about building gear for their portion of the entire supply chain, and it is mostly about knowing one leg ahead and one leg behind, apart from knowing the details of their operations. That is enough for them. This is sometimes causing problems when you have to recall, you know that it depends on which part of the entire chain you are in. For example, in the case of retail, it is hardly likely that you are the one executing the recall on your own, but it is the information that someone finds out that they supplied you with the goods that need to be recalled. It is highly inefficient. It is mostly not that these systems and the other systems could not be changed to work differently, the reason that they are working as they are is that this is	BC

		the way that they have been designed, and that is the way they have been working for years. I think the world has been waking up to evaluate their past operations and see that there is a need to change to be more effective. For example, now, it is not the case that you build a massive warehouse to stock things, and hope that people would buy, but it is more likely that you want to pass that burden to your suppliers, and your suppliers will pass the burden to their suppliers. So essentially, it is the producers having the stock and transforming their operations to something that if they can get an order, then they produce and ship products that are ordered without carrying any stock. And of course, the globalization of things affects the behavior of not having physical stock, but having goods on the demand, which is more efficient, therefore, it would help you to know the inventory of your suppliers. And since your supplier does not necessarily carry the stock, you need to see beyond that, meaning the supplier of your supplier or the producer. You really understand the concept while operating; for instance, if I sell the stock existing in the hand, how long it will take for me to get a refill. The same thing happens in the construction business as well, despite their saying that there is a trust, relying upon their contracts it is not working like this. The supplier uses the subcontractor to produce something or buy something that they need, and there is this bullwhip effect that they experience when people are not honest or cannot live up to the expectations. This is the problem with raw materials: a delay in the early chain may end up with a huge delay in the end, or a late arrival of something could stop the construction of vessels for months. So, it is a matter of trust. Additionally, the chains that companies are involved in are very complex, long, and hard to manage, and therefore, the lack of visibility prevents the companies from being highly effective. Ultimately, everyone is only seeing their own operations, not beyond that, which leads to the ultimate problem. And blockchain and the transformation that it brings would securely connect these pieces and provide the participants with the entire view of the operation. Thereby, it is not only the company acting at the end of the chain that would benefit, but also parties having a role earlier in the chain because they would be able to see the demand at the end, plan their own operations, and schedule things, carry the stocks to be prepared for the fact that the order will come. So, overall, the end-to-end visibility in a secure way is the promise of blockchain solutions would have as opposed to traditional ways of handling the supply chains.	

7	Researcher	As it is known, conventional supply chain systems are built on complex systems requiring a lot of effort to change anything or everything throughout the whole network. So, does the blockchain universe rely upon more adaptable rules rather than supply chain technologies? If you think that way, what are those rules?	
8	R8	I would say "yes". You make the rules. Because ultimately, blockchain technology is not the supply chain solution, it is an enabler that you build upon. So, you make the rules when you build it up. It is used as a backbone for separate systems or it could be a protocol for all the participants to join and act accordingly. It is up to you to make the rules and the way that it works: Is it the chain of custody or is it another model? If there are the same rules everyone in the chain abides, meaning everyone plays with the same rules and there are no exceptions, it would be beneficial for all participants.	BC
9	Researcher	What are the potential blockchain use cases for green and sustainable supply chain practices?	
10	R8	I think it is down to transparency. It could prevent greenwashing. It is about companies telling that they are acting sustainably, but in reality, they do not know, or they do not care. However, if what they have done is publicly announced, such as paying adequate prices for some raw materials going from third world countries… If it all goes public, meaning that anyone can verify what they claim or if there would be a quote doing something else, there is hard evidence of them lying. I think the motivation for acting sustainably is because the concrete actions you do are publicly announced. It is not like doing a press release that we are the most sustainable company of the year, and then being caught up a few weeks later, because there is an NGO doing an audit in one of your factories that you are not acting in a way that you announced. It is more like providing anyone with the evidence that you are saying that you are doing these things, ultimately you are acting on that. There is verification; other parties involved verify your actions. That is one example of how it can be used. There are various examples involving money, environment.	BC, A-En, A-Ec, A-So
11	Researcher	How do you see the future of blockchain technology within the supply chain networks in the short, medium, and long terms?	

12	R8	A few years ago, there was a lot of interest, the usual suspects like Gartner bringing up blockchain on the hype cycle, and then major players, like IBM investing heavily in the technology, also selling and carrying out it. Walmart is one of the most well-known examples of a company using blockchain for the supply chain. I think they are still expanding. Then, a lot of other companies faced the problem because the blockchain is not the end of everything. To make use of blockchain technology, the company and its suppliers would need to go through digital transformation, meaning all the process needs to be digital. As regards the example of the food industry, it is not something that has already happened. As Cargill CEO says, they still use pen and paper a lot. They have manual processes; not all the data is in the digital form of being captured automatically. Lineal work with pen and paper, that goes really bad with blockchain. There are some advances in other areas: transporting industry being digitalized, warehouse operations benefiting IoT solutions per se… These are becoming more automated, and driving towards more automated solutions, and ultimately heading to something more adaptable for solutions like blockchain. First, the companies need to go to the digital transformation phase, and once they get there, they are more likely to connect to the platform for supply chain management, and actually see the benefits of that. But now, the companies that can afford more like pilots trying to experiment and trying to benefit. We are pretty much in the experimentation phase, but we also face something like Gartner Hype Cycle and IBM, and all the news around supply chain management and blockchain, which cause and create some false beliefs and hype. Roughly, one or two years ago, in a lot of companies that blockchain became synonymous with supply chains, and they wanted to invest in that, and there are a lot of failed examples. They had some blockchain consultancies to help them with, which they thought that it would help them in some way. It is pretty much what happened with the big data projects; they did not have clear goals, and they failed. The general opinion was: “Big Data was a false promise.” It took some time for companies to understand what it is all about and where the benefits are. Now, there are different blockchain technologies, some of which are mostly suitable for Fintech, transactions, and not for supply chain management, so to say. So, the current state is that there are many failed examples and false expectations, and the demand or the hype is going down. Even if sometimes, it seems that this new	BC, OF

