Technological Forecasting & Social Change 175 (2022) 121403

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage: www.elsevier.com/locate/techfore

Blockchain as a sustainability-oriented innovation?: Opportunities for and resistance to Blockchain technology as a driver of sustainability in global food supply chains

Nicola Friedman [a], Jarrod Ormiston [b,*]

[a] University College Maastricht, Maastricht University, Minderbroedersberg 4-6, 6211 LK, Maastricht, Netherlands

[b] Department of Organization, Strategy and Entrepreneurship, School of Business and Economics, Maastricht University, Minderbroedersberg 4-6, 6211 LK, Maastricht, Netherlands

ARTICLE INFO

Keywords:
Blockchain
Food supply chains
Innovation resistance
Sustainability
Sustainability-oriented innovation

ABSTRACT

Blockchain technology has been forwarded as an innovation to address pressing sustainability challenges in global food supply chains. However, limited studies have critically examined the technology's role in advancing sustainability. Drawing on the literature on sustainability-oriented innovation and innovation resistance theory, we explore the potential of blockchain technology to contribute to sustainable transformations within food supply chains. We reflect on 18 expert interviews with various actors across global food supply chains to evaluate the opportunities for, and resistance to, Blockchain technology as a driver of sustainability. The findings reveal that Blockchain is used within food supply chains as both a tool for sustainability as well as a broader philosophical mindset for addressing sustainability challenges. We reveal the opportunities for Blockchain technology as a sustainability-oriented innovation that can ensure fairer supply chains, enhance food traceability, and drive environmental sustainability. We also unpack the resistance to Blockchain that hinder its potential as a sustainability-oriented innovation which include functional and psychological barriers alongside cooperative barriers and protection of the status quo. Our study contributes to the broader literature on sustainability-oriented innovation and innovation resistance theory.

1. Introduction

Developing a sustainable global food system that embraces economic, social and environmental objectives is crucial as society approaches its planetary boundaries and the world is confronted with unsustainable consumption patterns (Hoekstra and Wiedmann, 2014; Sjauw-Koen-Fa, 2010). Realizing sustainability within global food supply chains is complicated by various challenges such as food traceability, transparency and harmful environmental impact ((Dabbene et al., 2014); Govindan, 2018; Teh et al., 2019), and the diverse stakeholders involved in the sector (Dania et al., 2018). Overcoming these challenges requires multi-stakeholder innovations that address economic, social and environmental challenges (Godfray et al., 2010).

Blockchain technology is gaining momentum as an innovation that can drive sustainability in global supply chains (Marsal-Llacuna, 2018; 2020; Saberi et al., 2019). Blockchain is an open, distributed ledger technology that offers new ways of securing and transmitting data through a peer-to-peer environment by permanent and verifiable records of transactions (Iansiti and Lakhani, 2017; Tillemann et al., 2019). The technology has been touted to have significant potential for supply chain sustainability by advancing security, accountability and efficiency (Chang et al., 2019; Kewell et al., 2017; Wang et al., 2019). In this sense, Blockchain technology is being framed as a potential Sustainability-Oriented Innovation (SOI) (Adams et al., 2016; Jay and Gerand, 2015). For food supply chains in particular, Blockchain has been forwarded as a solution for the current challenges through its potential to reinforce food security (Tse et al., 2017), reduce fraud (Kshetri, 2018), ensure fair labor practices (Saberi et al., 2019), and reduce waste and CO_2 emissions (Kouhizadeh and Sarkis, 2018). Only limited studies have explored how the technology can help overcome the existing challenges in food supply chains (Kouhizadeh and Sarkis, 2018; Wang et al., 2019). This study explores the role of Blockchain technology as an SOI to address challenges within global food supply chains.

* Corresponding author.
E-mail address: j.ormiston@maastrichtuniversity.nl (J. Ormiston).

https://doi.org/10.1016/j.techfore.2021.121403
Received 30 August 2020; Received in revised form 24 November 2021; Accepted 25 November 2021
Available online 5 December 2021

Given the hype surrounding Blockchain technology (Michelman, 2017), the study takes a critical perspective on its potential as an SOI to avoid a pro-innovation bias. Similar to the broader innovation literature, research on SOI can be characterized by a pro-innovation, pro-change bias, with limited understanding of resistance and opposition to SOI (Godin and Vinck, 2017; Heidenreich and Handrich, 2015; Ziegler, 2020). The study engages with innovation resistance theory (Ram, 1987; Ram and Sheth, 1989; Sheth, 1981) to provide a critical lens through which to examine the challenges, opposition and resistance to Blockchain technology as an SOI. Innovation resistance refers to the rejection or opposition to new products, services or process innovations based on challenges to the status quo and conflicts with beliefs, values and norms (Kleijnen et al., 2009; Ram and Sheth, 1989). It is argued that studying innovation resistance is vital when studying disruptive innovations such as Blockchain technology in order to appreciate the challenges and pain points preventing further adoption (Bauer, 2017; Chen and Kuo, 2017; Talke and Heidenreich, 2014). Through this lens, the study aims to critically examine Blockchain technology as an SOI in food supply chains and unpack how current resistance to the technology might shape future adoption. The paper is thereby guided by the following research question: *What are the opportunities for, and resistance to, Blockchain as a Sustainability-Oriented Innovation (SOI) in food supply chains?*

The study is based on 18 interviews with both Blockchain experts and food supply chain experts including Blockchain consultants, Blockchain researchers, IT experts, Blockchain entrepreneurs, supply chain managers and logistics managers. The findings reveal that Blockchain is used within food supply chains as both a tool for sustainability as well as a broader philosophical mindset for addressing sustainability challenges. The results highlight the opportunities for Blockchain technology as a sustainability-oriented innovation that can: (i) address fraud and human rights violation, (ii) ensure fairer supply chains, (iii) enhance food traceability, (iv) create shared economic value, and (v) drive environmental sustainability. The analysis shows that realizing radical transformation in global food supply chains requires stakeholders to overcome multiple forms of resistance to Blockchain technology including: (i) actively protecting the status quo, (ii) cooperative barriers, (iii) functional barriers and (iv) psychological barriers.

This research contributes to the broader literature on SOI and innovation resistance theory by critically evaluating the Blockchain's potential as a sustainability-oriented innovation. By extending innovation resistance theory to studies of SOI, the study contributes to overcoming the pro-innovation bias in studies of SOI. The findings highlight how protecting the status quo becomes a form of active resistance enacted by incumbents who profit from unsustainable practices. Further, by examining innovation resistance in the context of global supply chains the findings reveal cooperative barriers as an underexplored form of resistance to innovation, which is particularly emphasized in the context of SOI. The study contributes to practice by showing myriad ways in which Blockchain addresses sustainability challenges and how the technology can reconcile financial performance with sustainability objectives. The analysis suggests that when implemented appropriately, the Blockchain philosophy guided by principles of democracy and decentralization assists in creating sustainable and equitable supply chains.

The article is organized as follows. Section 2 reviews the literature on Blockchain technology and sustainability in food supply chains. Section 2.1 describes Blockchain technology and its core features. Section 2.2 links the literature on sustainable food supply chains with literature on the main attributes of Blockchain applications. Sections 2.3 and 2.4 introduce the literature on sustainability-oriented innovation and innovation resistance theory to conceptually frame the study. Section 3 outlines the research methods, detailing the experts interviewed and illustrating the data structure that emerged from the analysis. Section 4 presents the findings on the opportunities for Blockchain technology in driving sustainability in food supply chains and resistance to the technology as a sustainability-oriented innovation. Section 5 discusses the contributions of the study to the literature on sustainability-oriented innovation and innovation resistance theory. Section 6 provides recommendations for future research, outlines practical implications, and discusses the limitations of the study.

2. Literature review

2.1. Understanding the main attributes of Blockchain technology

Blockchain technology has arguably become one of the most hyped technologies over the past decade (Pereira et al., 2019; Pólvora et al., 2020). Blockchain emerged in 2008 when it was developed by Satoshi Nakamoto to prevent double spending, a problem unique to digital currencies (Nakamoto, 2008). Nakamoto conceptualized the Bitcoin and framed it as a peer-to-peer electronic cash system that uses digital signatures that serve as a timestamp for each transaction. The distributed ledger underlying Bitcoin is the Blockchain technology, which is argued to allow for secure online transactions without intermediaries such as financial institutions (Crosby et al., 2016). Although Bitcoin remains one of the most used Blockchain applications (Yli-Huumo et al., 2016), it is important to differentiate the cryptocurrency from the Blockchain technology (Galen et al., 2018).

Blockchain technology is defined as an "open, distributed ledger that can record transactions between two parties efficiently and in a verifiable and permanent way" (Iansiti and Lakhani, 2017, p.1). The name "Blockchain" describes the way the technology functions: information is stored on different blocks which are then linked together and constitute a chain of verified data. Tillemann et al. (2019) describes three basic steps on how Blockchain works: (i) encryption-facilitated data exchanges occur between Blockchain participants; (ii) once verified by the Blockchain network, these transactions are grouped together to produce a locked data "block"; (iii) finally, these blocks are linked to the previous ones by a hash key (a unique mathematical code) that create a chain that is based on a validation principle, hence creating a Blockchain. Blockchains are described as having three layers or features: (i) the storing of permanent, auditable and unchangeable digital records which provides data security, (ii) the exchange of digital assets in real time, which provides transparency (iii) the execution of smart contracts, with contributes to efficiency. All three of these layers are underpinned by the decentralization on Blockchain (Deloitte Insights, 2018). The four main attributes of Blockchain can thereby be viewed as: security, transparency, efficiency and decentralization.

2.1.1. Data security

Blockchains are perceived as a highly secure way of storing data. Since every addition of a "block" relies on the consensus of all participants in the system each transaction is verified (Crosby et al., 2016). This peer-to-peer consensus mechanism makes Blockchains difficult to modify by violators (Wang et al., 2021). Also, public ledgers cannot be deleted after they have once been approved by all nodes (Yli-Huumo et al., 2016). This so-called immutability feature protects data from tampering. Additionally, security is strengthened via public key cryptography. This means that each authorized user of the Blockchain receives their personal "key" (digital code) to access the data. The digital identities of the transaction partners are then validated through algorithms before the peer-to-peer exchange can take place.

2.1.2. Transparency

Secure access by authorized entities and public visibility enhance the transparency of Blockchains (Mukkamala et al., 2018). While only authorized peers may access the Blockchain, all network members can view the full record of transactions. All participants of the Blockchain network must verify a "block" through consensus which ensures that the history of records is reliable (Kim and Shin, 2019). Through digital signatures, Blockchains can easily prove an identity which gives authentication only to those allowed to participate in the transaction and ensures that identities are not faked (Galen et al., 2019).

2.1.3. *Efficiency*

Efficiency is a key attribute of Blockchains as data can be shared digitally and instantly. The efficiency attribute of Blockchain creates possibilities to execute smart contracts, which are automatic and digital contracts or agreements that reduce mental and computational transaction costs and increase security (Szabo, 1997). Smart contracts are depicted as a more visible way of executing agreements by enabling a tamper-proof and conflict-free way of exchanging value (Chang et al., 2019; Cong and He, 2019). Smart contracts provide potential benefits over previous paper-based forms of contracting in a digital environment by maintaining records the of provenance of the assets being transferred and ensuring instant outcomes without involving third parties (Alharby and Van Moorsel, 2017; Deloitte Insights, 2018; Magazzeni et al., 2017). The intermediary-free environment can exhibit fewer data errors, reduce transaction costs, and avoid reliance on individual servers (Mukkamala et al., 2018; Tillemann et al., 2019).

2.1.4. *Decentralization*

The decentralized structure of Blockchain technology allows all members to collectively build the network in a peer-to-peer environment. Each member receives their own copy of the ledger. Data is thereby distributed among the network and no longer stored in one centralized database (Wang et al., 2021). The decentralized nature of the technology also contributes to security by increasing its robustness to external disruptions. The distributed ledger technology can establish trust between distrustful parties by allowing for safe transactions in which honest parties are compensated (Kosba et al., 2016). No single party has control over the entire database, providing more transparency to the network and enabling trust among its members (Batwa and Norrman, 2020).

2.2. *Applications for Blockchain technology in global food supply chains*

With an estimated global population of 9,7 billion by 2050,[1] the goal of reaching food security is a grand challenge. Food security is defined as a state in which “all people, at all times have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life” (FAO, 1996, p.2). The causes of food insecurity are multifaceted and stem from social and economic inequities as well as environmental disruptions (Pérez-Escamilla, 2017). The consequences of food insecurity often reinforce other socioeconomic issues such as poverty, malnutrition, infectious diseases and unemployment (Barrett, 2010).

Developing a sustainable food system requires the enhancement of sustainability in food supply chains (Chiffoleau and Dourian, 2020). Food supply chains represent all actors and activities involved in making food available for the end customer, from harvest, through processing, distribution, retail to consumption (Mbow et al., 2019). In achieving food security, food supply chain management needs to ensure food quality, safety, freshness whilst also ensuring environmental sustainability (Zhong et al., 2017). Enhancing sustainability in food supply chains is perceived as essential for tacking the Sustainable Development Goals (SDGs), as the food and agriculture sector is directly or indirectly associated with each of the 17 SGDs (Dressler and Bucher, 2018; Pérez-Escamilla, 2017).

Our review of extant literature on sustainability challenges in food supply chains highlights three major challenges: food traceability, supply chain transparency and environmental impact that could potentially be addressed through Blockchain applications.

