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Configurational approaches to blockchain-enabled sustainability strategies

Tiziana Russo-Spena, Nadia Di Paola and Cristina Mele
Dipartimento di Economia Management Istituzioni, Università degli Studi di Napoli Federico II, Napoli, Italy

Abstract

Purpose – Blockchain technology (BC) has emerged as a transformative tool for driving sustainability across various sectors, with notable implications for the agri-food industry. However, documented success stories and sector-specific research have been limited. This study examines the mechanisms by which BC facilitates the achievement of sustainability goals. Specifically, it investigates how BC-related benefits contribute to companies' success in attaining sustainability outcomes and supporting their strategies.

Design/methodology/approach – This study uses Qualitative Comparative Analysis (QCA) to examine the connections between adoption conditions and sustainability outcomes. It uses crisp-set QCA and Boolean algebra to represent the case membership as dichotomous values (0 or 1). Semi-structured interviews were conducted with 52 Italian agri-food firms and BC providers, identified through snowball sampling. This configurational approach reveals how companies adopt BC and its impact on achieving sustainability goals.

Findings – The results reveal that BC supports sustainability by (1) strengthening business relationships, (2) providing technical resources, (3) enhancing process effectiveness, and (4) sustaining market performance. Based on how these benefits combine, this study identifies three distinct adoption pathways: technology-driven, process-driven, and value-driven, each representing a unique strategy for leveraging BC to achieve sustainability goals.

Originality/value – This study deepens how BC intersects sustainability and offers actionable insights into its benefits and adoption configurations. It stands out as one of the first studies to examine the detailed pathways that companies follow when integrating BC into sustainability strategies. By addressing this emerging topic, this study underscores the context-specific mechanisms through which BC facilitates sustainable business transformations.

Keywords Agri-food business, Blockchain technology, Qualitative comparative analysis (QCA), Sustainability strategies, Sustainability goals

Paper type Research article

1. Introduction

Sustainability has emerged as a pivotal concern in global policy and business discourse, as evidenced by high-profile initiatives such as the United Nations 2030 Agenda—featuring the 17 Sustainable Development Goals (SDGs)—and the European Green Deal, both of which advocate for a comprehensive and systemic transformation toward sustainability. However, despite the increasing visibility and normative influence of these frameworks, the practical realisation of sustainability goals remains a complex and unresolved issue for many organisations, industries, and communities. Recent studies underscore these challenges by examining integrated sustainability performance frameworks and the evolving landscape of sustainability reporting practices (Arianpoor and Salehi, 2021; Salehi and Arianpoor, 2021; Arianpoor *et al.*, 2023). The persistent gap between sustainability ambitions and implementation outcomes underscores the critical need for innovative, technology-driven solutions to support and accelerate achieving these goals (Arianpoor and Borhani, 2024; Louta *et al.*, 2024). Within this context, emerging

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digital technologies, particularly blockchain (BC), have attracted significant interest because of their potential to facilitate sustainable transformation by enabling transparent, decentralised information systems that increase perceived trust and reduce asymmetries among stakeholders, while improving efficiency and coordination among organisations (Blanco-González-Tejero *et al.*, 2024). BC, a decentralised ledger system (Nakamoto, 2008) characterised by transparency, immutability, and secure transaction verification (Pan *et al.*, 2020), has evolved far beyond its initial applications in cryptocurrency and fintech (Tapscott and Tapscott, 2017; Russo-Spena *et al.*, 2022). The agri-food industry has major environmental and social implications and is a key sustainability sector (Dai *et al.*, 2023; Giganti *et al.*, 2024). BC improves safety and traceability (Antonucci *et al.*, 2019; Feng *et al.*, 2020), supports flexible value chains, and drives innovation (Cozzio *et al.*, 2023; Sharma *et al.*, 2024). It helps create smart agri-food systems when integrated with complementary technologies, such as the Internet of Things (IoT) and artificial intelligence (AI) (Rehman *et al.*, 2023; Sezer *et al.*, 2024).

Despite the extensive literature on BC's business benefits, its role as a strategic enabler of sustainability remains insufficiently investigated and empirically substantiated (Arianpoor *et al.*, 2023; Spigarelli *et al.*, 2024). Many recent studies have used conceptual or one-dimensional perspectives to focus on specific applications or indirect effects. For example, BC has been investigated for its ability to reduce environmental impacts and raise awareness about energy, water, and land consumption (Mukherjee *et al.*, 2021; Jan *et al.*, 2024; Rani *et al.*, 2024), as well as its capacity to foster inclusive trade, enhance market information, and ensure greater legal certainty (Sezer *et al.*, 2024). However, integrating BC into organisations and supply chains presents several challenges. High implementation costs (Yadav *et al.*, 2024), technical barriers, resistance to data sharing, and the need for organisational process redesign can hinder widespread adoption (Jiang *et al.*, 2022; Spigarelli *et al.*, 2024). These obstacles are exacerbated by limited awareness and the absence of standardised frameworks for BC integration (Koehler *et al.*, 2022; Kouhizadeh *et al.*, 2020; Mulligan *et al.*, 2024). Furthermore, studies that adopt excessively positive evaluations often overestimate the innovative potential of BC without providing concrete evidence to substantiate their claims (Ali *et al.*, 2021; Spigarelli *et al.*, 2024). In addition, the degree of BC adoption and its impact vary significantly across industries and among firms within the same sector, reflecting differences in integration levels and strategic approaches (Bag *et al.*, 2022; Kannan *et al.*, 2024; Jiang *et al.*, 2022; Schinckus, 2020). This variability highlights the need for a deeper exploration of BC's tangible and measurable benefits to strategic processes, particularly in advancing sustainability implementation (Aslam *et al.*, 2023; Dadsena *et al.*, 2024; Friedman and Ormiston, 2022) and reporting practices (Arianpoor and Salehi, 2021; Salehi and Arianpoor, 2021). Indeed, except for a few notable contributions (Arianpoor *et al.*, 2023), a clear understanding of how BC enables sustainability-oriented strategies and drives value creation is still lacking. Building on this foundation, this study seeks to expand the empirical base by exploring how BC's benefits can be configured to make sustainability goals more operational and actionable within organisational contexts. Developing such insights is crucial for enabling organisations to make informed investment decisions and fully leverage the transformative potential of BC (Friedman and Ormiston, 2022; Oguntegbe *et al.*, 2022).