		traceability solution comes up once a week at least – somebody picks up some platform, builds something on it, and then they have a product. Traceability itself is confused to be a supply chain management solution or it could be even sold as such, which hurts the industry again. The companies realize that capturing some data points may be good for traceability, but it is not to do anything with supply chain management. Today, companies are being more interested in advanced supply chain management. Some of these software companies are not clear with what they actually provide, the companies as buyers are not clear with what they get or what they need. I think, a few years ago, there was a lot of demand; however, failed examples caused demand to diminish somewhat. There is a second coming or a new way of things, and companies learn from their past mistakes, and now there are more companies involved in trying to solve common problems by having standards of applied solutions. It is not tied to a specific blockchain or a specific technology, it is more about having a protocol that could be adapted to different technologies. This could lead to a network or a backbone of things that would connect these different players, and I think blockchain has a major role in that or it could have, depending on what happens, of course. Now, this Covid-19 outbreak is actually highlighting the inefficiencies in supply chains, the companies will be more open to new solutions, but they need concrete solutions, not the technology. And also, I think, the blockchain itself is not a supply chain management solution. What a lot of companies do is that they build other tiers on top of the blockchain, creating a lot of centralized software on top of this decentralized or distributed software. This is where differences are, and it is not easy to see what you are getting. Think of a financial example… Let's say you have malicious transactions. What if you had an off-chain verification or observation, which could tell you that there are malicious transactions; for example, someone stole your money, or illegal money came to your bank account. If it was an on-chain solution, it could prevent that transaction from happening. Whatever it is, it seems that biases on building things outside off-chain, it is not necessarily reading the real benefits of this distributed or decentralized technology. So, what the future will bring is really hard to see. There could be competing technologies. It is really hard to estimate the impact of these failed projects because there are so many name companies already	

		coming out with the failed projects, which is likely to have a huge impact on the adoption of the technology.	
13	Researcher	According to a recent report from Gartner, nearly 85% of blockchain implementation projects through supply chains have failed or likely to fail in the short term. As we understand from your response, it is all about setting the right project goals and objective functions associated with the project planning. When you think about this kind of statistics, what is your expectation of blockchain technology in the next 3 or 5 years? Will it be hype or is there going to be solid use cases for the sustainability aspect of supply chain management?	
14	R8	I think there is a lot of promise. There are a lot of competing technologies, and it is also about cryptocurrencies in both good and bad ways. The public blockchains are operating on a core currency of that platform, which is being used for payments through transactions. The thing that people should understand correctly is that whatever you do with transactions they should be of greater value than the cost of them to carry out. For example, there was a company that I have audited personally, they wanted to have a blockchain-based supply chain solution, and they were offered one based on the public blockchain, but a pallet of the goods was costing in general around 7 dollars by that time, and the total transaction cost for the yearly production was about 2 or 2.5 million dollars, which was too much. It was questionable that the transactions happening on the blockchain and the cost of the goods for the company were still high, so naturally, they could not accept the solution. And also the solution that they were offered did not have supply chain management features. It was more of a simple traceability solution. I have seen a lot of technologies come and go, and have found a lot of familiar things, like BPM (i.e., business process management), which is not in high demand anymore. But what it actually brought in or what the promise of that was it would automate all your processes, then there is robotic process automation (RPA), which is being widely adopted since there is a lot of promise for that. It could benefit from a process framework, or regulated, controlled process execution engine like blockchain could be, but then it does not need a cryptocurrency for that. That would fall more into the scope of DLTs, and there is a lot of promise in the field of Fintech. I think, in the coming	BC, OF

		years, of course, it depends on who comes out with what, but cybersecurity, the financial transactions, and maybe smart contracts may be applied for a smarter process execution environment. It is likely to emerge; however, it is questionable whether it will be called blockchain or is it diverging into different fields with new names, it is really hard to predict. But also, there are new use cases emerging from the fields like IoT, IoT and Blockchain together, being used to add value to an existing solution. So there are drivers that could keep Blockchain as such and help it to advance or to get mature in the field. There are also some drivers that solely focus on the specific features of it, where most of the value comes from, and that could create multiple new technologies out of Blockchain and this would let Blockchain be mature on its own medium to live up to the expectations but not in high demand from the areas other finance, we'll see.	
15	Researcher	According to your perspective, which industries are likely to benefit most from the supply chain use cases of Blockchain technology, and could you explain why you think that way?	
16	R8	It's a quite broad question again. First, you need to define what is benefiting from blockchain? Say, being more efficient or actually focusing on more sustainable things, I mean not purely on money… I believe, the industries where the supply chains are more complex in terms of being the longest or having more participants in the chain which somehow requires more control, or consisting of companies that would like to have a more robust chain network, include the clothing industry, the food industry, just because there are all ingredients and various products are coming from different parts of the world depending on the season. It is not all year round but you can supply some products to some countries and there could be some problems like diseases or pollution affecting where you should import your goods from. Also, there are a lot of players in the food industry that are not available in the retail chain. Smaller producers are mostly selling their crops directly to their consumers or the food service industry in a local area. But then, disruptions like this pandemic that we are now experiencing is creating the need to change these things. Under normal circumstances, you would source your food products from your known suppliers, but now suddenly the borders are closed and the transportation issues you will need to source elsewhere.	BC, OF