2.2.1. *Food traceability*

Food traceability is essential for food quality and safety and one of the biggest challenges to ensuring sustainability in food supply chains (Corallo et al., 2020). The interconnectedness and globalization of the food supply network creates vulnerabilities if food products cannot be tracked and traced throughout every level of the chain (Dabbene et al., 2013; Whipple et al., 2009). The vulnerability of food supply chains is mainly due to the nature of produce, as perishable goods require precise management to meet high standards of food safety and quality (Marucheck et al., 2011). Traceability is also essential for effectively managing recalls in supply chains (Kumar and Schmitz, 2011), as traceability can minimize risks and contain hazards which could compromise food security (Lyles et al., 2008; Turi et al., 2014).

Blockchain can potentially enhance traceability in food supply chains through decentralized and secure databases that ensure trust and safely store data allowing for better food security (Kshetri, 2018). It is argued that the absence of intermediaries in Blockchain applications can contribute to simplified and integrated supply chains, reducing the risks associated with recalls (FAO, 2019; Wang et al., 2021). Further, smart contracts could play an important role in Blockchain’s contribution to traceability improvements in agricultural value chains as they can better track products allowing for better verification of the product’s origin and quality (FAO and IUT, 2019; IFAD, 2019).

2.2.2. *Supply chain transparency*

The lack of transparency regarding labor practices and human rights abuses are key contributors to unsustainability within food supply chains (Teh et al., 2019; Trienekens et al., 2012). The complexity of food supply chains and geographic spread create opportunities for unsafe working conditions and modern slavery practices that violate worker’s rights (Maloni and Brown, 2006). The lack of transparency also contributes to fraud and corruption within food supply chains (Dabbene et al., 2013; (Silvestre et al., 2018). Fraud and corruption can lead to irreversible social and economic harm and therefore need addressing to achieve food supply chain sustainability.

This distributed trust mechanisms embedded in Blockchain technology has the potential to make supply chains considerably more transparent (Chang et al., 2019; Francisco and Swanson, 2018; Kopyto et al., 2020). As the data in a Blockchain is immutable and relies on the consensus of the network, unauthorized changes are not possible, which can assist in reducing fraud and corruption by ensuring the authenticity of agricultural products (Tripoli & Schmidhuber, 2019). By enhancing trust and multilateral collaboration among supply chain actors, Blockchain technology can also assist in creating an enabling environment for verifying and monitoring supply chain activities and ensure sustainable labor practices (Batwa and Norrman, 2020; Chang et al., 2019; IFAD, 2019; Kouhizadeh and Sarkis, 2018).

2.2.3. *Environmental impact*

The negative environmental impact of an unsustainable food supply system is driven by two interrelated issues: waste creation and pressure on planetary boundaries (Campbell et al., 2017; Dania et al., 2018; FAO, 2017; 2019; Govindan, 2018). It is estimated that one third of food produced is lost or wasted in supply chain activities such as harvesting, shipping, storage and the retail level (FAO, 2019). Alexander et al. (2017) find that overall food system losses are the highest in agricultural residues and other losses prior to the harvest, however, the highest rates of losses are associated with livestock production. For affluent economies, food waste and waste associated with packaging remains particularity high in the post-consumer stage (Parfitt et al., 2010; Schmidt and Matthies, 2018). Food loss and waste account for about 8% of global anthropogenic greenhouse gas emissions and therefore, represent a significant contributor to climate change (FAO, 2017).

An expanding world population has raised the demand for food which in return has led to an increasing pressure on our Earth’s biophysical limits. Campbell et al. (2017) find agricultural production to be

[1] https://www.un.org/development/desa/en/news/population/world-population-prospects-2019.html

the major driver of the earth system exceeding planetary boundaries Rockström et al. (2009), particularly to the two planetary boundaries that have been transgressed: (i) biosphere integrity and (ii) biochemical flows. Agricultural food production accounts for about 30% of global greenhouse gasses (Foley et al., 2011; IPCC, 2014) and occupies about 40% of the Earth's land (Clark et al., 2019), making food production one of the largest contributors to climate change (Swinburn et al., 2019). Besides the release of emissions from food production, transportation also contributes to raising greenhouse gas levels as food often travels long distances ("food miles") before it reaches the consumers plate industry (Maloni and Brown, 2006).

Blockchain has been put forward as a technology that can help address environmental sustainability challenges by offering a secure and verifiable record that can be used to reinforce entitlements to natural resources and incentivize environmentally sound actions (Le Sève et al., 2018). Voshmgir et al. (2019) highlight the potential of Blockchain applications for the implementation of the SDGs, of which the most promising cases were found in the context of SDG 7 (affordable and clean energy) and SDG 12 (responsible consumption and production). The potential of Blockchain to advance impact monitoring is another example of improving environmental sustainability (Kouhizadeh and Sarkis, 2018). Creating possibilities to show where food originates, how food is processed and distributed, and under which environmental conditions food is produced, Blockchain can reduce environmental impact and encourage the concept of a circular economy (Casado-Vara et al., 2018).

Table 1 below summarizes the linkages between sustainability challenges in food supply chains could and the attributes of Blockchain technology.

This short review exemplifies how Blockchain solutions have been touted as being able to transform supply chain management (Centobelli et al., 2021), as a "rare innovation that could provide both profits and social purpose" (Golden and Price, 2018, p.3), Building on these insights, we aim to explore how Blockchain technology could contribute to the triple bottom line view of sustainability through the combination of social, environmental and economic dimensions (Elkington, 1998). To do so, we now introduce the literature of Sustainability-Oriented Innovation (SOI) as a conceptual framework to understand how Blockchain is driving sustainability and innovation in global food supply chains.

2.3. Sustainability-Oriented innovation (SOI)

Sustainability-Oriented Innovation (SOI) "involves making intentional changes to an organization's philosophy and values, as well as to its products, processes or practices, to serve the specific purpose of creating and realizing social and environmental value in addition to economic returns" (Adams et al., 2016, p.181). The recent academic literature on SOI suggest three different types of innovation: technological, organizational and institutional/social (Adams et al., 2016; Jay and Gerand, 2015). Fig. 1 visualizes these three types of SOI.

INSERT - Fig. 1:A Continuum of Sustainable-Oriented Innovations

2.3.1. Technological innovation

Technological innovation is the first stage of innovating for sustainability and focuses on organization-level activities that reduce harm and improve technological efficiency though changes to products, processes or infrastructure (Adams et al., 2016). Product innovation involves improvements of the environmental/social performance of existing goods and services, such as eco-friendly materials, recyclability, product durability and longevity as well as fair trade and organic products (Jay and Gerand, 2015; Klewitz and Hansen, 2014). Process innovation aims to improve the overall eco-efficiency or social justice elements of business operations such as less polluting, safer and resource efficient processes or enhancing labor practices (Jay and Gerand, 2015; Klewitz and Hansen, 2014). Infrastructure innovation refers to a more far-reaching attempts to reconceptualize production and consumption

Table 1
Possibilities for Blockchain to address sustainability challenges in food supply chains.

Challenge	Issues related to challenge	Example of challenge	Examples: possibilities of blockchain to address these challenges
Food traceability	**Food insecurity** • Lack of quality and safety control • Risk to public health, spread of diseases **Lack of quality** • Contamination, spoilage	Horsemeat scandal in Europe 2013 E. coli contamination in bean sprouts in Germany in 2011	• Securely store data to enhance trust and reinforce food security (Kshetri, 2018). • Track and trace for better verification of the product's origin and quality (FAO, 2019; FAO and IUT, 2019; Francisco and Swanson, 2018; IFAD, 2019). • Transaction data can be safely managed through a blockchain network that is difficult to modify (Casado-Vara et al., 2018). • Traceability can contribute to increasing efficiency and effectiveness in supply chain management (Wang et al., 2021)
Supply chain transparency	**Human rights abuse** • Ensuring fair labor practices & wages, health and safety • Gender equality and social protection **Fraud & Corruption** • Manipulation and mislabeling of products • Power abuse for private benefit	Exploitation of small farmers Human trafficking in the seafood industry Milk quality incident in China in 2008 causing severe health issues to infants	• Historical performance and sustainability data can be made available on the Blockchain and thus ensure sustainable practices (Kouhizadeh and Sarkis, 2018). • The reliability and security of data can address fraud and other manipulative activities (Kshetri, 2018). • Blockchain-based supply chains can provide better assurance of human rights and fair work practices through verifying sources (Saberi et al., 2019). • Facilitate sharing and tracking of information and

(continued on next page)

Table 1 (*continued*)

Challenge	**Issues related to challenge**	**Example of challenge**	**Examples: possibilities of blockchain to address these challenges**
			promote multilateral collaboration (Chang et al., 2019; Wang et al., 2021) • Legal accountability for fraudulent behavior can ensure authenticity of agricultural products (Tripoli and Schmidhuber, 2018)
Environmental impact	**Waste creation** • Food loss & waste; • Food packaging; **Pressure on planetary boundaries** • Agricultural production as major contributor to global greenhouse gas emissions • Nature resource use	Approximately one third of the global food production is wasted Food production accounts for 30% of global greenhouse gasses and occupies about 40% of the earth's land	• Address environmental governance challenges by delivering secure and verifiable records (Le Sève, Mason, and Nassiry, 2018) • Product and material data and movement can be monitored through Blockchain, therefore providing the opportunity to trace green quality, recyclability, carbon footprints, resource use as well as waste (Kouhizadeh and Sarkis, 2018). • Blockchains could be used to verify that purportedly green products are environmentally friendly (Saberi et al., 2019). • Blockchain offers a unique opportunity to improve accountability and transparency in carbon markets and energy markets (Chen, 2018).

chains though the provision of adequate infrastructure such as setting up a recycling plant or improving the health, safety and development of employees (Jay and Gerand, 2015). Ultimately, all three types of technological innovation focus on doing the same things but better in terms of sustainability.

2.3.2. Organizational innovation

Organizational innovation aims to move beyond the concept of sustainability as an add on, towards consideration of how sustainability can be integrated within the organization, its culture, practices and overarching strategy (Adams et al., 2016). SOI on the organizational level means changing the nature of the deliverable in ways that aim to address social and environmental challenges (Adams et al., 2016; Jay and Gerand, 2015). Organizational innovation requires fundamental shifts in the value proposition, value creation & delivery and value capture at the core of the organization, which implies tackling "unsustainability at its source rather than as an add-on to counter-act negative outcomes of business" (Bocken et al., 2014, p.44). Research on SOI at the organizational level has focused on how organizational performance is enhanced through re-imaging business models in ways that prioritize sustainability (Buhl et al., 2019).

2.3.3. Institutional/Social innovation

Institutional innovation, sometimes referred to as social innovation, extends beyond the individual organization to a broader set of stakeholders and ultimately creates societal changes and requires a radical shift in perspective on the role of business in society (Adams et al., 2016). The creation of "system changing" innovations requires the mobilization of new systems solutions and collaboration between the private, public and civil sector (Adams et al., 2016). Game-changing systemic innovations stem from continuous dialog, partnerships and collaborative initiatives with different actors (Jay et al., 2015).

Research on SOI suggests that activities of innovating for sustainability are an ongoing, dynamic and an unfolding process that plays out on a continuum from technological to organization to institutional change (Adams et al., 2016; Klewitz and Hansen, 2014). SOI is a path that starts "from being internally oriented, incremental and efficiency-focused to being more radical and systemic" (Adams et al., 2016, p. 194). Before examining where Blockchain technology fits on this path towards sustainability, we review the literature on innovation resistance theory to focus our attention on potential barriers to Blockchain as an SOI.

2.4. Resistance to sustainability-oriented innovation

To unpack the barriers and challenges of Blockchain technology as a sustainability-oriented innovation we draw on the literature on innovation resistance theory (Ram, 1987; Ram and Sheth, 1989; Sheth, 1981). Innovation resistance is defined as the rejection, postponement or opposition to new products, services or process innovations based on "potential changes from a satisfactory status quo or because it conflicts with their belief structure" (Ram and Sheth, 1989, p. 6.). The rise of innovation resistance research has emerged in response to high failure rate experience by novel innovations, which poses questions beyond process of diffusion and adoption (Chen and Kuo, 2017; Kleijnen et al., 2009). Studying resistance to innovation aligns with critical studies of innovation that try to overcome the pro-adoption, pro-innovation and pro-change bias in the broader innovation literature, which often frames resistance as irrational (Bauer, 2017; Heidenreich and Handrich, 2015; Thomas et al., 2017). Through this lens, resistance is viewed as normal, expected, and thereby necessary to recognize and manage to facilitate and promote innovation adoption (Talke and Heidenreich, 2014).