Accordingly, this study is guided by the following research question: R1) How does BC support companies achieving sustainability goals? R2) What are the possible configurations of the benefits that enable firms to realise these goals?

To address these research questions, this study adopts a configurational approach, which is particularly appropriate for investigating causal complexity, namely, the coexistence of multiple interrelated conditions that collectively shape outcomes. Specifically, this study employs a crisp-set qualitative comparative analysis (csQCA) to analyse data obtained from in-depth interviews with managers of agri-food companies using BC technology and their technology providers (Kumar *et al.*, 2022). The agri-food sector is well-positioned to benefit from BC, given its inherent structure and the critical importance of food sustainability (Gidanti *et al.*, 2024). As technological innovation transforms this industry, new market entrants reshape traditional practices, generating opportunities to improve efficiency, product quality, and sustainability performance (Rana *et al.*, 2021; Paul *et al.*, 2021). By employing a complexity-oriented perspective, this study moves beyond linear explanations using QCA (Kumar *et al.*, 2022) to capture the nuanced interplay of factors that influence the role of BC in promoting sustainability. This approach is particularly valuable in the context of interdependent systems, such as the agri-food supply chain, where dynamic interactions among technological, environmental, and organisational dimensions give rise to intricate patterns of causality (Mazzucchelli *et al.*, 2021).

This study makes three key contributions to the literature on business sustainability strategies. First, while existing studies emphasise BC's potential and general benefits, this study advances the field by empirically examining four specific and actionable benefits: strengthening business relationships, providing technical resources, enhancing operational process effectiveness, and sustaining market performance. Second, it provides new insights into the diverse pathways that firms adopt and leverage BC, offering a detailed understanding of its real-world applications. The findings revealed that the impact of BC on sustainability is amplified when BC benefits converge under specific conditions. Third, this study identifies three approaches to BC adoption: technology-driven, process-driven, and value-driven. These approaches illustrate the varying degrees to which BC facilitates sustainable business transformation depending on how effectively firms integrate and leverage BC benefits within their strategic processes.

The remainder of this paper is structured as follows. Section 2 reviews the relevant literature and outlines the study's propositions. Section 3 details the methodology, and Section 4 presents the analysis and results. The following sections discuss these findings and introduce the proposed framework. Section 6 highlights the contributions and implications for practitioners and suggests directions for future research.

2. Literature background

Several theoretical studies and conceptual models (Pan *et al.*, 2020; Jan *et al.*, 2024; Sharma *et al.*, 2024) have systematically examined and provided evidence of the multifaceted benefits of BC adoption, highlighting its diverse and measurable impacts on sustainability strategies (Park and Li, 2021; Jan *et al.*, 2024). The broader literature on blockchain consistently highlights its contribution to sustainability by increasing operational transparency and advancing sustainability through fraud reduction, improved traceability, and inclusive innovation (Jiang *et al.*, 2022; Rana *et al.*, 2019). Beyond a purely technological focus, numerous studies underscore the critical importance of adopting comprehensive sustainability performance metrics and examining their interdependencies (Arianpoor and Salehi, 2021; Arianpoor *et al.*, 2023; Zimon *et al.*, 2022), particularly in addressing the urgency posed by contemporary crises (Arianpoor and Tajdar, 2024). In doing so, they highlight the pressing need for an integrated framework that captures both the strategic intent and leverage mechanisms inherent to sustainable business practices.

Such an expanded lens paves the way for future scholarly inquiry into BC-enabled sustainability strategies, promoting a shift from isolated, case-specific implementations to a broader, integrated-level examination of blockchain's potential to reshape sustainability strategies. It provides firms with a robust foundation for evaluating sustainability performance through a multidimensional lens (Arianpoor and Salehi, 2021), reinforcing the strategic value of technologies such as blockchain in meeting integrated sustainability goals.

This is particularly evident in sectors such as agri-food, where complexity and the imperative for transparency and quality assurance have driven growing interest in BC owing to its transformative potential across multiple supply chain dimensions (Mangla *et al.*, 2002; Jan *et al.*, 2024). Research demonstrates that reliable mechanisms to verify product origin, ensure safety, and promote sustainability address the growing consumer demand for ethical, high-quality food products (Rana *et al.*, 2021). In the agri-food business, BC technology strengthens food safety by enabling the rapid identification of contamination sources and efficient recall processes, thus mitigating supply chain risks (Hao *et al.*, 2020; Iftekhar *et al.*, 2020).

In addition to consumer-facing benefits, BC contributes to operational efficiency by allowing precise inventory tracking, waste reduction, and resource allocation optimisation, which are key factors in meeting environmental goals and achieving economic sustainability (Sharma *et al.*, 2024; Jan *et al.*, 2024). Moreover, many studies recognise that technological solutions alone cannot resolve sustainability issues in supply chains (Rani *et al.*, 2024; Vu *et al.*, 2022). Achieving high levels of traceability and transparency to address social or environmental goals requires the willingness and ability to share internal data and redesign processes and activities (Bag *et al.*, 2022; Lezzi *et al.*, 2024; Xue *et al.*, 2021), as well as to manage perceptions of legitimacy and system trustworthiness within the wider network of stakeholders (Blanco-González-Tejero *et al.*, 2024). Effective BC adoption profoundly affects the organisational processes and resources necessary for successful implementation (Jiang *et al.*, 2022; Nandi *et al.*, 2020; Zhao *et al.*, 2019). Despite extensive research, a significant gap remains in understanding how BC benefits are realised and combined to contribute effectively to a company's sustainability strategy. Much of the literature focuses on the isolated aspects of BC or simulation-based models (Pan *et al.*, 2020), neglecting empirical insights into their broader effects (Spigarelli *et al.*, 2024). Addressing this gap requires a comprehensive approach to examine the extensive implications of BC, particularly its role in aligning competitive strategies with socio-environmental objectives (Bag *et al.*, 2022; Arianpoor and Borhani, 2024). The next section investigates these interconnected aspects and outlines the research propositions.