		You don't potentially even know where to source from. So, it causes a lot of complications in a supply chain even when you find a new supplier. I think the clothing industry is notorious in terms of having these long chains, while the food industry has some other problems. Then, I think another prominent example is the construction industry, where they are sourcing many different things and using outsourcing not only in the first line of providers but throughout the chain. So, visibility in that is almost nonexistent.	
17	Researcher	Before we get into Track 2 and Track 3, we need to ask a more technical question regarding the comparison between public blockchains and private blockchains. Could you please briefly explain the essential differences between those two mechanisms?	
18	R8	If we generalize for the sake of this interview, you would say that public blockchain is a network where the nodes are upheld by unknown participants, getting paid in the form of the core cryptocurrency of that platform. So it is a two-fold thing that this currency of the platform, which is being used to pay for miners (i.e., people upholding the network, providing stories, etc.) could be even set to be a standard oftentimes that this core currency of the platform is also used for speculative purposes for trading. It is a currency that is available in those crypto exchanges. And due to the lack of regulation mainly, in some countries, companies using cryptocurrencies fall into the grey area. They don't want to buy a cryptocurrency to be able to use a platform. If you compare that to a cloud platform, you would pay for your use but you would know what the call says. When you attach to the speculative aspect of this currency, today the cost of your transaction is 2 dollars to say, and if the price of the currency goes up to 10 dollars let's say, it's a really an uncertainty factor. This core transaction, which is mostly about transferring this currency of the platform from one address to another, could be cheap, but then when you combine smart contracts to them where it requires storage, computation, the cost of this transaction could be higher. I see some brilliant works created on public blockchains but when auditing things like logging into the system costing a few dollars per login, it is something that causes these systems never going into production. Therefore, the decision to move on to production and paying too much for a simple operation that would occur numerous times a day was just deemed too costly. That's the cost aspect of the public blockchains. For private blockchains, this is closer to	BC, OF

		being something like buying something from a public cloud where you pay for the computing resources so that the companies feel that they are more in control. Depending on what you are creating, it is not decentralized anymore, its distributed instead. If one company owns all the resources required to run the blockchain and has access exclusively to the stories, it is questionable whether they anymore have an immutable blockchain. Because even it could be hard, there are still ways that they could change things, erase things, or not record something that they don't want to tell anyone else. That's an oversimplification because nothing is preventing you from running a private blockchain for a group of companies. So everyone would have their own copy of the data and it would be more of a decentralized nature. I think the lack of cryptocurrencies and the ownership are being the main differences.	
19	Researcher	For the sake of which one you mean?	
20	R8	On a public blockchain, if it was a smaller network, you could maybe take over and change things, like false transactions, and such. But if you are talking about major public blockchains, you could say that data is immutable and decentralized, whereas in private blockchains, unless you have a group of companies and a distributed technology and data, it is not decentralized but you would not use any cryptocurrency to pay for the transactions.	
21	Researcher	So, Track 2 deals with the blockchain characteristics and the aspects of SSCM. Maybe I need to explain it a little more in detail than that in case you couldn't find a chance to take a look at our interview guide. As we go through the literature, we see a lot of different aspects of Blockchain, hereby we summarized six different characteristics of Blockchain, though there might be some more that you might want to add at the end. But as a summary, our list consists of decentralization, data immutability, transparency, security and integrity of data, smart executions, and versatility. By saying versatility, it might seem a bit latent, which I will elaborate on this a bit more later on. On the other hand, we just divided the aspects of SSCM into three parts: environmental concerns, economic concerns, and social concerns. Here, social concerns stand for inter-organizational and intra-organizational issues that we can dig into when thinking of overall organizational aspects of sustainability.	

		Actually, we will try to search for correlations between BC characteristics with these aspects of sustainability one by one. Let's start with decentralization. How can blockchain's decentralized database architecture impact the environmental concerns of a supply chain, energy conservation, recycling, waste management, any kind of greening activities coming to mind? And why? And lastly, we will ask you to attribute the level of correlation on a 3-point scale, like low-medium-high.	
22	R8	Regarding decentralization, this is something that you might not even know. It is not easy to understand like, if you are buying from a supplier, you can't really know how sustainable their actions are unless you are paying someone else to do the hard work and you would audit them regularly. And still, if there was a more sustainable supplier in the market, how would you even know? This is like thinking ahead of time, meaning if they were a decentralized supply chain solution and it could enable the suppliers to just connect to that, and the buyers seeing them and enabling them to tackle less hassle to purchase from them, they could rank them based on other aspects than the price of the product. They could pay more for more sustainable production. The decentralized nature can prevent some greenwash. But it could also make sourcing more effective. In that regard, I would say the impact would be medium-to-high.	BC-D, A-En
23	Researcher	Next, we have data immutability. How would you correlate it to environmental concerns?	
24	R8	I think this is more bordering on transparency. But I think it is affecting the integrity of transactions. If I say, I have sent the goods today, that is being recorded and then the shipping agent confirming the receipt of the goods, verifications are happening but also the immutable record of things is creating trust because it is something through which I don't need to audit every transaction as they happen. But I can go back and see that the suppliers were fulfilling their obligations as agreed by going back to that data anytime. I think that's relieving the stress of doing audits as they happen or observing whether it happens for real. From the sustainability perspective, it could also be a reason that a small supplier in an emerging economy is getting paid accordingly, or identifying that it is getting paid fairly in line with the market rates or even more than the market price. If that's being recorded, I think it would ease the audit. Furthermore, when we are calculating the	BC-I, A-En