Innovation resistance theorists contend that understanding innovation adoption and diffusion holistically requires an appreciation of rejection and resistance (Heidenreich and Handrich, 2015). As argued by Ram (1987), adoption of innovation only begins after resistance is overcome, and thereby the resistance perspective, rather than an adoption perspective, provides a more complete view of innovations after their conception (Godin and Vinck, 2017). Bauer (2017) utilizes the pain analogy to explain innovation resistance, maintaining that analyzing resistance focuses innovators on where attention is needed, encourages self-awareness by innovators, and assists in developing

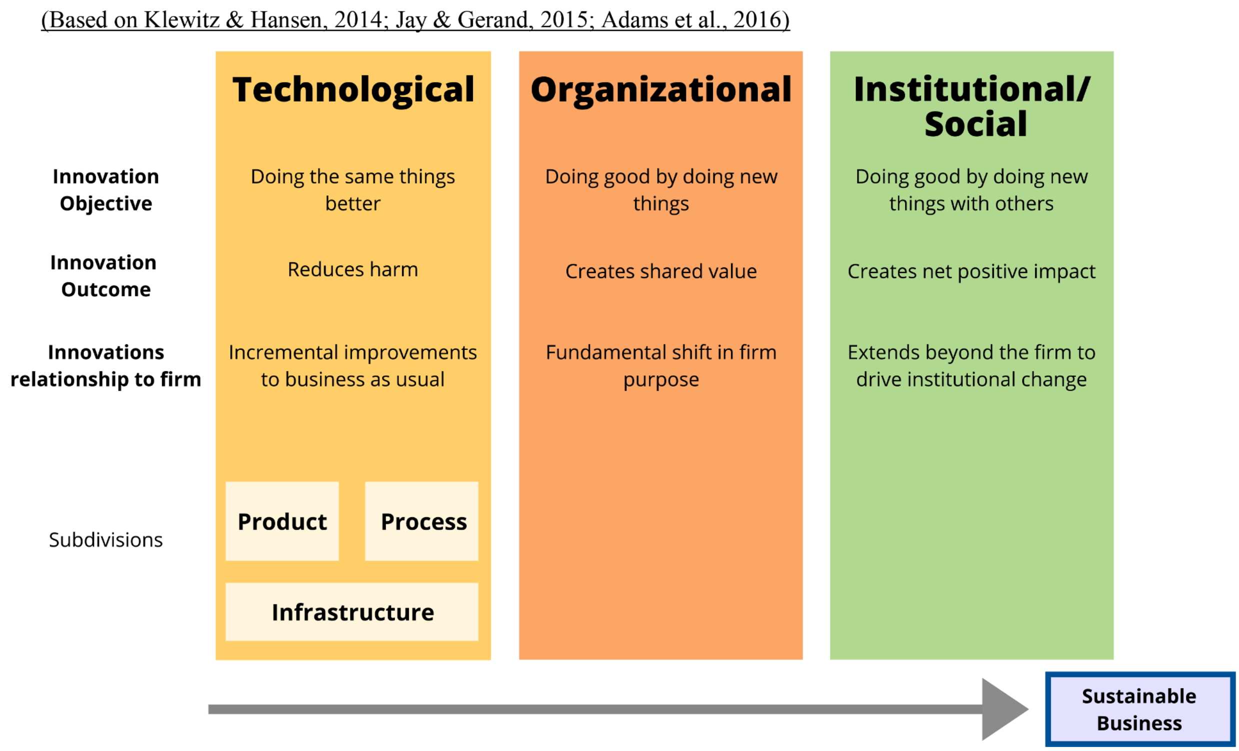

Fig. 1. A continuum of sustainable-oriented innovations (Based on Adams et al., 2016; Jay and Gerand, 2015; Klewitz and Hansen, 2014).

strategic adaptations. Focusing on resistance also shifts attention to the role of power and political influence on innovation (Thomas et al., 2017), highlighting how powerful social actors and incumbents shape innovation adoption processes.

The growing field of research on innovation resistance offers a counter to the wealth of studies on innovation adoption (Heidenreich and Handrich, 2015; Huang et al., 2021). Studies of innovation resistance have explored fields of direct relevance to our interest in Blockchain technology and food supply chains (e.g. Hew et al., 2019; Rieple and Snijders, 2018). Innovation resistance theory is particularly well suited to the study of sustainability-oriented innovation as it focuses our attention away from the proponents of innovation to also consider the counterpoints, and potential collateral impacts of innovation (Godin and Vinck, 2017). Understanding why innovations that are potentially useful for society are not diffused and adopted is essential for analyzing SOI (Hietschold et al., 2020).

Whilst innovation resistance theory has often focused on end consumers (Huang et al., 2021), we build on recent literature (Hietschold et al., 2020) that moves beyond the individual end consumer to explore how multiple actors throughout the supply chain are involved in innovation resistance. We consider the role of broad range of actors in innovation resistance including incumbents, NGOs, public institutions, and local communities (Godin and Vinck, 2017; Moldovan and Goldenberg, 2004). In doing so, we respond to Thomas et al. (2017) call to appreciate the diverse social actors engaged in socio-technical resistance, rather than focusing merely on innovators as proponents and end users as resistors.

2.4.1. *Forms of innovation resistance*

Innovation resistance theory general differentiates between two main forms of resistance: passive innovation resistance and active innovation resistance (Hietschold et al., 2020; Kleijnen et al., 2009; Rogers, 2003). Passive innovation resistance refers to resistance that takes place prior to the evaluation stage, based on negative predispositions towards innovation in general, without specific attention to the new product (Heidenreich and Handrich, 2015; Joachim et al., 2018). Passive innovation resistance is argued to emerge based on either (i) an inclination to resist change in general; and/or (ii) a satisfaction with the status quo (Huang et al., 2021; Talke and Heidenreich, 2014). Alternatively, active innovation resistance emerges from a negative evaluation of an innovation based on attitudes, intentions or behavior (Huang et al., 2021; Talke and Heidenreich, 2014). The active innovation resistance literature differentiates between functional barriers and psychological barriers (Antioco and Kleijnen, 2010; Ram and Sheth, 1989). We draw on the comprehensive typologies offered by Talke and Heidenreich (2014), and subsequently tested by Joachim et al. (2018), which summarize the dominant types of active resistance.

Functional barriers refer to resistance that stems from perceptions of innovations as dysfunctional or inadequate for needs and usage (Talke and Heidenreich, 2014). The main functional barriers explored in the literature are the value, complexity and communicability barriers. *Value barriers* emerge if the added performance and benefits are not perceived as significantly higher than current substitutes (Ram and Sheth, 1989). *Complexity barriers* occur when the technology is viewed as difficult to understand or use (Kleijnen et al., 2009). *Communicability barriers* emerge when it is hard to describe the benefits of an innovation (Rogers, 2003; Talke and Heidenreich, 2014). As summarized by Joachim et al. (2018) and Talke and Heidenreich (2014), other functional barriers include: *trialability* and *visibility barriers* which emerge when the innovation is not able to be tested or observed prior to adoption; *compatibility* and *co-dependence barriers* when the innovation is not aligned with existing practices or require additional products or services; *amenability barriers* when an innovation cannot be easily modified; and*, realization barriers* when to time horizons for benefits of the innovation are too far into the future.

Psychological barriers refer to resistance that emerges due to conflicts with users' prior beliefs and perception of risk associated with innovation (Antioco and Kleijnen, 2010; Kleijnen et al., 2009; Ram and Sheth, 1989). The main psychological barriers explored in the literature are image, norm and usage barriers. *Image barriers* are based on identity of innovation which may relate to branding or country of origin (Ram and Sheth, 1989). *Norm barriers* emerge when innovation clashes with societal or groups norms, traditions, values (Kleijnen et al., 2009; Ram and Sheth, 1989). *Usage barriers* occur when the innovation is not compatible with current practices and habits Ram and Sheth's (1989). Research on psychological barriers has also explored risk barriers including *functional risk, personal risk, economic risk* and *social risk barriers* (Joachim et al., 2018; Talke and Heidenreich, 2014). Building on these studies, our paper explores active resistance to Blockchain for sustainability in food supply chains.

3. Materials and method

In order to understand the opportunities and forms of resistance to Blockchain as a sustainability-oriented innovation (SO1) we conducted an exploratory qualitative study drawing on expert interviews. An exploratory approach was considered appropriate given the novelty of Blockchain technology, and the limited research on its implementation with food supply chains. Our study aimed to build on insights outlined the literature review on the potential alignment between sustainability challenges in food supply chain and the attributes of Blockchain. Through expert interviews, we aimed to uncover practical insights on the opportunities and resistance to the technology in food supply chains. As outlined in the previous section, our analysis of the interviews was guided by the conceptual framing of SOI (Adams et al., 2016; Jay and Gerand, 2015) and theory of innovation resistance (Ram, 1987; Ram and Sheth, 1989; Sheth, 1981).

3.1. Data collection & participant selection

Semi-structured interviews were conducted with participants with expertise with Blockchain applications in the food supply system. Utilizing semi-structured interviews ensured interviewees could share their knowledge and experience in an open way and allowed the exploration of novel themes (Gray, 2014). The interview questions were based on the literature on the challenges in global food supply chains as well as on Blockchain technology.

We targeted two overlapping groups of experts for participation in this study. First, we approached 'Blockchain expert', who were knowledgeable about the capabilities of Blockchain technology for sustainability. This first group of experts included Blockchain consultants, Blockchain researchers, IT experts, entrepreneurs and managers from relevant companies involved in digital technologies. The second group of experts were 'Food supply chain experts' who have been working implementing Blockchain technology within food and agriculture supply chains. We utilized the professional social network LinkedIn to identify and reach out to relevant experts. Additionally, the authors' own professional networks were used for finding potential interviewees. We invited 44 Blockchain experts and food supply chain experts to participate in the study. In total 18 participants agreed to be interviewed. Appendix 1 provides an overview of the interviewee's background, expertise, organization and sector.

The interviews were conducted between April and June in 2020. The interviews covered the following main themes: (i) sustainability-related problems experienced in organization's supply chain/s; (ii) applications and perceived application for Blockchain technology; (iii) challenges and resistance related to implementing Blockchain technology, (iv) drivers and benefits of utilizing Blockchain technology; (v) future outlook on Blockchain technology in food supply chains. We conducted the interviews remotely via phone calls and videoconferencing due to the restrictions related to the COVID-19 pandemic. The interviews lasted between 25 and 55 min, with 704 min of interviews conducted in total. All interviews were recorded and later transcribed by the lead author.

3.2. Data analysis

The transcripts were analyzed through thematic analysis, based on the steps outlined by Braun and Clarke (2006), and (Gioia et al., 2013). This approach aimed to uncover similarities and differences in expert opinions and interpretation on the potential for Blockchain whilst also generating unanticipated insights. The first stage of involved both authors reading that same transcript and discussing relevant insights. In the second stage of analysis, the first author inductively coded all 18 transcripts in the qualitative data analysis software ATLAS.ti to derive the first order categories that represent the dominant, reoccurring themes that emerged from coding of the interviews. We used the 'theoretical saturation' approach as we saw consistent themes emerge from the coding that we could utilize to distill our findings in higher order themes (Gioia et al., 2013); Glaser and Strauss, 1967). The third stage of analysis involved both authors discussing these first order categories and abductively linking them to concepts in the extant literature to generate the second order themes. In the final stage of analysis, the second order themes were clustered into aggregate theoretical dimensions in order to structure the findings section and the identify the contributions of the study. A detailed visualization of the data structure and the identified themes and theoretical dimensions is depicted in Fig. 2.

4. Findings

Our paper was guided by the research question: What are the opportunities for, and resistance to, Blockchain as a Sustainability-Oriented Innovation (SOI) in food supply chains? The analysis of the data reveals three major findings. First, a significant distinction was identified in which Blockchain was associated with a larger (i) philosophical mindset to drive organizational and institutional innovation or merely depicted as (ii) a tool to drive technological innovation for sustainability. Second, experts highlighted five opportunities of Blockchain as a SOI: (i) fraud and human rights violations; (ii) fairer supply chains; (iii) food traceability; (iv) financial benefits; (v) environmental benefits. Finally, the experts identify four points of resistance to implementing Blockchain for sustainability in food supply chains: (i) actively protecting the status quo, (ii) cooperative barriers, (iii) functional barriers and (iv) psychological barriers.

4.1. Mindset vs. tool

Our findings reveal a wide range of perspectives on the role of Blockchain technology in driving sustainability within global food supply chains. While some experts view Blockchain simply as a tool to contribute to sustainable innovation, others expressed how the philosophy behind the technology could drive organizational and institutional innovation.