2.1 BC's benefits and sustainability strategy

This study focuses on four critical dimensions of BC benefits: business relationships, technical resources, operational processes, and market performance. These dimensions, grounded in the existing literature and detailed in the text, were selected for their potential to yield actionable insights that inform and enhance organisational decision-making and performance outcomes.

Business relationships: BC is pivotal for transforming business relationships (Rejeb *et al.*, 2021). BC contributes to fair relationships by fostering trust, enabling knowledge sharing, and influencing power dynamics (Mulligan *et al.*, 2024; Rani *et al.*, 2024). Most importantly, BC's potential to enhance collaboration among supply chain participants underlines its pivotal role in establishing resilient and sustainable agri-food systems (Rogerson and Parry, 2020; Rejeb *et al.*, 2021). By providing a secure and transparent framework, BC allows companies to engage in collaborative efforts more confidently, promoting balanced and equitable interactions between the parties (Khan *et al.*, 2022). Peer-to-peer collaborations have demonstrated significant efficiency gains and growth opportunities, paving the way for more substantial and enduring partnerships (Pandey *et al.*, 2024; Rogerson and Parry, 2020; Rani *et al.*, 2024). This potential to strengthen and sustain long-term collaborations highlights BC's broader role in advancing sustainable supply chain integration (Friedman and Ormiston, 2022), fostering innovative and cooperative approaches to business relationships.

Technical resources: Some scholars have debated the integration of BC with the Internet of Things (IoT) and other technologies, such as Artificial Intelligence (AI), for applications in data recording, monitoring, coding, and sharing (Iftekhar *et al.*, 2020; Liu *et al.*, 2021; Zhu and Li, 2021). This integration is particularly significant because BC enhances communication and transparency within proprietary IoT systems (Dey and Shekhawat, 2021). Moreover, synergy between BC and Communication Technology (ICT) has driven advancements in smart farming, information security, and sustainable water management (Jan *et al.*, 2024; Liu *et al.*, 2021). By addressing IoT-related data-use challenges, BC facilitates the effective management of these systems, enabling companies to harness the full potential of their technological investments (Kamble *et al.*, 2020). This capability is vital for fostering sustainable development because it ensures that technological innovations meaningfully contribute to long-term environmental and social goals (Angelis and da Silva, 2019; Stranieri *et al.*, 2021).

Operational processes: New data processes are transformed through real-time data capture and secure BC-based monitoring, reducing reliance on costly manual checks, while improving operational efficiency and accountability (Hasan *et al.*, 2020; Pan *et al.*, 2020). Studies demonstrate that these advancements are particularly important in areas such as inventory management, forecasting, and regulatory oversight, where the dematerialisation of processes has significantly streamlined operations (Kamble *et al.*, 2020; Lezzi *et al.*, 2024). Such transformations minimise human error, enhance consistency and speed, and support environmental practices by optimising resource use and reducing waste (Xue *et al.*, 2021). Beyond operational improvements, BC facilitates the creation of new organisational knowledge, extending beyond technical data to encompass insights into operational and business intelligence (Martinez *et al.*, 2019; Nandi *et al.*, 2020; Pan *et al.*, 2020). For example, BC-enabled order management systems leverage platform data to drive organisational process efficiency and efficacy, and align business strategies with sustainable growth objectives (Martinez *et al.*, 2019). BC has become a crucial enabler of business performance and long-term sustainability goals by integrating operational efficiency with data-driven business intelligence.

Market performance: Integrating BC into certification processes enhances sustainability efforts and improves market performance and brand reputation (Nandi *et al.*, 2020; Rana *et al.*, 2021). By providing a transparent and verifiable certification framework, such as organic or fair trade, BC enables companies to align with increasing consumer demand for ethical and environmentally conscious practices (Kouhizadeh *et al.*, 2020; Rana *et al.*, 2021). This alignment reinforces a company's market position while fostering trust among stakeholders. Moreover, token-based systems powered by BC further elevate brand reputation by promoting customer engagement and loyalty through innovative and interactive methods (Aslam *et al.*, 2023). Beyond reputation, these systems are critical in addressing challenges, such as food fraud, which can severely impact financial performance and erode consumer confidence (Li *et al.*, 2021). Consequently, BC integration enhances operational transparency and establishes a foundation for sustainable market growth by building trust and delivering value to businesses and consumers.

Concentrating on these dimensions facilitates a deeper understanding of how BC can generate tangible benefits while offering insights into emerging pathways for organisations to address sustainability strategies. This analysis underpins the following proposition:

Proposition 1. BC supports sustainability goals by strengthening relationships, providing new technical resources, enhancing operational processes effectiveness, and sustaining market performance.

Each dimension represents a distinct benefit; however, their combined effects may be more significant than their individual contribution. The interplay between strengthened relationships, new resources, enhanced operational processes, and improved market performance creates a synergistic framework that enables businesses to pursue sustainability (Cozzio *et al.*, 2023). Similarly, strong relationships can foster new data efficiency, further reinforcing sustainability strategies (Dey and Shekhawat, 2021; Xu *et al.*, 2024). This multidimensional impact underscores the importance of viewing BC benefits as interconnected, rather than isolated. Thus, the analysis proposes the following proposition.

Proposition 2. The combined benefits of BC across relationships, technical resources, operational processes and market performance create a synergistic effect that supports sustainability goals.

3. Research design

This study employed Qualitative Comparative Analysis (QCA) to investigate BC's contributions to sustainability goals by strengthening relationships, introducing new technical resources, enhancing operational process efficiency, and maintaining market performance. The QCA was chosen for its capacity to identify causal relationships between conditions and outcomes, focusing on cases within a multidimensional framework (Ragin and

Strand, 2008). Its application has gained prominence in business and management research, especially in exploring causality under complex (Chen and Chen, 2024; Fu *et al.*, 2024; Vargas-Zeledon and Lee, 2024), dynamic (Chen *et al.*, 2023; Gómez-Olmedo *et al.*, 2024; Huang *et al.*, 2023; Yao and Li, 2023), and uncertain conditions (Casalegno *et al.*, 2023; Wei *et al.*, 2024).