		carbon footprint, it is mostly based on the product itself and the country of origin, and then it is being aggregated. So, it is not giving a company doing more or doing better things to improve its return on investment for sustainable actions. However, if all their actions are recorded, we could actually, so to say, calculate the carbon footprint of this product coming from the specific supplier, in that regard. Again it would be a medium-to-high impact, but it could be even low depending on how concisely the data was being recorded into the blockchain and then the immutable aspect of creating the trust. So the bottom line is, with fewer data points it could be a low impact because we are not seeing anything different. But with more data points, it actually confirms whatever aspects of value it would add to the overall impact.	
25	Researcher	Next, we have transparency. Can it be something that cuts two ways? I mean, a couple of respondents prior to this session reflected that transparency can be an aspect that can be considered as a downside in terms of data privacy, confidentiality, fair competition, etc. Would you agree?	
26	R8	Yes, I agree. It is creating a lot of concern. If you are going to publicly announce where you are sourcing your goods from, where this information could be seen as classified by many companies, it could be even a problem because the competitors would know where the company is sourcing, if they know where and how the company sources these goods, they could maybe bet more to get its suppliers, or maybe to understand the cost structure and being able to compete with this company because they have all the details. So, yes, it is a two-fold issue. At the same time, it creates a promise. But it is also something that you have to be cautious about. It is not a fair world, there is a competition out there. By revealing classified information about your business or strategy, you could be exposing something that is actually helping your competition to outcompete you within the market. This is a tough one. But also it depends on how you define it. I think Deloitte is using the word “radical transparency”. This is something most companies are not ready for yet. I think the problem there is that announcing information as such isn’t always of that great value. As you said, the buyer or the end-consumer is just seeing or who produced a particular item or where it comes from. What is the difference of just printing the name of the producer on a package as opposed to putting that on a blockchain, which is actually way more complex and possibly requires a lot	BC-T, A-En

		more investment for that to happen? But, there are a lot of hidden values. Some sustainable actions of a company depend on whether they have a consumer product or whatever they are selling what they produce to other companies. Let's say one company is actually producing from waste, meaning they are helping the environment. So by passing on the information not just about availability, meaning how much they can supply to a buyer, but also what is the environmental impact of that, another company could use this information to tell their end consumers that by using their product they would actually help to save the oceans or to create better lives in some part of the world, or to preserve rainforests. Regarding recycling, there are also inefficiencies in that. Waste could be useful for someone if whoever that could actually use that knows it is available. Otherwise, if they are not aware that this waste is available, then it could actually turn out to be just waste. To create this kind of an operational supply chain that allows processing the waste of a certain company by some other stakeholders through recycling or product transformation, they need to be aware of where and how much is available. Right now during this corona crisis, in many countries, the restaurants are closed by law, hotels are all empty, borders are closed, now the food suppliers are actually creating food waste since they don't have a buyer for what they produce. Their standard and typical sources have just disappeared. So, if there was a system where their production for sale info was available to retailers and so that to consumers they would be in better shape. Because then the food they produce would be fully utilized. Getting back to transparency, it is a two-fold thing. It has a lot of promise, especially because consumers are getting more aware of environmental issues. You could show them you are using more environmentally friendly transportation and also practices to produce, just to reflect on how you stand out from the competition. You just have to be aware that if and only if you are just using it for the provenance of information, then the impact could be low. Typically, it is not enough and maybe it doesn't justify the use of a blockchain, the cost of using it just for provenance could be higher than just printing on a product package, so to say.	
27	Researcher	So on a 3-point scale how would you rate it?	

28	R8	I would say high because there is a promise of being high. But, of course, as in the previous point, the fewer the data points the lower the impact. But if we think that we are doing everything by which we can really make full use of the blockchain's potential, then the impact is high.	
29	Researcher	The fourth characteristic of Blockchain that we included in our interview guide is the security and integrity of data. What would you say about the potential impact of this aspect on the environmental concerns of a supply chain?	
30	R8	This is something that ties into the previous points, meaning decentralization, immutability, and a bit of transparency as well. Regarding the security aspect, it is hard for some other party to falsify transactions so you would know exactly who did and what. It is harder to pretend to be someone else. You actually capture the real identification of the participants. And as such, it is adding to the value that you could say that the producer who really produced this thing has given this information. It could be like, so to say, from the sustainability perspective, this person really knows or is among the few ones that really know about sustainability. For example, with the food produced, it often involves offline data that is available, maybe only at the farm, including the amount of water consumption. It is fully captured by some agency distilling the water but say, if you had your own water supply, also this wouldn't know how much water you have really used. So, there could be these differences and sustainable actions being recorded by a person or an entity having this strong identification. I think this is the promise in that regard, meaning you really know that it enforces the trust again. You can live up to the expectations and say that it has really been this actor who has provided the information. The emphasis comes from the thing that there could be government agencies or third parties involved in the sorting of the goods, and they could verify what you have said. But I think it is more like even if you wouldn't know the name of the person or the company of whoever giving that information, but you can see it is tightly coupled with the supply chain, like they have really provided the material, or the produced being used by another company and being sold at the retailer and being now in your hands as a consumer, in that case, you can really trust that the information being correct.	BC-SI, A-En
31	Researcher	So, how would you rate it on a 3-point scale?	