4.1.1. The blockchain philosophy as a driver for organizational & institutional innovation

Proponents of the Blockchain philosophy argue that the aims of Blockchain are aligned with the objectives of sustainability in that it strives for equitable opportunities and for the empowerment of the disadvantaged. Many participants argue that Blockchain thereby goes beyond the technological application into a more philosophical state of mind:

[Blockchain] is really a cultural thing. Blockchain is a different kind of mind set (Co-Founder –Start-up 6)

You don't really implement a little bit of Blockchain, if you do a Blockchain then you need the ecosystem to use it. (Founder – SME 2)

This philosophy is strongly dominated by the notion of decentralization. One interview participant expresses that they use *"Blockchain to have redistribution by design…" (Head of Technology – Start-up 3)*. Interviewees consistently highlighted the decentralized nature of Blockchain as to this philosophy:

I believe in the decentralized future a lot. It's not a set central body trying to take all, it's not a winner takes all; it's a team taking all… So, I do think that everybody getting their fair shares is a way more

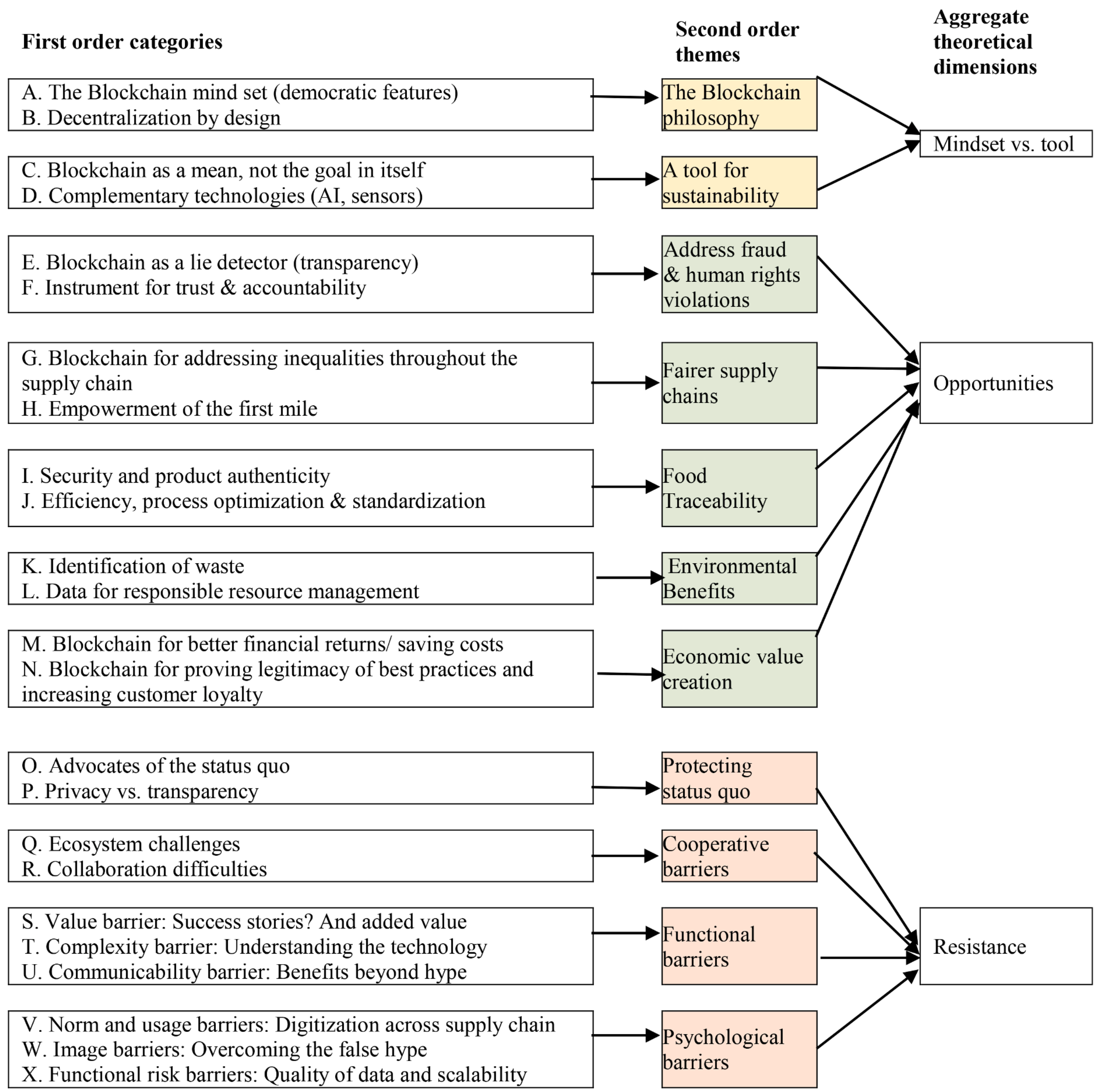

Fig. 2. Visualization of data structure.

sustainable solution of working together. (Co-Founder – Start-up 6).

And I think this is what you see in the Blockchain community, this ethos of using power and having new basis of democracy in a decentralized place, global economy and global world and power to the people. Some of the Blockchain enthusiasts also have this political object. (Founder – SME 2)

Participants also reflected upon how this philosophy is underpinned by the principle of democratic participation, that strives for openness, collaboration and shared value creation for the common good that leave little room for distrust and fraud.

Blockchain is more democratic in the very nature of being decentralized (Founder – SME 2)

If you can trap truth in a block, and have it publicly available, then you can hold companies accountable. (Head of Entrepreneurial Development – Research 5)

Taken together, democratic participation and decentralization are central to the Blockchain philosophy which align with the sustainability principle of equally respecting the needs of society. The notion of redistributing wealth and power is also addressed by the sustainability agenda as it aims to grant every person their fair share. Similarly, the goal of eradicating fraud and activities of exploitation can be found in both the Blockchain philosophy as well as the principles of sustainability.

I think blockchain can and will be a powering tool for sustainability. And I think the reasons for that can be pretty simply distilled down to if we look at the actual, original reasons that Bitcoin was created, it all had to do with trust, transparency, and inclusion. And if those things don't define the current push for sustainability, I really don't know what does. (Founder - Start-up 8)

This focus on fairer structures, creating shared value and positive impact as key principles of the Blockchain philosophy highlight its role as a sustainability-oriented innovation for organizational as well as systemic social change.

Why not operate ethically and morally? If we build a system that exposes, and reinforces good behavior and dissuades bad behavior, then everyone wins. (CEO & Co-Founder– Start-up 5)

When prioritizing equality, democratic participation and respecting the needs of society blockchain functions as an innovation that radically reshapes organizations and institutions in a more sustainable and just way.

4.1.2. Blockchain as a tool to drive technological innovation for sustainability

In contrast to the Blockchain philosophy, many experts view Blockchain technology as "*just another technology [which] will play a role in applications" (Founder – SME 2).* This finding reveals how Blockchain is perceived merely as a tool for sustainability but not more or less important than other technologies or innovations. Some experts suggested that Blockchain is a means to achieve a goal like food traceability but that "*having Blockchain can never be a goal in itself" (Logistics Manager – SME 1).* This finding suggests that the technical element of Blockchain only constitutes a small part of an entire project in which it can be utilized, and that sustainability motivations themselves are key for creating meaningful impact. Through this lens, Blockchain is merely as a tool for sustainability that contributes on a technological level for organizational optimization and is not believed to cause institutional change.

To reiterate the point that Blockchain technology is not sustainable in its own right, one expert describes Blockchain as a tool that "*can be applied to both sustainable and unsustainable uses and supports both equally*" (*Co-Founder – Start-up 6).* For Blockchain to be a tool for sustainable practices, many experts see the need for complementary technologies:

Blockchain won't change the world. Basically, how I see it is that IoT [Internet of Things] and other devices will generate data. AI will interpret that data and we need to have a way to safely secure the data and that's where Blockchain and distributed ledger technologies come in. (Co-Founder – Start-up 6)

Several interview participants identified AI (artificial intelligence), sensors and IoT (Internet of Things) devices as necessary complementary technologies that enhance the trustworthiness of data. For example, machine learning could be helpful to predict when things will go wrong - such as a foodborne disease (*Co-Founder – Start-up 6*). This finding reveals that Blockchain serves predominantly as a data record system and has little potential for generating and interpreting data for sustainable practices. It can be framed as a single tool needed in a larger toolbox of technologies or as an "*enabling technology… that will have a contribution but will not solve the sustainability problem"* (*Founder, SME 2*). As a result, Blockchain by itself is not inherently sustainable or unsustainable; it depends rather on how it is applied that demonstrates its potential for SOI. The same respondent (*Founder, SME 2*) further elaborates that Blockchain "*is not synonymous for innovation*" and that "*innovation is a lot more than Blockchain*". This concern was also put forward by a Blockchain Growth Agent (*Start-up 1*) by stating that "*it is just a technology to store data in a way that you know where it comes from in a collective way*". These quotes emphasize the critical viewpoint on the technology for driving SOI and offer a counter to the initial hype for Blockchain.

Our findings thereby reveal diverging opinions on where to place Blockchain technology on the continuum of SOI. While the blockchain philosophy advocates would agree that blockchain is driving wider organizational and institutional changes, the participants limiting blockchain to its technological capacities do not see this potential without other components such as complementary technologies and core sustainability motives.

4.2. Opportunities for Blockchain in food supply chains

The experts highlighted five opportunities for Blockchain as a sustainability-oriented innovation in food supply chains. The expert insights suggest that Blockchain's potential is greater for the social and economic dimensions of sustainability than for the environmental dimension. The environmental benefits of Blockchain technology appear to be a positive flow on effects from the economic motives and therefore, do not appear to constitute the main objective of Blockchain for food supply chain sustainability.

4.2.1. Blockchain for addressing fraud and human rights violation

Blockchain is a technology that can enhance transparency for both upstream and downstream actors in food supply chains. The participants highlight that a transparent supply chain is crucial for addressing fraud and human rights violations by providing reliable information on labor practices and ensuring product authenticity. One interview participant spoke about the role of Blockchain *"as a lie detector" (Head of Technology – Start-up 3),* referring to the technology's ability to shine light onto negative supply chain activities such as exploitive behaviors, mislabeled products and unequal value capture. The real-time visibility afforded by Blockchain can help to detect and reduce unethical practices. For example, Blockchain technology can be used to monitor and reveal when low quality products are sold as first-class items (*CEO & Co-Founder – Start-up 2*) or when environmental conditions (such as temperature), necessary for food security, are upheld (*CEO & Co-Founder – Start-up 5*).

The responses show that another "*key element of Blockchain is that it brings trust" (CEO – Start-up 4)* by providing customers and retailers with data on the product origin and on the operations and management through the supply chain. Allowing for more visibility, Blockchain serves as *"a tool [in] helping to supervise that the rules are being followed" (Supply Chain Director – MNC 1).* This element of trust is essential for food retailers to prove the legitimacy of their products to their customers and also creates reliability among the supply chain actors. For example, Blockchain can verify to farmers that their products are sold for the right price and that they are receiving a fair share:

With blockchain you have the potential to shift the profit margin because if you have that level of trust then the costumers say: "wait a minute why am I paying $30 a pound when the fishers are only getting $4?" And in the supply chain with blockchain it makes it a lot more difficult for those unscrupulous middlemen to exploit that. (Program Manager – NGO 1)

The experts explain that *"Blockchain technology is about accountability" (Program Manager – NGO 1)*. The technology helps to hold entities accountable for their decisions and behaviors and proves the validity of claims by connecting all relevant supply chain actors. For instance, Blockchain can verify whether the retailer's claims on the labor practices and origin of a product were upheld. Similarly, retailers can be assured that the products from their distributors comply with their health standards and labor conditions. The following quote exemplifies a way in how Blockchain can contribute to accountability:

We could connect to the organic certification agency platform to confirm from their Blockchain wallet, that it's actually organic. So, we're looking into ways to add more and more information to prove the legitimacy of the sustainability claims in the platform. (Blockchain Growth Agent – Start-up 1)

Transparency, trust and accountability are elements essential for the social dimension of sustainable development they assist with enforcing human rights, food security and identifying exploitation and fraud. These elements are also beneficial for the economic dimension because they enhance customer's loyalty and reduce financial exploitation and other hazards.

4.2.2. Blockchain for fairer supply chains

Respondents identified an unequal distribution of wealth across food supply chains as another key social sustainability challenge that could be addressed through Blockchain technology. As explained by experts within two start-ups, Blockchain as a data sharing platform has the potential to equally involve all actors in the supply chain:

We have unethical businesses; we have small business being abused by large business. If we level the playing field with Blockchain, if we get people egalitarian access to the data, then we can start to address some of these inequalities". (CEO – Start-up 5)

Blockchain enables democratic features in accessing and providing data that can drive social sustainability. For example, a consumer could receive insight into a farmer's wage for a given product and see if this gives the farmers an opportunity to earn a decent living income, thereby driving financial inclusion across the supply chain.

One of the things that Blockchain can do most powerfully is change the financial realities for the origins of our supply chains. It can be used again as a means of credit, it can be used as a means to actually help people migrate from cash into digital, which can be more easily saved and built up over time. (Founder - Start-up 8)

Empowering those who before had little say in production and distribution decisions is an avenue to making food supply chains fairer. The interviews revealed that the supply chain actors within the first mile of the product (such as farmers, fishermen, etc.) are generally disempowered. Applications of Blockchain technology can empower the disenfranchised actors through enhancing fair treatment, and social and financial rewards, as exemplified in the following quotes:

So, what we're trying to do is to connect consumers to our farmers using a loyalty mechanism that runs on Blockchain. (Head of technology – Start-up 3)

Once you've got the that first mile captured… you then also have the identification needed to capture the human slavery elements. So, even in terms of social impact you can reward best practices… (Founder – Start-up 4)

These insights show that a set of opportunities can be created for the first mile by utilizing Blockchain that extend well beyond equal treatment within the supply chain. Once Blockchain is implemented and the supply chain is digitized, the infrastructure for financial rewards and incentives will be better aligned. The interviewees suggest that creating fairer supply chains also creates economic benefits as customers become more easily connected to the first mile. For instance, the Head of Technology from Start-up 3 describes their initiatives on *"tipping the farmer"* which utilizes Blockchain to embrace the idea of a fairer value distribution among the supply chain that provides customers with possibilities to contribute to impact programs. Working towards a living income for farmers this start-up uses the technology to simultaneously address social and economic sustainability challenges:

We're working on a micro lending mechanism where consumers lend money to farmers. So again, consumers connect to farmers…and then consumers like you and me and provide micro loans to farmers. (Head of Technology – Start-up 3)

4.2.3. Blockchain and food traceability

The experts argue that the underlying features of Blockchain technology can enhance food traceability which can ensure food security and hazard control. As food diseases represent a health threat to customers, food traceability is important for minimizing outbreaks. Food integrity is an important part of sustainability as it addresses the wellbeing of customers as well as the financial health of retailers that are held accountable for the food hazards.