QCA, which is based on a configurational approach, is particularly suited for examining the interplay of factors influencing the role of BC in promoting sustainability. Rooted in the principle of causal complexity, the configurational approach explores how different combinations of technological, organisational, and contextual factors may converge to produce similar sustainability outcomes (Di Paola *et al.*, 2025). QCA conceptualises cases as configurations of relevant conditions and identifies causal recipes leading to the outcome. Several studies have demonstrated that it is useful in both small-N (10–50 cases) and large-N (over 50 cases) studies (Greckhamer *et al.*, 2013).

This approach was further enriched through an iterative and analytical abstraction process to synthesise theoretical frameworks with empirical insights. Specifically, the abstraction and synthesis methodology proposed by Rahmani and Leifels (2018) was adopted because it closely aligns with the QCA's focus on identifying combinations of conditions that led to specific outcomes. The detailed steps of this process are outlined below:

3.1 Crisp-set qualitative comparative analysis

The extant literature conceptualizes QCA as a methodology and data-analysis technique. First, QCA affects research design, notably case selection, data collection, and concept identification (Schneider and Wagemann, 2012). This study purposively selected an intermediate number of cases and examined them using a cross-sectional design and semi-structured interviews (Thomann and Maggetti, 2020). The iterative nature of QCA investigations has encouraged researchers to move back and forth between relevant knowledge and case studies (Thomann and Maggetti, 2020).

This study involved a case-oriented QCA application by implementing crisp-set qualitative comparative analysis (csQCA). In csQCA, the membership of cases in the outcome and conditions is represented by dichotomous values, namely, 0 for non-membership in the set and 1 for membership in the set. The QCA assesses the existence of a relationship between conditions and the outcome of interest (Fiss, 2011), elucidating connections between necessity or sufficiency for both individual conditions and their combinations (Di Paola *et al.*, 2025). A condition is considered sufficient when its occurrence ensures the outcome although it may arise in its absence. Conversely, a condition is deemed necessary when its existence is imperative for the outcome. Without this, the outcome cannot occur.

The three salient characteristics of QCA are as follows: (1) conjunctural causation—multiple conditions may yield outcomes; (2) equifinality—diverse configurations can result in identical outcomes; and (3) causal asymmetry—conditions and outcomes are linked through asymmetrical relationships (Delery and Doty, 1996).

3.2 Data collection and measures

This study focuses on cases in Italy, a country renowned for its pivotal role in agri-food production, exports, and territorial preservation. Italy's distinction as the European leader in "Protected Denomination of Origin," "Protected Geographical Indication," and "Traditional Speciality Guaranteed" products underscores its dedication to quality and diversity within the agri-food sector.

Data collection employed a snowball sampling method initiated through the Italia4Blockchain, the leading BC association in Italy. This approach enabled identifying a network comprising providers offering BC-based services and their clients, such as agri-food firms, that actively incorporate BC into their operations. Fifty-two firms, 20 technology providers and 32 agri-food enterprises satisfied the study criteria and participated in the study

(Appendix). Analysing providers and their client firms allowed for a nuanced exploration of the technical and organisational dimensions of BC adoption.

Two researchers conducted semi-structured interviews over 18 months starting in January 2021 to gather in-depth data. Online or in-person interviews lasted approximately an hour. Drawing on theoretical frameworks, the interview questions analysed the literature-supported benefits of BC adoption (Table 1) and were directed to both groups. They focus on the benefits and reasons that drive agri-food enterprises to embrace BC services and their overall perspectives. Furthermore, the interviews explored the sustainability strategies of these organizations to gain insight into their primary goals and developmental trajectories. For agri-food companies, participants were predominantly CEOs, supplemented by production, quality, and marketing managers, who provided diverse organizational perspectives on BC adoption. The interviews targeted individuals who directly supported clients during the BC adoption process, ensuring that the responses reflected strategic and operational insights. All interviews were transcribed and translated to support comprehensive analysis and interpretation.

3.3 Data analysis and synthesis

The analysis was based on knowledge of and involvement with the cases. After identifying the conditions and measures for analysis, each researcher individually analysed the transcripts, categorized the study's conditions and outcomes, and independently coded the data using a binary rating (Berg-Schlosser and De Meur, 2009). The interviewer's response guided the assignment of binary ratings, with a value of one or zero indicating whether the benefits discussed were perceived as achieved. The same method was used to evaluate sustainability goals, allowing for the identification of companies' primary focus areas and developmental trajectories. Through an iterative process of comparing interview responses with insights from the literature, the two researchers collaboratively refined and validated the identified measures

Table 1. Measurements

Benefits on (condition)	Items	Value	Measurement
Business relationships	Foster connections with customers, suppliers, auditors, and institutions Streamline and optimise the flow of information with all key stakeholders	0 or 1	0 = no benefits perceived 1 = benefits perceived
Technical resources	Provide the accessibility of advanced tools and technologies Optimise technologies resource integration and utilisation Refine data analysis capabilities to inform decisions	0 or 1	
Operational processes	Improve efficiency and effectiveness across operational processes (logistics, transportation, sales, etc.)	0 or 1	
Market performance	Achieve increased sales and improved customer retention Enter new markets and channels Strengthen brand awareness and cultivate a positive brand image	0 or 1	
Outcome			
Sustainability Goals	Achieve energy savings, raw material efficiency or reuse, water conservation, and reduced emissions Ensure fair market prices, contribute to local community projects, support smallholder farmers, and enhance compliance with ethical standards	0 or 1	0 = no goals pursued 1 = goals pursue

Source(s): Authors' own work

by establishing complete inclusion or exclusion from the set (Schneider and Wagemann, 2012). Table 1 presents the operationalization of these criteria.

The R statistical packages Set Methods and fsQCA (Dusa, 2019; Oana and Schneider, 2021), and fsQCA software (Ragin and Davey, 2022) were used to investigate and simplify the truth table of all possible condition combinations and corresponding cases for csQCA. These procedures yield sufficient and necessary conditions (or combinations thereof) for positive and negative outcomes (Medina-Molina and de la Sierra Rey-Tienda, 2022). The results of the solution paths emerging from the analysis were then interpreted.