32	R8	Thinking it purely from the security, even though it is more of the integrity, but as such it has a high impact because I think mostly it has to do with the media and the companies using greenwash. So, having false claims, integrity here has a high impact.	BC-SI, A-En
33	Researcher	Next, we have smart executions, which is done by smart contracts as you would appreciate. So, would you say that there is a correlation between this aspect and the environmental concerns?	
34	R8	I would say the impact is medium-to-high. I think the promise here is automation. Like the previous scenario, say being aware of wastes available, or even goods available at some supplier, then the automation of getting notified of goods and waste available, which can enable new business models. Then, if there is a new business model where the common standards of the way of doing business today, the impact would be high. But now it is just medium-to-high because it requires the creation of these new business models. For companies that really use them, the impact would be really high. I think there is a promise of really transforming the way we do business. Having a standard like a pre-program process in which every participant knows how it works, they can then trust it because it is fair, meaning it is not giving precedence to bigger buyers, companies, or bigger suppliers. As long as everyone would be on the same page and the process would be known, then it is something that could be trusted. But still, I think the promise of that is process automation, giving some inputs if it yields a known output.	BC-SE, A-En
35	Researchers	So next, we have versatility. Maybe I need to explain this a little in detail. After going through the literature, we just encountered four different versions of blockchain technology through the test of time. Blockchain 1.0 actually stands for the introduction of Bitcoin for financial applications, whereas Blockchain 2.0 refers to the use of smart contracts. And Blockchain 3.0 is the hype that people are in need of using blockchain technology for industrial cases. Lastly, Blockchain 4.0 implies the use of technology by integrating it with different kinds of disruptive technologies such as AI, IoT, Machine Learning, Deep Learning, Augmented Analytics, etc. So, by saying versatility we are just inferring these four versions of BC technology evolved within the last twelve years, so to say. So, we are asking how can the versatility aspect of this technology impact environmental concerns?	

36	R8	I think this is probably the hardest one. There is maybe a deep role ahead, like the lack of digitalization from the companies who should be using this. Also, it requires these other technologies to develop as well. Yes, there are some benefits to have already, but I think at the moment the benefit is low, just because these other technologies are also at their early stages, not just blockchain. And I think it is also causing problems because even if you say versatility, it means that just having blockchain doesn't mean anything unless you know the specifics. I mean, is it a platform to be used only for financial transactions? Because there are platforms that even if they incorporate smart contracts as being more in the field of Blockchain 2.0, they are only being used for financial technologies. So, how would the company that is not really in the market to buy the technology but to buy the solutions differentiate between all these different versions? They don't know which version they need so they trust the supplier. Thus, I think that versatility here is also hurting blockchain as such. If you look in history, when you started versioning the technology, it was clear that at some point it might be the end of the technology.	BC-V, A-En
37	Researcher	So, are you just referring to it as having a low impact?	
38	R8	Yes, it is correct.	BC-V, A-En
39	Researcher	So, let's move on to the economic concerns of sustainable supply chains. By tracking the same logic as is the case with the previous section, how would you see the correlation between decentralization and the economic concerns of a supply chain?	
40	R8	This has a lot of promise, especially considering the aspect that allows sharing the cost and also getting the benefit. For instance, everyone involved would pay their own bill and they could still benefit from having a common system. Repeating the previous cases, say recycling, if I can just connect to a platform to be known of raw material, which might be waste for someone and it is getting available for pickup, then it means I can actually benefit from it a lot. By just paying my own bills for using the system and then connected to all these potential suppliers of raw material for me, it could be a high impact. But then again, the downside of that with these cryptocurrency platforms, even if it could provide me integrity that makes it harder for someone to exploit,	BC-D, A-Ec

		attack, manipulate, falsify, or steal the data, it still has a cost, and that cost could negate the benefit. If I am using to track the custody of a pallet of goods, which is having a low value, then the overall cost of these transactions for just having a system of a record-type solution, it could be too high.	
41	Researcher	So either way, the impact would be high, positively, or negatively?	
42	R8	That's correct.	BC-D, A-Ec
43	Researcher	So next, we have data immutability. How would you see the impact of it on a 3-point scale?	
44	R8	I would say medium. Because even if we are talking about let's say, pen and paper, fax, or whatever to record anything like contracts, orders, things like just having the information recorded in the same way in two different systems, which are established at the buyer and the supplier separately, it is not efficient as such, meaning there is room for improvement but also it is something that already exists. In a simple scenario, it already exists, meaning it is not anything new, and then it is all about the cost, what is the benefit of having that? There are other processes such as back-office functions like accounting, if it requires, say, another integration to have the information starting blockchain to be transported to our SAP, or a specific accounting system, then it could be that the cost of this integration alone is too much and negates the benefit of having some automation for that. And also the legal aspect, like digital signatures, what is actually being considered as a real contract in your area in that industry? Is it something that a contract could be done on a blockchain? We are not there yet.	BC-I, A-Ec
45	Researcher	So next, we have transparency. How would you correlate it with the economic concerns?	
46	R8	I think there is a medium-to-high impact. It all comes down to a type of information that is being made available.	BC-T, A-Ec
47	Researcher	The fourth one is the security and integrity of data again. How would you rate the correlation of it with the economic concerns?	