The experts emphasize that the security and authenticity of food data is the first aspect necessary for food traceability. Blockchain technology can address concerns on data security and authenticity cryptography, a method of storing and transmitting data that can only be changed through authorized peers. As Blockchain "*provides a cryptographic seal… that is stamped and distributed all over a community, so, that it cannot be messed around with*" you can *"create traceability which in return creates trust" (Professor – Research 3)*. The safety of the data as well its authenticity provides more security in terms of the product's information and location. One participant illustrated the value of security for product authenticity as follows:

Can someone still game the system and figure out another way to have their product somewhere else? Yes, but you are making it much harder. You are having more control mechanisms. It is like thinking of theft. Can you eliminate theft 100%? No, but you can make it much harder for people… to defraud the system. (Associate Professor – Research 1)

While the security of the data is crucial for food integrity, the collection of data points in real time also provides opportunities for instant access across the supply chain, which allows for quicker responses to food hazards before reaching the consumer. The economic benefit of this efficiency is one put forward by the interview participants:

We have information, everyone sees this, we can see this information quickly. So now rather than a few weeks with a Blockchain platform you can do this [food recalls] in less than 5 s. (Associate Professor – Research 1)

The experts suggest that food traceability on Blockchain can be much more efficient in terms of time as well as pinpointing the exact product origin. Additionally, Blockchain technology drives greater efficiency through encouraging supply chain standardization:

[Blockchain] circumvents the interoperability issue… basically getting around this whole issue of having to translate different software languages by just one system where everyone's already bought into the same IT infrastructure" (Research Fellow – Research 2).

4.2.4. Blockchain for (shared) economic value creation

Despite the strong links to sustainability objectives, many experts emphasized how the adaption of Blockchain technology in food supply chains is driven by financial interests: "*money is the driver" (Co-Founder – Start-up 6)*. While "*[sustainability] is a great side effect" (CEO – Start-up 7)* of attempts to reduce cost, the sustainability motive is not viewed by all experts as the main reason for utilizing the technology. Cost savings are identified as a core economic driver for implementing Blockchain. For example, Blockchain increases efficiency in food recalls by allowing quicker and more precise access to product information. This also includes a reduction in unnecessary food waste, as the granularity and accuracy provided by the technology prevents entire products from being discarded due to a possible health risk. Furthermore, reduced transaction costs through Blockchain lead to larger economic value capture for businesses by removing the need for third parties.

Next to the direct financial benefits of utilizing Blockchain the indirect financial opportunity of enhanced customer loyalty was consistently highlighted by the participants. Many experts reflected on how customer preferences sustainability in food supply chains was driving the adoption of Blockchain technology and placing companies are put under increasing pressure to reveal provenance:

And the big driver here is the consumer, so people are getting more and more aware of what they're actually purchasing. And they want to have an insight into their footprint of the things they buy. So how is that impacting people? And I think that's also the catalyst for start-ups that come up with solutions. (Co-Founder – Consultant 2)

There's this whole movement going on. Consumers now are becoming more aware. Ecological products are selling better at a higher margin in retail… the consumer will be more willing to pay slightly more money to know that the product is being/ has been produced in a good way. In order to ensure that blockchain can provide a role there, because it stores data in a way that cannot be changed and manipulated. Now, that's a that's a value added. (Founder & owner, SME 2)

In this context, it was expressed that Blockchain can be helpful for companies who want to prove the legitimacy of their sustainable practices to their consumers. For instance, the Supply Chain Director from MNC 1 stated:

"[with Blockchain,] you have the technological means to control the whole flows along the supply chain and make sure that what is produced is indeed responsible and sustainable. So that is the benefit of Blockchain for us as a company to accelerate and extend sustainability".

Similarly, the CEO of Start-up 2 explained that they use Blockchain to help food producers deliver "*proof to their customer base*" and to "*maintain [their] market growth*" and that in revealing the product's facts they can benefit from attaining "*a competitive advantage*". This CEO also shared the outcomes of their traceability pilot on high quality mangos that are now seeing the highest acceptance rates into food retailers. As a result, Blockchain can create value for food retailers by increasing customer loyalty. Blockchain can also create economic value for food producers by providing product authenticity. Question remains about the extent to which this economic value creation is shared across food supply chains. This criticism was also expressed by a respondent who stated that Blockchain applications will be marketed from the start as a sustainability project but "*ultimately, [they are] efficiency projects*" (*Co-Founder – Start-up 6).* This concern highlights the issue of greenwashing which questions the initial motivations for Blockchain applications and draws a fine line between economic value capture and sustainability outcomes.

4.2.5. Blockchain and environmental sustainability

As touched upon in the previous section, Blockchain technology can be used for reducing food waste in food supply chains. As one participant points out: "*it's about saving costs… in the end, it's all about saving resources. So, reducing waste, saving time for shipping, saving time in general. So, it's more about all the reductions of resource by using Blockchain" (CEO – Start-up 7).* Blockchain affords better traceability of products throughout the supply chain, which in turn enables more efficient use of the food and prevents it from going straight to the landfill. While the motivations for reducing of resource use may differ, Blockchain holds the opportunity to create environmental benefits through addressing unnecessary waste:

When products are expired and the ability to track when those products are expiring… with things that have a very short shelf life. You probably find that a lot of those product are being discarded improperly… There could have been more use of those products. (Associate Professor – Research 1)

The highly digitized and visible environment in which Blockchain operates provides also offers opportunities for responsible resource management. One participant highlighted how this visibility could drive environmental practices in the seafood industry:

…You can get to a point where they can have some rights-based fishery management in place … and then you can get some control over what is the carrying capacity, where they're fishing and things like that. So, you can actually have some management. (Founder – Start-up 4)

This quote exemplifies how Blockchain technology, once in place, provides the necessary data that can offer insights into the consumption of resources occurring in the supply chain. Therein lies the opportunity for making use of that data for sustainable resource management, which would address a major ecological objective of sustainable development.

4.3. Resistance to Blockchain technology in food supply chains

The experts highlight four main forms of resistance for implementing Blockchain technology as a SOI in food supply chains: (i) active resistance through protecting the status quo; (ii) cooperative barriers; (iii) functional barriers; and (iv) psychological barriers. These forms of resistance highlight obstacles that need to be overcome to realize Blockchain's potential for sustainability in food supply chains.

4.3.1. Protecting the status quo as active resistance

Our findings suggest that satisfaction with, and protection of, the status quo is the most dominant form of resistance to Blockchain technology as a sustainability-oriented innovation. Rather than serving as a passive form of resistance, the interviewees reflected on how incumbents who benefit from current unsustainable practices are actively resistant to the transparency offered by Blockchain. These supply chain actors who benefit from the status quo appear to be actively resisting the implementation of the technology. The transparency and accountability Blockchain provide are troubling for some supply chain actors that benefit from opaque or fraudulent behavior, for instance the "*middlemen that aren't providing value and have been relying on information asymmetry as their business model" (Program Manager – NGO 1).* Resistance comes from the beneficiaries of the status quo that require a non-transparent supply chain to capture economic value for themselves. This type of resistance was emphasized also by a Co-Founder (*Start-up 6*) who expressed that "*the status quo benefits from a lack of transparency. So, they will try to do everything to keep the status quo."*

Another form of active protection of the status quo stems from "*a privacy and competition data sharing perspective" (Supply Chain Director – MNC 1).* This ultimately boils down to those actors who are concerned about the trade-off between privacy and transparency. Interview participants expressed that a limited openness to data sharing is a challenge and that those resisting this mindset are often concerned with privacy questions and the misuse of their data. This distrust extends to the unwillingness to participate in a more transparent data sharing network as this may force actors to share "*commercially sensitive information*" *(CEO & Co-Founder, Start-up 2).*

A fear of accountability becoming mainstream practice remains a key issue for certain governments, businesses and institutions which hinders transparent systems from becoming the new norm (*Head of Entrepreneurial Development – Research 5*). A Co-Founder (*Start-up 6*) points out that "*sustainable practices will cost them more money… so they are trying to hold on to the status quo as long as they can*". What seems like a concern on privacy related matters may reveal an underlining fear of becoming exposed to unethical practices which are associated with great costs once exposed. Ultimately, the findings show that active resistance occurs at different ends, whether it is the profit exploiting middleman or privacy concerned retailers, this resistance to transparency based on protecting the status quo creates continued challenges for supply chain sustainability.

4.3.2. Cooperative barriers

Through focusing on the supply chain, we observed another form of active innovation resistance, *cooperation barriers*, not explored in the extant innovation resistance literature. Cooperation and collaboration difficulties appear to be a reoccurring challenge in implementing Blockchain as a SOI, as forwarded in the following quote:

The biggest problem is getting the ecosystem working, building a coalition of the willing and somehow addressing all the conflicting interests of the different parties in the chain. (Founder – SME 2)

Several forms of resistance identified by the interviewees relate to cooperative barriers involved in building the Blockchain within the food supply ecosystem. Involving the myriad actors in a food supply chain requires careful design decisions on who will be part of the ecosystem. This influences decisions on whether to use a public or a private Blockchain, and who will be granted access to the Blockchain before implementation. Uncertainty on which design to choose and who will be part of the ecosystem is an important component of this challenge that is put forward by the CEO from Start-up 2 as in their case "*it was more of an internal facing challenge of what are we going to use and why"*. This quote highlights the organizational challenges on figuring out what type of Blockchain is the most suitable. Another interviewee highlights that "*it is not just a software you are downloading… the organizational culture is a completely different way of doing business" (CEO – Start-up 7).*

The presence of cooperation barriers raises the question: *"how do you incentivize different entities to be part of this?" (Associate Professor – Research 1).* One expert gave the example of Walmart, in which its suppliers were required to participate in the Blockchain initiative, however, Walmart incentivized them to cooperate by helping them understand this would also reduce their food loss. Whereas incentives are key for overcoming collaboration difficulties there remains the issue of "*each system running independently*" (*CEO – Start-up 5*). Similarly, a program manager (Research 4) stated that "*standardization and working together, etc. is more difficult to achieve than just simply adding or using new technology"*. This provides evidence that there is a lack of willingness to cooperate among the different supply chain actors.

4.3.3. Functional barriers (value, complexity and communicability)

Experts identified three key functional barriers contributing to resistance of Blockchain applications for SOI in food supply chains: value, complexity and communicability barriers.

Value barriers were identified throughout the interviews when experts described a lack of success stories of Blockchain applications. Many experts explained that the initial excitement for Blockchain in the past years did not equate to realized sustainability benefits of the technology. A Supply Chain Director (*MNC 1*) offered a counter to the excitement for Blockchain arguing that "*the overall benefits so far, do not seem to be too big*" and that "*there are other ways to reach similar goals in an easier way*". The potential benefits that Blockchain brings were viewed by some experts as not outweighing the new challenges that emerge. In response to lacking success stories, many respondents suggested that Blockchain may be unnecessary, and could be viewed as "*only marginally better than an independent database" (Program Manager - NGO 1)*. It appears many supply chain actors are concerned that Blockchain is overrated and that simply using better databases could reach the same goals.

Complexity barriers stem from perceptions that an innovation is difficult to understand or use (Joachim et al., 2018). The complexity and lack of education regarding Blockchain technology emerged in our study as contributing to the false expectations surrounding Blockchain technology. This theme was found as participants expressed that "*for many people, Blockchain is something they don't really understand"* and that "*there certainly is an issue of skills" (Professor– Research 3)*. The following quote also exemplifies how this challenge:

When it comes to implementing it [Blockchain] for business, it has two other big issues: very few people understand how it works, and most management teams don't have the time nor interest in learning about it. (CEO & Co-Founder– Start-up 5)

Many respondents suggested that a lack of awareness and understanding for Blockchain exemplified by people's frequent confusion between Blockchain and Bitcoin. Similarly, confusion also arises between the distinction of public and private Blockchains and about the degree of privacy for both. This complexity barrier is further explored by the founder of SME 2 describing that "*many people when they hear about Blockchain, they have absolutely no clue what it is. Absolutely no idea.*"

Many respondents also suggested an overall sense within food supply chains that Blockchain is too difficult to use. The difficulty goes beyond the design challenges to lacking skills and increasing complexity which includes a lack of literacy (*Head of Technology - Start-up 3*) and legal complexity (*Program Manager - Research 4*). The perception of Blockchain being a problem solver for every sustainability issue is therefore misleading and does not acknowledge the knowledge and skills needed for applying the technology.

Communicability barriers were regularly cited by the experts as a reoccurring challenge due the inability of supply chain actors to articulate the need for Blockchain in its applications. Many supply chain actors appear to be utilizing Blockchain technology without a clear understanding of the sustainability problem they are addressing. As reflected in the following quotes, the 'cart is leading the horse' in many cases when it comes to Blockchain adoption.

Blockchain was put forward in all sorts of application areas where it was simply not feasible. (Founder - SME 2)

How does it [Blockchain] help my business? And that's where I think a lot of Blockchain for food companies are running into a wall is that they don't have an answer to that question. (CEO & Co-Founder – Business 5)

This challenge highlights the need for companies to clearly think about the technical or sustainability issues they are trying to solve and to evaluate whether Blockchain is the right solution to the problem. The experts note that *"there are a lot of organizations that hear the buzzword Blockchain. And they say, we're going to find a problem that can be solved with this. That is the wrong way" (CEO – Start-up 7)*. As there are "*a large number of people who associate Blockchain with innovation*" *(Founder – SME 2)*, the hype for the technology is a reason for many businesses to utilize Blockchain. The interviewees suggest that this hype can quickly translate into false expectations of the capacities of Blockchain. Subsequently, the hype can trigger an eagerness to make use of the technology without understanding its purpose.

4.3.4. Psychological barriers (norms, usage, image and functional risk)

Experts identified norm barriers, usage barriers, image barriers and function risk as psychological barriers contributing to the resistance of Blockchain in food supply chains.