Following Rahmani and Leifels's (2018) iterative process, researchers moved back and forth between empirical findings and theoretical constructs to refine their analysis. This approach ensured that the emergent patterns in the data were grounded in real-world evidence and within a broader theoretical framework. Through iterative abstraction, subsequent analysis allowed for the integration of multiple perspectives, capturing a deeper exploration of the causal pathways underpinning the role of BC in advancing sustainability goals. This process produced a new conceptual framework that was not purely conceptual but grounded in tangible and practical evidence, making it applicable across diverse contexts.

4. Results

4.1 Necessity and sufficiency tests

The initial dataset contained dichotomous values, and no additional calibration was required before conducting necessity and sufficiency tests. The analysis examined positive and negative outcomes associated with when companies achieve sustainability goals related to BC-based services (Y) and when companies attain no environmental or social goals associated with implementing BC-based services (∼Y), respectively.

The necessity analysis utilised a consistency level of 0.9 for both situations (Y and ∼Y), as per Legewie (2013), and an RoN score greater than 0.5 (Oana and Schneider, 2021) (Table 2).

Necessity analysis showed that none of the analysed conditions, either in terms of their existence or absence, is necessary for Y or ∼ Y.

After the necessity test, a sufficiency analysis was conducted. Literature on sufficiency tests proposes a minimum consistency level of 0.75. The data enabled the attainment of a higher threshold of 0.85. The frequency threshold is set to 1. Table 3 presents parsimonious solutions for the sufficiency test for both Y and Y (Ragin and Strand, 2008).

Figure 1 illustrates the parsimonious solutions for the sufficiency test for both Y and Y, in the form of radar plots.

Table 2. Overview of the necessity test

	Y Cons.Nec	Cov.Nec	RoN	∼Y Cons.Nec	Cov.Nec	RoN
Technical resources	0.5385	0.5385	0.6	0.462	0.462	0.65
Process efficiency	0.6154	0.5714	0.6	0.462	0.429	0.6
Business relations	0.9615	0.5682	0.2	0.731	0.432	0.2
Market performance	0.8462	0.5366	0.3	0.731	0.463	0.3
∼Technical resources	0.4615	0.4615	0.6	0.538	0.538	0.6
∼Process efficiency	0.3846	0.4167	0.6	0.538	0.583	0.7
∼Business relations	0.0385	0.125	0.8	0.269	0.875	0.9
∼Market performance	0.1538	0.3636	0.8	0.269	0.636	0.9

Note(s) ~Signals the negation of the condition or the outcome
Source(s): Authors' own work

Table 3. Overview of the sufficiency test

Path	Y 1 A	1 B		~Y 2 A	2 B
Technical resources	○	●	Technical resources	●	●
Process efficiency	●	○	Process efficiency		○
Business relations		●	Business relations	○	
Market performance	○	●	Market performance		○
Raw coverage	0.077	0.154	Raw coverage	0.154	0.154
Unique coverage	0.077	0.154	Unique coverage	0.115	0.115
Consistency	1	1	Consistency	1	1
Solution coverage	0.231		Solution coverage	0.269	
Solution consistency	1		Solution consistency	1	

Note(s): ● = causal condition present,
○ = causal condition absent
Source(s): Authors' own work

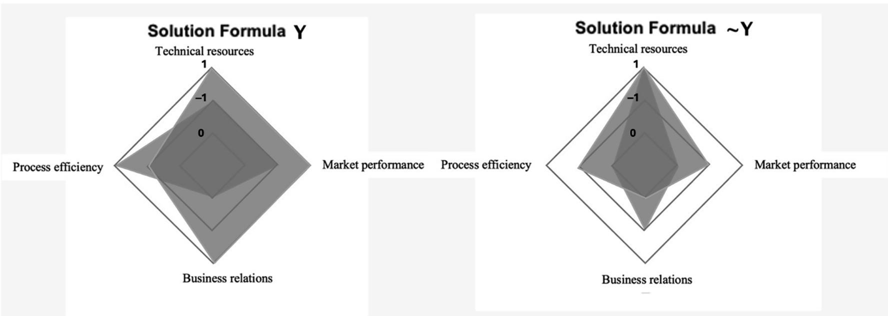

Figure 1. Radar charts of the sufficiency test. Source: Authors' own work

4.2 Robustness check

Oana and Schneider (2021) proposed a procedure to verify the robustness of their analysis results. This study implements csQCA and encompasses a sensitivity test for frequency and consistency parameters and the calculation of the robustness parameters using a fit-oriented methodology. Table 4 presents the results of the robustness test.

Table 4. Robustness test

	Condition	0	0.5	1
Sensitivity ranges - Y				
parameters	raw consistency	lower: 0.7	threshold: 0.85	upper: 0.99
	frequency	lower: 1	threshold: 1	upper: 2
Robustness parameters				
fit oriented	Rfcons: 1	Rfcov: 0.667	RFSC_minTS: 0.667	RFsc_maxTS: 0.286
Sensitivity ranges - ~ Y				
parameters	raw consistency	lower: 0.76	threshold: 0.85	upper: 0.99
	frequency	lower: 1	threshold: 1	upper: 2
Robustness parameters				
fit oriented	Rfcons: 1	Rfcov: 0.572	RFSC_minTS: 0.571	RFsc_maxTS: 0.538

Source(s): Authors' own work

The test identified a range of parameters that fit when the solution remains robust. In addition, it produced two alternative solutions to finalise the fit-oriented test by selecting fit parameters outside the sensitivity range. In this step of the procedure, a frequency threshold of 3 was set for both Y and ∼Y and a consistency threshold of 0.75 for Y and 0.65 for ∼ Y. Then, the procedure determined the robustness of the solution by examining its overlap with the alternative solutions. RFSC_minTS and RFsc_maxTS quantified the overlap with alternative solutions, whereas Rfcons and Rfcov indicated a fit for consistency and coverage (Table 4).