48	R8	I think this is also a high impact, clearly. All these security breaches, crimes around hacking systems, they are just increasing as such the preventive measures, which are costing the companies a lot in terms of handling cybersecurity and malicious attacks out there. Whether it is a breach that you suffered or just the precautions that you bought for that not to happen, it has a high price. So, having a highly secure system helps you come out of the box. I think this has a high economical value.	BC-SI, A-Ec
49	Researcher	Got you. The fifth one is smart executions. What would you say about that in this regard?	
50	R8	I would say for the time being it is low-to-medium. That's because it is not a standard feature, rather it has to be created. So, there is potential but to reap the benefits of that is not something for everyone. For a bigger company or a huge corporation, it could be medium or even a high impact. Say, they could bring all their suppliers to a regulated standard process and force everyone to follow that process. Because it is done on a system level. So, it could be a cost-efficient way to do that. Then again, it requires custom programming to actually realize that process and in order for someone to reap the benefits, it requires more custom programming, integrations, or maybe even new business models to relieve the benefits. That's why I think the world is not ready for it yet. The incentives to invest in doing that all over are not that mature yet. There is a lot of promise but it is hard to see the return on investment.	BC-SE, A-Ec
51	Researcher	We have versatility, which is the last one. What would you say about its impact on the economical concerns?	
52	R8	I think it is still the same thing. It is not helping any, it just makes it blurry and hasty. The technical people can appreciate it but the business side of things is not buying technology or a specific version, they only want solutions. So, the economic value is probably low. I think the most value will come from the technology itself, that may be entering into something to make it more viable, easier, scalable, which is the real promise that everyone is waiting for. For now, versatility, with respect to your definition, is more of a burden. I don't see any impact from versatility.	BC-V, A-Ec

53	Researcher	So, the last pillar of sustainable supply chain management we have here is social concerns, which stand for organizational concerns of a company through our interview guide. These organizational concerns could be either interdepartmental (i.e., intra-organizational) or inter-organizational. So, just following the same logic, let's start with decentralization. How would you correlate decentralization with the social concerns of a supply chain? And on a 3-point scale, how would you rate the level of this correlation?	
54	R8	I would say medium, with the potential to be high, considering the current state of things. It requires a lot of things to happen before we can reach the point of high. The thing is, having decentralized data available helps to create trust and also opens the data to other concerned parties, whether it is a buyer, end-consumer, or a regulatory body within governments. It could ease things, but of course, it is not the standard way of doing things. So, it creates a need for a change. If it only changes for one company's practices or even a few company's practices, probably the cost associated with it would be too high for that to become the new norm. We talked about food earlier. If we bring up food safety, there are a lot of regulatory aspects of that. If you could trust the recorded data about actions revolving around the food safety to be correct, that could relieve some manual audit processes and it could bale the chains in the process, so there is a motivation and as such in the current state, again I would say medium impact but there is potential to be more impactful.	BC-D, A-So
55	Researcher	So, the next one data immutability. How would you correlate it to the social concerns of a supply chain?	
56	R8	Actually, this goes with decentralization. To believe that it is really a system of records with correct data as recorded, it can be audited back in time. You can actually trust that data to be correct and accurate and also trust that data to be seen in the same way by all the participants in the chain. I would give it a high impact.	BC-I, A-So
57	Researcher	So, next, we have transparency again.	

58	R8	Even if we have discussed this before, I would give it a medium-to-high impact. There is a potential to be high. But it all revolves around what you are communicating with and who you are providing that information to. So, as we discussed earlier, there is a growing interest from the consumers to know more about the food, not just the origin of it, not the name of the producer solely, but everything that was done to that before they actually purchased it.	BC-T, A-So
59	Researcher	But, it is also good for organizational collaboration, right? In this case, employees would be more aware of what's going with each product or service, etc.	
60	R8	Definitely, because the traditional systems are really good at creating silos, but also the silos are created by the business models of these systems. If you buy an ERP, you will buy a license to use a module. You don't buy more modules, for a warehouse worker, so to say, because it costs more and you don't see the benefit. But still, there are times when the warehouse worker would benefit from seeing things related to his work, such as coming orders, how to prepare things, how and where to load them, how it actually looks regarding the inbound and outbound logistics. For the intra-organizational point of view, I think it could be medium-to-high.	BC-T, A-So
61	Researcher	So, next, we have security and integrity of data, regarding its correlation with the economical concerns of SSCM?	
62	R8	Yes, I think this one again would have a medium-to-high impact, depending on the use case. Because within an organization, if it is your organization's own data, there are other safety measures. Say, it could be a system that cannot be used outside of the premises so that you can be sure that whoever gets into a particular screen and keyboard or accesses the server or the system, there is someone who really should be seeing or using it. So, in that regard, I would say there would be a medium impact.	BC-SI, A-So
63	Researcher	The fifth one again here is smart executions. What do you think about its potential use and impact on the social concerns of a supply chain?	
64	R8	I would say medium impact for this one again. There is also potential but in order to make use of it, it requires further actions, which requires having a cost depending on	BC-SE, A-So