The experts identified *norm* and *usage barriers* as the most common psychological barriers to Blockchain as a SOI. The interviewees highlighted the Blockchain technology, and its focus on transparency, offered a challenge to norms and traditions and established ways of working within global food supply change. There is a perception that implementing Blockchain technology requires a willingness to disrupt norms within the supply chain by embracing the ideas transparency and decentralization.

When thinking about Blockchain in supply chains, it necessitates psychological commitments… It is a huge thing just understanding the psychology of the organizational logic if you have to orient your whole infrastructure around the changes. (Founder - Research 2).

This challenges to norms within the supply chain are compounded by usage barriers linked to undesirable disruptions to established patterns and workflows. A representative from MNC 2 highlights that much of the data required for Blockchain to function does not exist, particularly not in mass manufacturing for example of dairy products. Next to lacking data, a Supply Chain Director (*MNC 1*) underlines that "*at the end of the day you need to be ensured that in the day-to-day business that the [Blockchain applications] are very easy and simple applications which can be used by a farmer for example*". Also, a logistics manager (*SME 1*) emphasizes this usage barrier through pointing out the issue of human error when things go wrong. For overcoming this barrier, a Supply Chain Director (*MNC 1*) states that "*trusted partners*" and "*good collaboration*" are key and that these conditions should not be underestimated.

Finally, the data reveals that there is no consensus over the technological maturity in developing countries. Opposing experiences on whether farmers/fishermen have the necessary technological equipment to participate in the Blockchain ecosystem and to enter their data were identified as further usage barriers. This can be seen in the following quotes:

The farmer does not have his own smartphone yet, not all of them at least. It's not like they're on the fields and they're entering the data. We want to go there but it's not there yet. (Head of Technology – Start-up 3)	What we've seen… is that the crew will have smartphones and that the crew will have less income but they will have a smartphone because… these smartphones are very, very affordable. (Founder – Start-up 4)

Image barriers were identified related to the negative connotations associated with the initial hype for Blockchain applications. This image barrier reveals a form of resistance against the Blockchain hype and the false expectations many have experienced. Many experts explained how much of the work they are doing to implement Blockchain technology involves overcoming these early misconceptions and false expectations.

The promises have been made in 2017 that Blockchain is going to change the world. We are trying to recover from all those false statements. (Co-Founder - Start-up 6)

They were proposing Blockchain as a solution in application areas where it was not appropriate. (Founder - SME 2)

The resistance to the hype was further expressed by questioning the technology's novelty. For example, one expert highlights that Blockchain "*is innovative in the way we use it but [that] the technology itself is not new… It is not the thing that's going to fix everything for us; It's just helping us get from A to B*" (*Associate Professor - Research 1*). Similarly, a Founder (*SME 2*) describes Blockchain as "*just a special type of database*" and Start-up 3 believes that "*the technology does not make a difference*". Although the enabling capacity is emphasizes throughout the respondents, some remain resistant, aligning with the notion that Blockchain is merely a tool, and "*will not solve sustainability issues by itself*" *(Supply Chain Director - MNC 1)*. The negative connotations that result from the resistance to the hype present another barrier to successful sustainability applications of Blockchain.

Finally, the data reveals technological limitations of Blockchain create *functional risk barriers.* The need for clean data in Blockchain applications is vital "*or no one will trust Blockchain" (CEO & Co-Founder– Start-up 5)*. As Blockchain is "*not just about getting data, you have to get good data"* the challenge is "*garbage in garbage out"* and the question then becomes: *"how do you prevent that from happening?" (Program manager - NGO 1)*. This shows Blockchain is limited by trustworthiness of data entry. This technological limitation was expressed by the Logistics Manager from SME 1 who participated in a Blockchain pilot for their cocoa supply chain. For them the main difficulty was making sure that the number of kilos of cocoa beans harvested corresponds to the number logged onto the Blockchain. Especially in supply chains with tangible goods a question arises which this quote exemplifies:

How do I trust or know for sure that whatever they typed in digitally is equal to what physically happened? Blockchain is also not going to increase the level of trustworthiness that the digital transaction and the physical transaction are equal. (Logistics Manager – SME 1)

5. Discussion

This research sought to understand how Blockchain technology addresses sustainability in global food supply chains and its role as a SOI for food supply chain management. The findings reveal that Blockchain is used within food supply chains as a tool for sustainability as well as a broader philosophical mindset for addressing sustainability challenges. We show that the opportunities for Blockchain technology link more to the social and economic pillars of sustainability, with comparatively less opportunities for environmental sustainability. Finally, we expose multiple forms of active resistance that hinder Blockchain's potential as a SOI.

5.1. The Blockchain philosophy for embracing sustainability objectives

The findings suggest that Blockchain technology has the potential to be more than a tool for sustainability due to its underlying philosophy that aligns with the objectives of sustainability. Blockchain proponents are guided by the principles of democratic participation and decentralization. Both principles have important contributions to sustainability.

Democratic participation provides the freedom to defend basic rights, protect justice, ensure equal representation, and exercise common responsibilities to respect life on earth (Shiva, 2005; UNDP 2003). Democratic participation as a principle of the Blockchain mindset strengthens its capacity as an innovation for sustainability (Chang et al., 2020; Marsal-Llacuna 2018; 2020). Building on the SOI literature, this move from a technology focus to a people focus is what Adams et al. (2016) describe as the incremental process of SOIs. Through its democratic features, Blockchain shows potential to move beyond a technological innovation to become a social/institutional innovation. As "technological innovation will be necessary but not sufficient for sustainable development" (Jay and Gerand, 2015, p.19) the need to understand Blockchain's democratic features in addition to its technological capacities is essential. The democratic philosophy of Blockchain should not be underestimated for delivering impact as equal involvement of all supply chain participants in innovating for sustainability is necessary to expand to societal change and go beyond incremental improvements to business as usual.

Blockchain's decentralization principle is also beneficial for sustainability outcomes as it can drive the distribution of value to farmers and other marginalized supply chain actors (Chang et al., 2020; Pazaitis et al., 2017; Pereira et al., 2019). The absence of a central authority helps for the empowerment of the individual actors (Ward, 2008), which helps to overcome corruption. Decentralization can lead to higher co-operation over competition and can facilitate strategic partnerships which can be beneficial for distributing sustainability responsibilities (Biswas et al., 2018).

A more critical examination of the philosophy, however, reveals possibilities for unsustainable practices to emerge through the implementation of Blockchain technology. We must question to what extent decentralization provides equal opportunity for all supply chain actors. Granting farmers access to the Blockchain does not automatically translate into more decision-making power and could also be perceived as a form of coercion through requirements to provide necessary data. We need to examine how democratic Blockchain applications actually are, and if they indeed fulfill the philosophy of equal opportunity. When it comes to advancing sustainability, centralization may even be beneficial for enforcing good governance and responsible resource management (Andrews, 2006). Taking this argument into account, a centralized regulatory body may be necessary for achieving sustainability as it reduces "free-riding" by punishing those who pursue exploitation (Isaac and Walker, 1988). The Blockchain philosophy must therefore be embraced with caution and must reveal clear objectives for sustainability, rather than a push toward a pure free-market ideology.

5.2. Blockchain as a sustainability-oriented innovation

Our study reveals five opportunities for Blockchain to advance sustainability within food supply chains: address fraud and human rights violations; ensure fairer supply chains; enhance food traceability; deliver environmental benefits; generate shared economic value creation.

The findings show the potential of Blockchain for food traceability and supply chain transparency. This validates Blockchain's potential for the social and economic dimensions of sustainability. Blockchain can assist in addressing social challenges by providing opportunities to legitimize human rights and fair work practices (Saberi et al., 2019), and address fraud and corruption and ensure food security (Kshetri, 2018). The findings also highlight the opportunity for Blockchain to contribute to wealth distribution across the supply chain by establishing a direct connection between customer and farmer/ producer. This insight adds to the literature in that Blockchain offers opportunities for shared value creation between supply chain actors, especially for businesses aiming to improve their social impact (Porter and Kramer, 2019).

The findings on economic value creation align with the potential of Blockchain dealt with in the literature on effective hazard control, improved accountability and reduced waste. Cost savings from mitigating supply chain risks through Blockchain (Francisco and Swanson, 2018) as well as waste reduction (Kouhizadeh and Sarkis, 2018) are validated in this research. Additionally, the findings indicate that Blockchain can enhance customer loyalty through legitimizing sustainable practices. This source of economic value capture through Blockchain contributes to the economic pillar. However, the economic driver must not be underestimated as for some actors it might outweigh the social and environmental elements.

The findings on Blockchain's environmental benefits reflect the literature on waste and resource management but practice seems to lag behind more conceptual conversations. In comparison to the social and economic dimension, less evidence was found for Blockchain's contribution to environmental sustainability. The findings did highlight Blockchain's potential for reducing food waste (Li et al., 2014); however, this is often the result of economic ambitions to save costs rather than actively seeking environmental benefits. Other than Blockchain's potential for sustainable management of resources in the seafood industry, no other Blockchain's opportunities for lowering resource extraction and emissions were observed.

A critical evaluation must be given to its claims of achieving financial and sustainability objectives simultaneously. Our findings suggest that Blockchain offers opportunities for greenwashing, i.e. "poor environmental performance and positive communication about environmental performance" (Delmas and Burbano, 2011, p. 65) As Blockchain provides ways to legitimize sustainable practices in supply chains, companies can misuse this opportunity for a financial benefit. This criticism resonates with the finding that Blockchain can be applied for both sustainable and unsustainable practices and highlights the need to consider the challenges that limit Blockchain as a sustainability-oriented innovation. Supply chain actors should be wary of the potential for greenwashing through Blockchain (Delmas and Burbano, 2011), which could dilute the momentum of Blockchain for sustainability.

5.3. Overcoming the resistance to Blockchain for sustainability

By applying an innovation resistance lens to SOI our findings assist in overcoming the pro-innovation, pro-adoption bias in studies of innovation more broadly, and SOI in particular (Godin and Vinck, 2017; Heidenreich and Handrich, 2015; Ziegler, 2020). By examining the resistance and challenges associated with an emerging technology such as Blockchain, we are able to paint a more complete picture of the challenges that need to be overcome in realizing the potential for sustainability in food supply chains (Bauer, 2017; Godin and Vinck, 2017).

We contribute to innovation resistance theory by showing how 'protection of the status quo' can also be a form of active resistance based on understanding of an innovation, not just passive form of resistance (Huang et al., 2021; Talke and Heidenreich, 2014). Our findings highlight how incumbents might exert their power through active resistance to protect against SOIs that challenge the unsustainable, yet profitable, status quo. In doing so we extend critical studies of innovation resistance by bringing attention to the role of power and entrenched interests in resisting sustainability innovation when it poses a direct threat to incumbents' unsustainable practices (Thomas et al., 2017). These findings align with an emerging stream of research focused on how incumbents adopt countering strategies to protect against the potentially disruptive innovations (Ben-Slimane et al., 2020; Blume et al., 2020).

By examining innovation resistance in the context of global supply chains we reveal *cooperative barriers* as an underexplored form of resistance in the context of SOI. We argue that cooperative barriers are higher in the context of SOI as the complexity of sustainability challenges requires collaborative action, which creates forms of resistance based on the number of social actors involved in innovation adoption and diffusion. These insights highlight the value of exploring innovation resistance across the whole ecosystem, rather than just focusing on end consumers (Godin and Vinck, 2017; Hietschold et al., 2020; Huang et al., 2021) and builds on Thomas et al. (2017) call to appreciate the diverse social actors engaged in socio-technical resistance. Further, by exploring multiple actors within the food supply chains, we contribute to calls to understand organization resistance to sustainable supply chain innovations (Wieland et al., 2016).

Finally, our study highlights the functional and psychological barriers that need to be overcome for Blockchain technology to be adopted as a SOI. Greater attention needs to be paid to complexity and communicability barriers given the inability of proponents to articulate Blockchain's functionality and its potential value. Extending Bauer's (2017) pain analogy, supply chain actors promoting Blockchain as a tool for sustainability need to articulate its potential value and show clear instances of how it can address sustainability challenges.

6. Conclusion, future research and limitations

This study provides evidence of Blockchain technology's potential as an SOI and the forms of resistance shaping its adoption. The ways in which Blockchain addresses social, economic and environmental challenges show how the technology can reconcile financial performance with sustainability objectives. The findings underline the potential for shared value creation, particularly for the social and economic pillar of sustainability. The Blockchain philosophy guided by principles of democracy and decentralization assists in creating more equitable supply chains. The initial excitement of Blockchain is demonstrated in its current applications as the technology provides new opportunities to improve food supply chain sustainability. Whether it is used as a tool or as a mindset for sustainability or both, Blockchain can be an important means to overcome the challenges in creating a sustainable food supply system.

The findings contribute to recent literature in providing a more nuanced picture of the Blockchain's possibilities for sustainability. This research therefore helps to understand Blockchain's realistic capacities for advancing the sustainability agenda and the need to further explore Blockchain's contributions to the environmental pillar. The results show that the technological component constitutes only a small fraction of the overall Blockchain for sustainability objective. We argue that the hype around Blockchain for sustainability (Pereira et al., 2019; Pólvora et al., 2020) ignores the forms of active resistance put forward in this research. These forms of active resistance that need to be overcome as currently, proponents of Blockchain paint an unrealistic picture of its potential for sustainability.