4.3 Configurations of blockchain benefits for sustainability goals

The sufficiency test solutions revealed two distinct pathways associated with positive outcomes (Solutions 1 A and 1 B) and two pathways related to negative outcomes (Solutions 2 A and 2 B).

The first path (1 A) represents a configuration in which sustainability goals are achieved through enhanced process efficiency despite the absence of both substantial resource augmentation and improved market performance. Firms that exemplify this pathway are predominantly small-scale enterprises that have adopted blockchain technology primarily for their technical functionalities. These enterprises leverage blockchain to enhance their tracking and tracing mechanisms, thereby significantly improving operational transparency, data accuracy, and resource optimization. Such enhancements are instrumental in supporting and maintaining sustainability objectives, emphasizing operational efficiency as a critical pathway toward sustainability. In these cases, the utilization of blockchain promotes streamlined internal processes, reduces operational redundancies, and minimizes resource wastage, thereby aligning directly with sustainability principles. Although some firms also reported improved regulatory compliance and accountability due to enhanced transparency, this aspect was primarily perceived as internally relevant and was not explicitly assessed in terms of its contribution to sustainability credentials.

1 B) The second path corresponds to a configuration in which the outcome of achieving sustainability goals is associated with the presence of substantial new resources, strengthened and more manageable relational networks, and improved market performance, combined with the absence of enhanced process efficiency. In this configuration, blockchain facilitates the deepening and broadening of relationships across supply chains, and enhances firms' strategic positioning in the marketplace. Notably, the blockchain's capacity to allow companies to foster extensive relationships involving institutional entities and certification bodies creates a robust ecosystem founded on transparency and trust. Firms following this pathway typically include medium-sized enterprises with certified premium products and significant international market reach. These companies strategically differentiate themselves by effectively utilizing blockchain-enabled transparency and traceability to reinforce consumer trust, product authenticity, and accountability throughout their supply chains. Additionally, blockchain adoption allows these firms to leverage enhanced information sharing and data interoperability, significantly improving their responsiveness to market demands and sustainability standards. The resultant strategic alignment with external stakeholders, including suppliers, distributors, regulatory agencies, and certification bodies, further solidifies their market positions and supports integrated sustainability goals.

Furthermore, two additional configurations identified by the sufficiency test result in negative outcomes for sustainability goals, indicating scenarios in which blockchain adoption fails to generate conducive sustainability benefits (Solutions 2 A and 2 B). Both configurations underscore the critical limitations associated with blockchain implementation, which primarily delivers new internal resources. In Solution 2 A, the acquisition of new resources alone yields negative outcomes when firms cannot translate these resources into stronger or more effective relational networks. Similarly, in Solution 2 B, the mere accumulation of new resources without concurrent improvements in process effectiveness or market performance resulted in unsatisfactory sustainability outcomes. These configurations illuminate significant constraints in focusing exclusively on blockchain-driven internal resource enhancement, without adequately addressing the relational dynamics within supply chains or achieving tangible improvements in market performance. Therefore, these findings emphasise the necessity for companies to strategically integrate blockchain-acquired resources with relational and market-oriented initiatives to realise comprehensive and meaningful sustainability goals.

5. A framework of blockchain adoption for sustainability

This study addresses BC as a technological innovation that can serve as a strategic enabler of systemic transformation in sustainability strategies (Arianpoor and Borhani, 2024; Kannan *et al.*, 2024; Tiscini *et al.*, 2020). Some successful international experiences confirm this trend in agri-food. The Silal Fresh case exemplifies how blockchain technology strengthens supply chain relationships by effectively addressing product safety concerns, extending product shelf life, and minimising waste. These effects permeate all supply chain partners, augmenting the overall efficiency and sustainability. The World Economic Forum indicates that this technology can address communication, privacy, and trust issues within supply chains (Van Niekerk, 2024). IBM's Food Chain also illustrates the increasing relevance of blockchain in advancing sustainability objectives. Farmer Connect, powered by IBM Blockchain, was initially designed to improve supply chain transparency by linking key stakeholders from growers to retailers, thereby ensuring enhanced efficiency, equity, and responsibility in coffee sourcing.

Building on the findings and through an iterative and analytical process of abstraction, this study synthesises theoretical frameworks with empirical insights (Rahmani and Leifels, 2018). Consequently, this study presents a comprehensive framework that defines three distinct approaches to BC adoption: technology-, process-, and value-driven (Figure 2).

These three approaches are positioned along a continuum that aligns with Bloomberg (2018) framework of digitisation, digitalisation, and cultural transformation in BC adoption. This framework provides a structured and holistic perspective offering insights into the various pathways through which BC adoption supports sustainability goals.

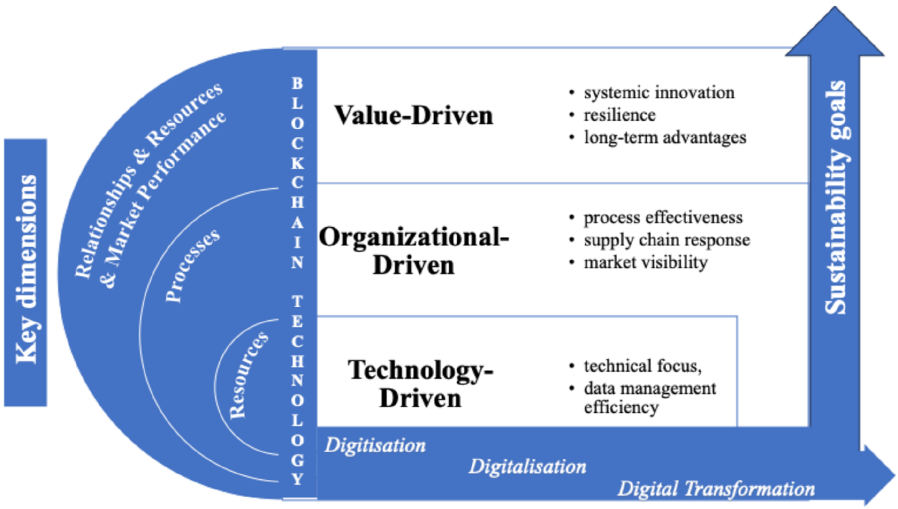

Figure 2. A framework of blockchain adoption for sustainability. Source: Authors' own work