		the use case, and it could be that the cost is too much so it can outweigh the benefit.	
65	Researcher	So lastly, we have versatility. What do you think about its potential impact on organizational concerns? Or maybe it is out of topic here we are not really sure about this one.	
66	R8	I think there is a high impact but in the wrong way. That's why I would give it a low rate in terms of correlation because again it is more a source of confusion than something that any organization could easily benefit from.	BC-V, A-So
67	Researcher	So, is there any other aspect of sustainable supply chain management or blockchain characteristics that you would like to draw attention to? Do you think that we are covering every aspect of blockchain through our interview guide or should we just work furthermore on our theoretical framework?	
68	R8	I think you've done a really good job! I see the benefit and I think it is very thorough. But I would like to hear your research question(s)?	
69	Researcher	Though it is not the final version, for now, our research question is: "How does blockchain technology impact the sustainability aspect of supply chain management?" By asking that we are just trying to search for answers to the concerns on what kind of benefits, challenges, and risks that blockchain technology brings in, or maybe we can identify some sort of critical success factors of blockchain to adopt it accurately through the supply chain networks. So in the end, we are just scratching if the blockchain technology is more than hype for supply chain management, which is set to be a major question to search for an answer.	
70	R8	I think your framework is good to approach these questions. Outside of these, I could give you an example. Besides, if I can think of something relevant to your case, I can send you an email so that you can come back to that if you want some details. I can't remember the details exactly but it was about one company that has some hundred millions of products produced each year. They wanted to implement a product-level traceability solution to tackle the problems with supply chain management because they had a lot of factories. When things went normal, it was using the designated routes, and they could control the production plants. However, everyone had their own ERP and there were a lot of different outsourced stakeholders in the supply chain. They also wanted to	

		tackle that when the peak season was there because they could potentially even deliver to the bigger end customers and not use the intermediate warehouses. Having this type of bulk commodity goods, having an item level traceability solution, 99.9% of the suppliers of this system would say: "It is not worth it." Because it is really hard to serialize these individual products coming from these high-speed production lines and then follow them other than at the batch level across the chains, even when using these dynamic chains. So, it was possible to craft such a solution using blockchain. I think this is probably just knowing that it can be done. I can't tell you who is using it. It was possible to do with using a blockchain. I think this is something maybe you can consider when you go through the aspects, like thinking of the ERP side of things, dynamics chains, dynamic supply chains, having item-level traceability coupled into that.	
71	Researcher	We'll definitely look into that. Thanks for the tip. We still have one more track, which is all about challenges and risks with the adoption of blockchain technology. Actually we listed six challenges and risks after going into the literature thoroughly, but of course, there might be some more, which you can add and lead us to focus on another aspect if you come up with any other. The list consists of the immaturity of BC technology (cybersecurity attacks, throughput, latency, the volume of data that blockchain can process, etc.), lack of awareness and technical competence, organizational collaboration, change management, cost and functionality (efficiency and effectiveness combined), and last but not least, legal and compliance. So let's start with Immaturity by asking: "What do you think about the potential impact of the immaturity of BC technology on the adoption of this technology?" And regarding the extent of it, how would you rate it on a 3-point scale (i.e., low-medium-high)?	
72	R8	I think there is a high impact and it is hurting the adoption. Companies keep hearing these stories that it is immature, it is really in the early stages, and also, they see some sort of failed projects, but they are also waiting to see the real benefits. In that regard, there is a high impact. Fewer companies want to be the pioneers to pay the higher price while waiting for whatever the prevailing blockchain technology or solution to come.	CR-IM
73	Researcher	Got it. The second one is lack of awareness and technical competence so how would you correlate it with the adoption of BC technology?	

74	R8	I would say high again. And in my mind, this would correlate with false expectations as well. There are a lot of misconceptions about this technology and its use. The companies potentially investing are at the mercy of the supplier. So, the suppliers can't help them with something they don't need and can make bad choices regarding the platform. And ultimately, it could be that whatever this project is for, it is a project for disaster.	CR-AWS
75	Researcher	So the next one is organizational collaboration. But we are asking you to also consider the effect of the upper management's involvement attached to this aspect as well.	
76	R8	I think there is a high impact regarding this one too, in terms of being promising. But I will still say it is medium-to-high because there needs to be a specific type of solution that addresses comprehensively the needs of the organization. So, just adopting a blockchain doesn't guarantee that it has any tremendous benefits to reap, even in the organizational aspects covered because it is whatever you build from it.	CR-OC
77	Researcher	The fourth one here is change management. According to the literature, this is a kind of challenge for any kind of technology adoption within industries, but when it comes to blockchain technology, what would you say about its impact?	
78	R8	I would again say, it is high. It could mean radical changes in the corporate strategy, in the business model, and also regarding what kind of business it will be for its buyers. It is really hard at this point because there is a lack of standards. How to hide your organization using a blockchain from your business partners? So, is it something that you would integrate everything that comes into a blockchain and then build everything to integrate with the blockchain so it is just the transport layer. As such, this probably does not offer that much benefit because some other effective and cheaper technologies are able to do the same.	CR-CM
79	Researcher	By saying that, you are considering the fact that it requires the involvement of multiple stakeholders throughout the supply chain network, suppliers, retailers, the main company, tier-1, tier-2 suppliers, and everything, right?	
80	R8	Yes, that totally affects the overall evaluation.	