The findings provide practical guidance on the sustainability issues for which Blockchain is most applicable. We found that Blockchain shows opportunities for ensuring fair supply chain practices and equal value distribution which can be beneficial for entities such as social enterprises, NGOs, fair trade agencies, etc. who want to prove their sustainability claims to their customers. The findings provide a more complete picture the capabilities and limitations for organisations considering implementing Blockchain applications. For those who are utilizing Blockchain for sustainability, the challenges identified reveal impediments that need to be overcome for creating impact. Practitioners would benefit from actively engaging with the forms of resistance in order to realize Blockchain's full potential for sustainability.

The findings and recommendations of this research must be considered in light of the limitations of the study. The limitations of the dataset and the research method must be acknowledged, as well as the researchers bias. We note that our article is based on a relatively small number of interviews and so the findings should be viewed as exploratory. Further, we did not distinguish between different food supply chains in our research. Although the participants represented varying food industries, generalizing this research to all food supply chains must be done with caution. The nature of a food product may be critical for successful Blockchain applications. By making no distinctions between different food supply chains, our research serves as a holistic study on the overall capacity of Blockchain for food system sustainability. Furthermore, the opportunities and resistance identified are limited to the interviewees' unique experiences.

Considering these limitations, future research should explore specific food supply chains to better understand the industry specific potential for Blockchain. Future research could incorporate different opinions of all supply chain actors involved in the Blockchain. Talking to the farmers, distributers, retailers and consumers within one study could better embrace the opportunities and challenges of Blockchain for sustainability and provide a more holistic picture. Finally, Blockchain's potential for environmental benefits for food supply chains requires more investigation as this was underrepresented in this research.

By highlighting both opportunities and resistance, this research evaluated Blockchain as a technology for contributing to food supply chain sustainability. To create the largest impact through Blockchain, we suggest embracing the opportunities and carefully addressing the multiple forms of resistance. The hype for Blockchain to transform food supply chains to become more sustainable can only be partially justified and thereby requires caution. We need to detach ourselves from the hype and start identifying relevant problems that the technology can address as we strive for a sustainable food supply system for all.

Appendix 1

Interview participant groupings

Grouping	#	Sub case	Interviewee	Expertise (Blockchain/ Food supply)	Type of Actor	Focus of company/ Organization/ Actor
Start-up	8	Start-up 1	Blockchain Growth Agent	Food Supply	Social Enterprise	Various food supply chains (coffee, coconut, sugarcane, pineapple, shrimp, vanilla)
		Start-up 2	CEO & Co-Founder	Food Supply/ Blockchain	Business	Mango, Citrus fruits
		Start-up 3	Head of Technology	Food Supply	Social Enterprise	Coffee & Cocoa supply chain
		Start-up 4	Founder	Food Supply/ Blockchain	Business	Seafood industry
		Start-up 5	CEO & Co-Founder	Food Supply/ Blockchain	Business	Various food supply chains
		Start-up 6	Co-Founder	Blockchain	Start up	Information Technology and Services
		Start-up 7	CEO & Digital Leader	Blockchain	Start up	Blockchain
		Start-up 8	Founder	Blockchain	Start-up	Information technology & services
SME	2	SME 1	Logistics Manager	Food Supply	Social Enterprise	Cocoa supply chain
		SME 2	Founder and owner	Blockchain	Business	Management Consulting
Multi-national Corporation	2	MNC 1	Supply Chain Director International Customers	Food Supply	Business	Various food supply chains
		MNC 2	Supply Chain Manager	Food Supply	Business	Dairy industry
Research institution	5	Research 1	Associate Professor in the Department of Information Technology & Analytics; Co-Director of Blockchain Hub	Blockchain	Research University	Supply chain Management & Logistics
		Research 2	Blockchain Research Fellow	Blockchain	Research University	Blockchain
		Research 3	Professor of Business Computing	Blockchain	Research University	IT
		Research 4	Program Manager	Blockchain	University of Applied Sciences	Blockchain projects
		Research 5	Head of Entrepreneurial Development	Blockchain	Public company	Information Technology and Services
NGO	1	NGO1	Program Manager for Tuna	Food Supply	International NGO	Environmentalism/ Conservation/ Ecology

Appendix 2: Example semi-structured interview questions

Interview Questions:

1. Background on organization: Quickly introduce your organization. What is your organization doing? What do you do? What is your role in the organization?
2. What are the sustainability-related problems you are encountering within your supply chain? Otherwise more general: What are sustainability-related problems in food/agri supply chains?
3. How does your organization use blockchain, and why is blockchain a good technology for this problem?
4. Could this problem be solved without blockchain? How?
5. What were the challenges in implementing blockchain in your organization, if any? Did you overcome this challenge? How?
6. Do you see any meaningful impact from your blockchain initiative? What was the timeframe to see this impact? How did you measure this impact?
7. How does the impact resulting from your blockchain application relate to the Sustainable Development Goals?
8. Who are the drivers for implementing blockchain for (food/agri) supply chain sustainability?
9. Is there any resistance for implementing blockchain in food supply chains? From whom?
10. In your opinion, is blockchain technology an innovation that drives sustainable practices?
11. Where do you see blockchain applications in food supply chains in the next 5 years?
12. What are other interesting blockchain initiatives you know of? Do you know of any blockchain initiatives that have achieved meaningful impact?

References

Adams, R., Jeanrenaud, S., Bessant, J., Denyer, D., Overy, P., 2016. Sustainability-oriented innovation: a systematic review. Int. J. Manag. Rev. 18 (2), 180–205.

Alexander, P., Brown, C., Arneth, A., Finnigan, J., Moran, D., Rounsevell, M.D., 2017. Losses, inefficiencies and waste in the global food system. Agric. Syst. 153, 190–200.

Alharby, M., Van Moorsel, A., 2017. Blockchain-based smart contracts: a systematic mapping study. arXiv preprint arXiv:1710.06372.

Andrews, R.N. (2006). Managing the environment, managing ourselves: a history of American environmental policy. Yale University Press.

Antioco, M., Kleijnen, M., 2010. Consumer adoption of technological innovations: effects of psychological and functional barriers in a lack of content versus a presence of content situation. Eur. J. Mark. 44 (11–12), 1700–1724.

Barrett, C.B., 2010. Measuring food insecurity. Science 327 (5967), 825–828.

Batwa, A., Norrman, A., 2020. A framework for exploring blockchain technology in supply chain management. Operat. Supply Chain Manag. 13 (3), 294–306.

Bauer, M.W., 2017. Resistance as a latent factor of innovation. In Critical Studies of Innovation. Edward Elgar Publishing, Cheltenham, UK.

Ben-Slimane, K., Diridollou, C., Hamadache, K., 2020. The legitimation strategies of early stage disruptive innovation. Technol. Forecast. Soc. Change 158, 120161.

Biswas, I., Raj, A., Srivastava, S.K., 2018. Supply chain channel coordination with triple bottom line approach. Transp. Res. E Logist. Transp. Rev. 115, 213–226.
Blume, M., Oberländer, A.M., Röglinger, M., Rosemann, M., Wyrtki, K., 2020. Ex ante assessment of disruptive threats: identifying relevant threats before one is disrupted. Technol. Forecast. Soc. Change 158, 120103.
Bocken, N., Short, S., Rana, P., Evans, S., 2014. A literature and practice review to develop sustainable business model archetypes. J. Clean. Prod. 65, 42–56.
Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. Qual. Res. Psychol. 3 (2), 77–101.
Buhl, A., Schmidt-Keilich, M., Muster, V., Blazejewski, S., Schrader, U., Harrach, C., Süßbauer, E., 2019. Design thinking for sustainability: why and how design thinking can foster sustainability-oriented innovation development. J. Clean. Prod. 231, 1248–1257.
. . Campbell, B., Beare, D., Bennett, E., Hall-Spencer, J., Ingram, J., Jaramillo, F., Shindell, D., 2017. Agriculture production as a major driver of the Earth system exceeding planetary boundaries Ecol. Soc. 22 (4).
Casado-Vara, R., Prieto, J., De la Prieta, F., Corchado, J.M., 2018. How Blockchain improves the supply chain: case study alimentary supply chain. Procedia Comput. Sci. 134, 393–398.
Centobelli, P., Cerchione, R., Esposito, E., Oropallo, E., 2021. Surfing blockchain wave, or drowning? Shaping the future of distributed ledgers and decentralized technologies. Technol. Forecast. Soc. Change 165, 120463.
Chang, S.E., Chen, Y.-C., Lu, M.-F., 2019. Supply chain re-engineering using blockchain technology: a case of smart contract based tracking process. Technol. Forecast. Soc. Change 144, 1–11.
Chang, V., Baudier, P., Zhang, H., Xu, Q., Zhang, J., Arami, M., 2020. How Blockchain can impact financial services – The overview, challenges and recommendations from expert interviewees. Technol. Forecast. Soc. Change 158.
Chen, D., 2018. Utility of the Blockchain for climate mitigation. The Journal of The British Blockchain Association 1 (1), 3577.
Chen, P.-.T., Kuo, S.-.C., 2017. Innovation resistance and strategic implications of enterprise social media websites in Taiwan through knowledge sharing perspective. Technol. Forecast. Soc. Change 118, 55–69.
Chiffoleau, Y., Dourian, T., 2020. Sustainable food supply chains: is shortening the answer? A literature review for a research and innovation agenda. Sustainability 12 (23), 9831.
Clark, M.A., Springmann, M., Hill, J., Tilman, D., 2019. Multiple health and environmental impacts of foods. Proc. Natl. Acad. Sci. 116 (46), 23357–23362.
Cong, L.W., He, Z., 2019. Blockchain disruption and smart contracts. Rev. Financ. Stud. 32 (5), 1754–1797.
Corallo, A., Latino, M.E., Menegoli, M., Pontrandolfo, P., 2020. A systematic literature review to explore traceability and lifecycle relationship. Int. J. Prod. Res. 58 (15), 4789–4807.
Crosby, M., Pattanayak, P., Verma, S., Kalyanaraman, V., 2016. Blockchain technology: Beyond bitcoin. Applied Innovation 2 (6–10), 71.
Dabbene, F., Gay, P., Tortia, C., 2014. Traceability issues in food supply chain management: a review. Biosystems Eng. 120, 65–80.
Dania, W., Xing, K., Amer, Y., 2018. Collaboration behavioural factors for sustainable agri-food supply chains: a systematic review. J. Clean. Prod. 186, 851–864.
Delmas, M.A., Burbano, V.C., 2011. The drivers of greenwashing. Calif. Manage. Rev. 54 (1), 64–87.
Deloitte Insights (2018). *Blockchain – A technical primer*. Retrieved from https://www2.deloitte.com/content/dam/insights/us/articles/4436_Blockchain-primer/DI_Blockchain_Primer.pdf.
Dressler, A., Bucher, J., 2018. Introducing a sustainability evaluation framework based on the Sustainable Development Goals applied to four cases of South African frugal innovation. Bus. Strategy Dev. 1 (4), 276–285.
Elkington, J., 1998. Cannibals With forks: The triple Bottom Line of 21st Century Business. New Society Publishers, Gabriola Island, British Columbia.
… & Foley, J.A., Ramankutty, N., Brauman, K.A., Cassidy, E.S., Gerber, J.S., Johnston, M., Zaks, D.P., 2011. Solutions for a cultivated planet. Nature 478 (7369), 337–342.
Food and Agriculture Organization of the United Nations (FAO). (1996). Rome declaration on world food security and world food summit plan of action.
Food and Agriculture Organization of the United Nations (FAO). (2017). Save food for a better climate.Retrieved from http://www.fao.org/3/a-i8000e.pdf.
Food and Agriculture Organization of the United Nations (FAO). (2019). The state of food and agriculture. Retrieved from http://www.fao.org/3/ca6122en/ca6122en.pdf.
Francisco, K., Swanson, D., 2018. The supply chain has no clothes: technology adoption of Blockchain for supply chain transparency. Logistics 2 (1), 2.
Galen, D., Brand, N., Boucherle, L., Davis, R., Do, N., & El-Baz, B., … Lee, J. (2018). Blockchain for Social Impact. Retrieved from Stanford Graduate School of Business: https://www.gsb.stanford.edu/sites/gsb/files/publication-pdf/study- Blockchain-impact-moving-beyond-hype.pdf.
Gioia, D.A., Corley, K.G., Hamilton, A.L., 2013. Seeking qualitative rigor in inductive research: notes on the Gioia methodology. Organ. Res. Methods 16 (1), 15–31.
Glaser, B., Strauss, A., 1967. The Discovery of Grounded Theory. Aldine Publishing Company, Hawthorne, NY (1967).
Godfray, H., Beddington, J., Crute, I., Haddad, L., Lawrence, D., Muir, J., …Toulmin, C., 2010. Food Security: the Challenge of Feeding 9 Billion People. Science 327 (5967), 812–818.
Godin, B., & Vinck, D. (2017). Introduction: innovation – from the forbidden to a cliché. In: C ritical Studies of Innovatio n.Edward Elgar Publishing.
Golden, S., & Price, A. (2018). Sustainable supply chains - better global outcomes with blockchain. Retrieved from New America: https://www.newamerica.org/digital-impact-governance-inititiative/policy-papers/sustainable-supply-chains/.
Govindan, K., 2018. Sustainable consumption and production in the food supply chain: a conceptual framework. Int. J. Prod. Econ. 195, 419–431.
Gray, D., 2014. Doing Research in the Real World. SAGE, London.
Heidenreich, S., Handrich, M., 2015. What about Passive Innovation Resistance? Investigating Adoption-Related Behavior from a Resistance Perspective. J. Prod. Innov. Manag. 32 (6), 878–903.
Hew, J.-.J., Leong, L.-.Y., Tan, G.W.-H., Ooi, K.-.B., Lee, V.-.H., 2019. The age of mobile social commerce: an Artificial Neural Network analysis on its resistances. Technol. Forecast. Soc. Change 144, 311–324.
Hietschold, N., Reinhardt, R., Gurtner, S., 2020. Who put the "NO" in Innovation? Innovation resistance leaders' behaviors and self-identities. Technol. Forecast. Soc. Change 158, 120177.
Hoekstra, A., Wiedmann, T., 2014. Humanity's unsustainable environmental footprint. Science 344 (6188), 1114–1117.
Huang, D., Jin, X., Coghlan, A., 2021. Advances in consumer innovation resistance research: a review and research agenda. Technol. Forecast. Soc. Change 166, 120594.
Iansiti, M., Lakhani, K., 2017. The truth about blockchain. Harv. Bus. Rev.
Intergovernmental Panel on Climate Change (IPCC), 2014. Climate Change 2014 – Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel On Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, p. 151.
International Fund for Agricultural Development (IFAD), 2019. Exploring the advantages of blockchain technology for smallholder farming. IFAD. Retrieved from. https://www.ifad.org/documents/38714170/39135645/blockchain_smallholders.pdf/d4506af0-79d1-04df-7800-98b380f80dfa.
Isaac, R.M., Walker, J.M., 1988. Group size effects in public goods provision: the voluntary contributions mechanism. Q. J. Econ. 103 (1), 179–199.
Jay, J., Gerard, M., 2015. Accelerating the theory and practice of sustainability- oriented innovation. MIT Sloan Research Paper. No. 5148-15.
Joachim, V., Spieth, P., Heidenreich, S., 2018. Active innovation resistance: an empirical study on functional and psychological barriers to innovation adoption in different contexts. Ind. Mark. Manag. 71, 95–107.
Kewell, B., Adams, R., Parry, G., 2017. Blockchain for good? Strategic Change 26 (5), 429–437.
Kim, J.S., Shin, N., 2019. The impact of Blockchain technology application on supply chain partnership and performance. Sustainability 11 (21), 6181.
Kleijnen, M., Lee, N., Wetzels, M., 2009. An exploration of consumer resistance to innovation and its antecedents. J. Econ. Psychol. 30 (3), 344–357.
Klewitz, J., Hansen, E.G., 2014. Sustainability-oriented innovation of SMEs: a systematic review. J. Clean. Prod. 65, 57–75.
Kopyto, M., Lechler, S., Heiko, A., Hartmann, E., 2020. Potentials of blockchain technology in supply chain management: long-term judgments of an international expert panel. Technol. Forecast. Soc. Change 161, 120330.
Kosba, A., Miller, A., Shi, E., Wen, Z., Papamanthou, C., 2016. Hawk: the blockchain model of cryptography and privacy-preserving smart contracts. Proc. - IEEE Symp. Secur. Priv. 839–858. IEEE.
Kouhizadeh, M., Sarkis, J., 2018. Blockchain practices, potentials, and perspectives in greening supply chains. Sustainability 10 (10), 3652.
Kshetri, N., 2018. Blockchain's roles in meeting key supply chain management objectives. Int. J. Inf. Manage. 39, 80–89.
Kumar, S., Schmitz, S., 2011. Managing recalls in a consumer product supply chain–root cause analysis and measures to mitigate risks. Int. J. Prod. Res. 49 (1), 235–253.
Le Sève, M., Mason, N., Nassiry, D, 2018. Delivering blockchain's potential for environmental sustainability. ODI. Retrieved from. https://www.odi.org/sites/odi.org.uk/files/resource-documents/12439.pdf.
Lyles, M., Flynn, B., Frohlich, M., 2008. All supply chains don't flow through: understanding supply chain issues in product recalls. Manag. Organ. Rev. 4 (2), 167–182.
Magazzeni, D., McBurney, P.J., Nash, W., 2017. Validation and verification of smart contracts: a research agenda. Computer (Long Beach Calif) 50 (9), 50–57.
Maloni, M.J., Brown, M.E., 2006. Corporate social responsibility in the supply chain: an application in the food industry. J. Bus. Ethics 68 (1), 35–52.
Marsal-Llacuna, M.-.L., 2018. Future living framework: is blockchain the next enabling network? Technol. Forecast. Soc. Change 128, 226–234.
Marsal-Llacuna, M.-.L., 2020. The people's smart city dashboard (PSCD): delivering on community-led governance with blockchain. Technol. Forecast. Soc. Change 158.
Marucheck, A., Greis, N., Mena, C., Cai, L., 2011. Product safety and security in the global supply chain: issues, challenges and research opportunities. J. Oper. Manage. 29 (7–8), 707–720.
Mbow, C., Rosenzweig, C., Barioni, L.G., Benton, T.G., Herrero, M., Krishnapillai, M., … Xu, Y. (2019). *Food Security*. In: climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. Retrieved from IPCC [Intergovernmental Panel on Climate Change]: https://www.ipcc.ch/srccl/chapter/chapter-5/.
Michelman, P., 2017. Seeing beyond the blockchain hype. MIT Sloan Manag. Rev. 58 (4), 17.
Moldovan, S., Goldenberg, J., 2004. Cellular automata modeling of resistance to innovations: effects and solutions. Technol. Forecast. Soc. Change 71 (5), 425–442.
Mukkamala, R.R., Vatrapu, R., Ray, P.K., Sengupta, G., Halder, S., 2018. Blockchain for Social Business: principles and Applications. IEEE Eng. Manage. Rev. 46 (4), 94–99.