The first technology-driven approach viewed BC as a technical innovation to renew resources and enhance data storage, retrieval, and utilisation (Hasan *et al.*, 2020; Martinez *et al.*, 2019). Companies adopting this approach discuss BC as a solution for foundational operational applications, emphasising internal and strictly digital interventions. BC allows companies to mitigate the risks associated with information storage, enables secure data storage, and facilitates internal objectives through a more fluid flow of information within the organisation (Liu *et al.*, 2021; Sharma *et al.*, 2024; Xue *et al.*, 2021). Organisations included in configuration paths that fail to establish a link between BC benefits and sustainability goals (Solution 2 A and Solution 2 B) fall into this category. While this approach acknowledges the benefits of BC regarding new digital resources and technological development, it does not recognise how these aspects could contribute to developing a broader strategic vision. By emphasising BC's functional and technical digitisation benefits, it prioritises immediate tangible advantages with limited impacts, such as data integrity and transaction accuracy.

In the case of a process-driven approach, the benefits of BC extend beyond secure data storage to emphasise organisational process effectiveness and integrate new data-driven decision-making capabilities to support sustainability strategies (Mukherjee *et al.*, 2021). Companies in the configuration path (1 A) exemplify this approach. The foundational data-driven advantage of BC, widely recognised in the literature (Xue *et al.*, 2021), highlights its value as a tool for achieving initial sustainability objectives. For instance, the formal coordination mechanisms enabled by BC contribute to improving organisational processes to respond efficiently to supply chain demands and strengthen chain positioning (Hasan *et al.*, 2020; Martinez *et al.*, 2019). However, this approach often prioritises individual choices and business goal-driven outcomes, focusing primarily on operational improvements and localised gains rather than systemic transformation. Companies adopting this strategy tend to operate in silos, leveraging BC solutions tailored to their strategic needs (Pan *et al.*, 2020). This reinforces a fragmented approach, in which companies privilege business advantages at the expense of shared long-term benefits (Kshetri, 2018).

The value-driven approach represents a holistic strategic framework in which BC technology fundamentally redefines business relations and value creation (Angelis and da Silva, 2019; Kannan *et al.*, 2024; Xu *et al.*, 2024). This approach entails cultural and operational transformations that aim for systemic innovation and alignment with broader sustainability goals. Companies in configuration path 1 B exemplify this approach. For these companies, the relational benefits of BC are viewed as integral to a comprehensive framework that connects them with a broader ecosystem of actors, including organisational stakeholders, institutional forces, and network partners (Li *et al.*, 2021). This perspective emphasises the crucial role of a company's internal capabilities, particularly its ability to harness emerging tools and technologies while fostering a culture of innovation. Complementary technologies such as sensors, the Internet of Things (IoT), and artificial intelligence (AI) are powerful catalysts for effective systemic transformation. This integration reinforces trust and enables companies to align responsible objectives with market performance metrics, ultimately enhancing long-term resilience, sustainability strategies, and value creation (Pandey *et al.*, 2024).

6. Contributions, implications and further research

These key findings illuminate how BC functions as a transformative tool for sustainability (Dadsena *et al.*, 2024; Tiscini *et al.*, 2020). Theoretical contributions show how BC transforms from a functional technology to a systemic innovation driver, providing managers actionable insights to match BC deployment with sustainability goals. According to this study, future research should focus on BC's contextual factors and systemic impact of BC. Table 5 presents these contributions to the relevant literature, practical implications, and future research opportunities.

Table 5. Contributions, implications, and further research

Theoretical contributions	Connections to literature	Implications for practitioners	Further research
1. BC as a Driver of Innovation and Sustainability	Extend BC's role beyond functional benefits to innovation and systemic transformation (e.g. Arianpoor and Borhani, 2024; Bag *et al.*, 2022; Jan *et al.*, 2024) Emphasise BC's transformative effects on transparency, efficiency, and trust (e.g. Dey and Shekhawat, 2021; Feng *et al.*, 2020; Friedman and Ormiston, 2022)	Leverage BC to foster innovation, streamline processes, and enhance stakeholder relationships Position BC as a strategic asset to optimise market performance and sustainability in business processes	RQ: What is the role of blockchain-related benefits to specific sustainability practices, such as in circular economy initiatives? RQ: What are the contributions of different BC-related benefits to the strategic alignment?
2. Complex Real-World Applications of BC for Sustainability	Highlight configurational effects of BC benefits and strategic alignment challenges (e.g. Jiang *et al.*, 2022; Mulligan *et al.*, 2024; Lezzi *et al.*, 2024) Provide evidence on synergic effects involving transparency, collaboration, and resource optimisation (e.g. Rehman *et al.*, 2023; Xu *et al.*, 2024)	Understand real-world complexities to align technical and strategic goals Align BC with broader strategies and stakeholder collaboration Optimise internal processes and external supply chain dynamics	RQ: How do the specific relational dynamics and technical competencies enabled by blockchain technology interact to drive sustainability outcomes? RQ: How does blockchain technology impact the sustainability practices of organisations beyond tier one suppliers in the agri-food supply chain? RQ: How does blockchain technology impact various organisational contexts or different industries?
3. Framework for Integrating BC into Organisational Strategies	Offer an evidence-based framework that integrates BC technological and value-driven dimensions. (e.g. Friedman and Ormiston, 2022; Mulligan *et al.*, 2024; Jan *et al.*, 2024)	Provide a roadmap for implementing BC across industries, balancing operational optimisation with external stakeholder integration Offer insights for integrating transparency, legitimacy, and stakeholder accountability in sustainability reporting	RQ: How do the technology-driven, process-driven, and value-driven pathways for blockchain implementation interact and evolve as companies experience new technology? RQ: To what extent can regulation or economic conjuncture impacts be systematically categorised and measured to assess BC's role as a technological and systemic enabler?

Source(s): Authors' own work

6.1 Theoretical contributions

This study examined how BC helps companies achieve sustainability goals. This study offers three key contributions that expand on the existing literature.