81	Researcher	So, the fifth one is cost and functionality. Once more, by saying functionality we are trying to cover the efficiency and effectiveness as a whole. Cost includes investment costs, overheads, all the project management costs as well.	
82	R8	I think there would be a high impact from it. Because it requires a lot of resources and a strategic investment approach. There has to be a clear driver to go through the project. So, the stake has to be high enough for you to benefit in order to make this investment. It is already available, and it is easy to set up. If you look at the features and say, the functionality of the blockchain platform, it is not doing much. What it does for you is how your organization would benefit from it. It requires a lot of custom things to happen, and not just technical things, changes in the internal processes, maybe strategies, business models, etc. Too many changes… It is not like buying a new ERP.	CR-CF
83	Researcher	Even if it comes to an ERP implementation, I think the project management process takes two years on average, so we guess it would even take more time when it comes to a blockchain technology implementation project, right?	
84	R8	Yes, that's true.	
85	Researcher	So, the last one is legal and compliance in this Track. How do you see it as a challenge to deal with when implementing a blockchain technology project?	
86	R8	Definitely high. I think a good example is Lufthansa, who has been using blockchain to store their loyalty points. As such, from the 1st of January this year, the German regulation required them to apply for a wallet provider license. So, if they were using a traditional database to store the same information, they wouldn't need the license. Even if they are not using any type of cryptocurrencies, the regulator sees that the use of blockchain correlates quickly to the use of cryptocurrencies and the wallets being holding assets of value. As such, Lufthansa as a provider has to have some sort of a cryptocurrency wallet provider license so they would be taking or assuring the government that their users are safe with them, even if we are talking about loyalty points, not massive amounts of Bitcoins or feared currencies. So, regulation has a lot of impacts.	CR-LC

87	Researcher	So one quick question. It is just out of this discussion but you know it is a thing that sticks with my mind. Regarding the forms of blockchains in the technical aspect, to name it public blockchains, private blockchains, and consortium blockchains, which are being called hybrid blockchains by many people, so most of the respondents prior to this session told us that private blockchains are more aligned with practical cases in the industry, not in the implementation phase but as the core of pilot projects. But when it comes to public blockchains, it seems to be a bit spooky because many people predict that the implementation of public blockchains through various industries will take more time than it is being forecasted. So, when you compare these three versions, how would you evaluate the potentials of them in terms of being applied to industrial use cases in years to come?	
88	R8	I think due to the legal aspect around cryptocurrencies and also the speculations about transaction costs, ultimately the price of the currency is affecting the cost of a transaction. Ask any business, would they buy a cloud service where the price is not known? I mean, think about a scenario where they wouldn't know the monthly cost so that it is something not clear. I think that is creating some confusion, but also the features… I have seen some companies trying to avoid the cost by doing batches. By recording some information about the batch, they are actually already hurting the granularity of the information. Considering the individual transactions anywhere else which are being aggregated on some level, actually an aggregate of such nature is something that you can't convert back to the individual transactions. The point of having that information stored on a public blockchain is negated so there is no point in doing that, in fact, it just creates a cost. Also, in a similar nature, say, classified information is being stored on a public blockchain in an encrypted form… So, if the idea was to be creating transparency, to be open and actually having it publicly out there in the encrypted form where it could be only the company itself who can traverse it back to the source data, it is again negatable because what is the benefit of doing that? But yes, there are some use cases where you need to have a system of records that doesn't change that much. And the transaction has a higher value than the transaction cost of the platform because ultimately you pay for storing the data but not viewing the data. But then it all boils down to use cases like how you read the data. I doubt that there are many use cases where people would actually download the entire blockchain data setup and node and	BC, OF

		view the data from the blockchain. They need some sort of a user interface, some ways of using it. Say, for governmental use, like a land registry or other registries, that are mostly to uphold the information and being of public nature. I think they would benefit from public blockchains because there is a clear use case. It is costing them way less than running a proprietary system for their users that are new to data. And it is being stored forever for the nominal cost, it costs them to upload the data on the blockchain. Then, regarding the consortium use cases, I think it is up to the consortium architectures itself. I think the problem there could be something that depends on what is to expect through the life of that consortia. How can it add up to things like having new members or changing members? This could be creating problems. But again going back to the private blockchain, if it is only the company owning all the data and the nodes, then it could be something that is just trying to catch out on the hype like using the word "blockchain" to announce something to be different from the future, like using it for marketing. It is really not being used properly but it is also easier just for a company to control and further develop it. They can assure that if they open and share the data throughout the organization, they would exactly know who has access to the data and it has been done securely. In the organizational use cases out there, what I've seen is that this major manufacturer that needs some smaller manufacturers (i.e., subcontractors) or their factories to help them in providing to fulfill orders, they would be using the blockchain to a good extent. Actually, all these participating factories that they don't own but only have a contract with to produce some parts or even doing complete deliveries for the major company, know that they are doing it according to the certain standards, like regarding production start time or delivery time so that the major company can organize the transport. This major company needs additional capacity or the information about the availability of extra capacity that they can extract from these other factories. It is a lot less contract work and they are highly efficient in that. But still, it is a private blockchain, which is entirely owned by this bigger factory. And the smaller ones are just using it, they don't have their own nodes or copies.	
89	Researcher	Got it. So, we are about to finish but back to challenges and risks one last time. Is there any other challenge or risk that you can suggest to us to think of?	

90	R8	Not really. This has been really comprehensive. But I will let you know after the interview if I can think of any.	
91	Researcher	Great, thanks. Is there anything else you would like to add before ending the interview?	
92	R8	No, I think we're done here.	
93	Researcher	And would it work for you if we get back to you for anything to be clarified or if any other question arises, perhaps through mails?	
94	R8	Yes, that's fine.	
95	Researcher	Okay. Would you like us to send a copy of the study before it is published?	
96	R8	Oh, yes, please.	
97	Researcher	Great. Indeed, thanks for taking the time to participate in our study, it nearly has been 2 hours, and thanks for your generosity.	
98	R8	Thank you. Good luck with your study. I'll be glad to review it before it gets published.	
99	Researcher	Thank you so much. Have a good day.	
100	R8	Thank you, bye-bye.	

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