Nakamoto, S. (2008), "Bitcoin. A peer-to-peer electronic cash system", available at: https://bitcoin.org/bitcoin.pdf (accessed 2 Febuay 2021).
Parfitt, J., Barthel, M., Macnaughton, S., 2010. Food waste within food supply chains: quantification and potential for change to 2050. Philos. Trans. R. Soc. Lond., B, Biol. Sci. 365 (1554), 3065–3081.
Pazaitis, A., De Filippi, P., Kostakis, V., 2017. Blockchain and value systems in the sharing economy: the illustrative case of Backfeed. Technol. Forecast. Soc. Change 125, 105–115.
Pereira, J., Tavalaei, M.M., Ozalp, H., 2019. Blockchain-based platforms: decentralized infrastructures and its boundary conditions. Technol. Forecast. Soc. Change 146, 94–102.
Pérez-Escamilla, R., 2017. Food security and the 2015–2030 sustainable development goals: from human to planetary health: perspectives and opinions. Curr. Dev. Nutr. (7), 1.
Pólvora, A., Nascimento, S., Lourenço, J.S., Scapolo, F., 2020. Blockchain for industrial transformations: a forward-looking approach with multi-stakeholder engagement for policy advice. Technol. Forecast. Soc. Change 157, 120091.
Porter, M.E., Kramer, M.R., 2019. Creating Shared Value. In: Lenssen, G., Smith, N. (Eds.), Managing Sustainable Business. Springer, Dordrecht.
Eds. Ram, 1987. A Model of Innovation Resistance. In: Wallendorf, Melanie, Anderson, Paul (Eds.), *In. Advances in Consumer Research Volume 14*. Association for Consumer Research, Provo, UT, pp. 208–212. Eds.
Ram, S., Sheth, N., 1989. Consumer Resistance to Innovations: the Marketing Problem and its solutions. J. Consum. Mark. 6 (2), 5–14.
Rieple, A., Snijders, S., 2018. The role of emotions in the choice to adopt, or resist, innovations by Irish dairy farmers. J. Bus. Res. 85, 23–31.
... & Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F.S., Lambin, E.F., Foley, J.A., 2009. A safe operating space for humanity. Nature 461 (7263), 472–475.
Rogers, E.M., 2003. Diffusion of Innovations, 5th ed. Free Press, New York.
Saberi, S., Kouhizadeh, M., Sarkis, J., Shen, L., 2019. Blockchain technology and its relationships to sustainable supply chain management. Int. J. Prod. Res. 57 (7), 2117–2135.
Schmidt, K., Matthies, E., 2018. Where to start fighting the food waste problem? Identifying most promising entry points for intervention programs to reduce household food waste and overconsumption of food. Resour. Conserv. Recycl. 139, 1–14.
Sheth, J.N., 1981. An Integrative Theory of Patronage Preference and Behavior. College of Commerce and Business Administration, Bureau of Economic and Business Research, University of Illinois, Urbana-Champaign, pp. 9–28.
Shiva, V., 2005. Earth Democracy: Justice, Sustainability, and Peace. South End Press, Cambridge, Mass.
Silvestre, B., Monteiro, M., Viana, F., de Sousa-Filho, J., 2018. Challenges for sustainable supply chain management: when stakeholder collaboration becomes conducive to corruption. J Clean Prod 194, 766–776.
Sjauw-Koen-Fa, A., 2010. Sustainability and security of the global food supply chain. Retrieved from Rabobank Group. https://economie.rabobank.com/contentassets/00f7b32db0404143adbc74903296384e/rabobank_imw_wb_report-final-2010-11-15_tcm64-127652.pdf.
... & Swinburn, B.A., Kraak, V.I., Allender, S., Atkins, V.J., Baker, P.I., Bogard, J.R., Dietz, W.H., 2019. The global syndemic of obesity, undernutrition, and climate change: the Lancet Commission report. Lancet North Am. Ed. 393 (10173), 791–846.
Szabo, N., 1997. Formalizing and securing relationships on public networks. First Monday 2.
Talke, K., Heidenreich, S., 2014. How to overcome pro-change bias: incorporating passive and active innovation resistance in innovation decision models. J. Prod. Innov. Manag. 31 (5), 894–907.
Teh, L., Caddell, R., Allison, E., Finkbeiner, E., Kittinger, J., Nakamura, K., Ota, Y., 2019. The role of human rights in implementing socially responsible seafood. PLoS ONE 14 (1), e0210241.
Thomas, H., Becerra, L., Garrido, S., 2017. Socio-technical dynamics of counter-hegemony and resistance. Critical Studies of Innovation. Edward Elgar Publishing, Cheltenham, UK.
Tillemann, T., Price, A., Tillemann-Dick, G., & Knight, A. (2019). The blueprint for blockchain and social innovation. Retrieved from New America: https://d1y8sb8igg2f8e.cloudfront.net/documents/The_Blueprint_for_Blockchain_and_Social_Innovation_2019-10-09_141628.pdf.
Trienekens, J., Wognum, P., Beulens, A., van der Vorst, J., 2012. Transparency in complex dynamic food supply chains. Adv. Eng. Inf. 26 (1), 55–65.
Tripoli, M., Schmidhuber, J., 2018. Emerging Opportunities for the Application of Blockchain in the Agri-food Industry. FAO and ICTSD, Rome and Geneva.
Tse, D., Zhang, B., Yang, Y., Cheng, C., Mu, H., 2017. Blockchain application in food supply information security. In 2017 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM) (pp. 1357-1361). IEEE.
Turi, A., Goncalves, G., Mocan, M., 2014. Challenges and competitiveness indicators for the sustainable development of the supply chain in food industry. Procedia Soc. Behav. Sci. 124, 133–141.
UNDP (United Nations Development Programme), 2003. World Resources 2002–2004. World Resources Institute, Washington, DC.
Voshmgir, S., Novakovic, T., Wildenberg, M., Rammel, C., 2019. Blockchain, web3 & the SDGs: sustainable development report. Research Institute for Cryptoeconomics & Vienna University of Economics.
Wang, Y., Singgih, M., Wang, J., Rit, M., 2019. Making sense of Blockchain technology: how will it transform supply chains? Int. J. Prod. Econ. 211, 221–236.
Wang, M., Wu, Y., Chen, B., Evans, M., 2021. Blockchain and supply chain management: a new paradigm for supply chain integration and collaboration. Operat. Supply Chain Manag. 14 (1), 111–122.
Ward, H., 2008. Liberal democracy and sustainability. Env. Polit. 17 (3), 386–409.
Whipple, J.M., Voss, M.D., Closs, D.J., 2009. Supply chain security practices in the food industry. Int. J. Phys. Distrib. Logist. Manag. 39, 574–594.
Wieland, A., Handfield, R.B., Durach, C.F., 2016. Mapping the landscape of future research themes in supply chain management. J. Bus. Logist. 37 (3), 205–212.
Yli-Huumo, J., Ko, D., Choi, S., Park, S., Smolander, K., 2016. Where is current research on Blockchain technology?—a systematic review. PLoS ONE 11 (10), e0163477.
Zhong, R., Xu, X., Wang, L., 2017. Food supply chain management: systems, implementations, and future research. Ind. Manag. Data Syst. 117 (9), 2085–2114.
Ziegler, R., 2020. Paludiculture as a critical sustainability innovation mission. Res. Policy 49 (5), 103979.

Nicola Friedman is a graduate of University College Maastricht. Her research explores the intersection of Blockchain technology and sustainability. She is currently studying a Master in Environment and Resource Management at the Vrije Universiteit Amsterdam.

Dr Jarrod Ormiston is Assistant Professor in Social Entrepreneurship in the Department of organization, Strategy and Entrepreneurship at the School of Business and Economics, Maastricht University. Jarrod's research focuses on supporting entrepreneurs in rural community, working with social enterprises to enhance their impact, and understanding the role of emotions in entrepreneurship. His research interests include social and sustainable entrepreneurship, impact investment, and innovative research methods in entrepreneurship research. Jarrod has worked as a consultant to the Australian Government, the OECD and United Nations on entrepreneurship and education.