First, this study highlights the evolution of BC from a functional tool to a catalyst for innovation and sustainability (Arianpoor and Borhani, 2024; Jan *et al.*, 2024; Angelis and da

Silva, 2019; Bag *et al.*, 2022; Dai *et al.*, 2023; Kannan *et al.*, 2024). Drawing on the extensive literature (Dey and Shekhawat, 2021; Feng *et al.*, 2020; Kamble *et al.*, 2020; Khanfar *et al.*, 2021; Li *et al.*, 2021), this analysis focuses on four critical benefits of BC: strengthening relationships, providing new resources, enhancing process effectiveness, and sustaining market performance. Evidence demonstrates how these benefits contribute to sustainability within a company's strategic focus (Proposition 1). Moving beyond general discussions of BC's advantages, this study addresses recent calls for more precise guidelines to analyse the antecedents, benefits, and sustainability impacts of BC adoption (Jan *et al.*, 2024; Jiang *et al.*, 2022). In particular, and in line with prior models of business sustainability performance that emphasise the role of digital infrastructure in achieving multi-dimensional outcomes, this research contributes by demonstrating how BC can be strategically operationalised to advance firm-level sustainability goals.

Second, findings provide novel insights into how firms adopt and leverage the multifaceted benefits of blockchain (BC) to achieve sustainability outcomes, reflecting the intricate dynamics of real-world applications. While prior studies have often focused on isolated examples or theoretical potential (Jan *et al.*, 2024; Jiang *et al.*, 2022), this study explores the configurational effects of BC benefits and their strategic implications. The analysis demonstrates that the impact of BC on sustainability is amplified when certain BC benefits synergise under specific conditions (Proposition 2). The results, which delineate two configurational paths, provide evidence of how companies adopt differentiated approaches to BC. First, the benefit of process enhancement (Solution 1 A) enables firms to align their operations with sustainability objectives by emphasising the role of BC in operational transparency, accuracy, and resource optimisation (Feng *et al.*, 2020; Kamble *et al.*, 2020; Xu *et al.*, 2024). This improved internal efficiency directly informs the primary sustainability goals. Second, the transformative impact of BC emerges when the combined benefits involve relational improvements, integration of new resources, and enhanced market performance (Solution 1 B). In this context, this study reveals that the relational benefits attributed to BC (Friedman and Ormiston, 2022; Dai *et al.*, 2023; Upadhyay *et al.*, 2021) are more significant when paired with advanced technological resources, such as AI and IoT. This synergy is further strengthened when the benefits of BC translate into improved market performance (Xu *et al.*, 2024; Rehman *et al.*, 2023; Kannan *et al.*, 2024). Thus, BC's effectiveness depends on strategic alignment, stakeholder collaboration, and coherence with broader organisational strategies. These approaches align with recent research on the importance of tailoring BC solutions to organisational contexts (Spigarelli *et al.*, 2024) but go further by offering differentiated pathways for implementation across different organisations.

Third, the study proposes an integrative framework delineating three archetypal approaches to embedding BC within organisational strategy: process-driven, technology-driven, and value-driven. This continuum extends from internal process optimisation to externally oriented collaboration and stakeholder engagement. In line with recent studies (Jan *et al.*, 2024; Mulligan *et al.*, 2024), our framework emphasises that unlocking the transformative potential of BC requires more than isolated technological applications, which calls for complementary organisational practices and context-sensitive strategic frameworks. By introducing context-sensitive configurations to BC adoption, the framework provides a more nuanced understanding of how organisations can navigate some of the sustainability trade-offs inherent to BC technologies (Schinckus, 2020), thereby facilitating the development of tailored, strategically aligned adoption pathways.

In addition, this study adds to the theoretical discourse on sustainability performance by addressing the increasing scholarly emphasis on the development and application of comprehensive multidimensional sustainability metrics (Arianpoor and Salehi, 2021; Arianpoor *et al.*, 2023; Zimon *et al.*, 2022). Specifically, the proposed framework can serve as an analytical lens for addressing the complex and interdependent dimensions of sustainability performance. In doing so, it offers a structured means for theorising how BC-enabled strategies simultaneously affect economic, environmental, and social outcomes while revealing their systemic interactions. This approach enhances the theoretical clarity on how organisations can interpret, manage, and integrate sustainability goals within technology-mediated contexts.

6.2 Implications for practitioners

This study presents several implications for practitioners regarding the tangible and practical enhancement of sustainability goals through BC implementation.

First, it provides evidence of how BC functions as a strategic asset, addressing complex sustainability challenges that create tangible impacts across interconnected aspects (Pandey *et al.*, 2024; Jiang *et al.*, 2022). BC's multiple and context-dependent impacts offer managers several opportunities to exploit, according to their perception that it may evolve from a foundational technological solution to a systemic driver of innovation and sustainability transformation. This dual role underscores the importance of adopting a tailored and multifaceted approach to BC to elucidate its transformative role in fostering sustainable and innovative practices in firms and across industries.

Second, the findings indicate that organisations can translate the advantages of BC implementation into sustainability goals, albeit under specific conditions. Notably, this virtuous mechanism can be initiated when management effectively guides technology implementation through comprehensive integration into business processes (Nandi *et al.*, 2020). This integration manifests as a substantial transformation of these processes, fundamentally altering work routines, digitalising, and streamlining activities throughout the entire value chain, encompassing operations, marketing, and logistics (Kamble *et al.*, 2020). On the other hand, comparable sustainability goals advantages can be attained by organisations that effectively utilise BC to enhance their competitive position in the market and optimise the management of interactions with stakeholders, including but not limited to primary stakeholders such as customers and suppliers. From this perspective, managers must develop more confidence in BC integrity and the capacity to manage data, thereby reducing errors and the system's vulnerability to misconduct (Rejeb *et al.*, 2021). These aspects encompass several activities such as payment processing, data storage, intelligent logistics management, and IoT transactions, whose credibility and adoption may increasingly depend not only on technical functionality but also on how their benefits are communicated and perceived by users and partners (Blanco-González-Tejero *et al.*, 2024). Nevertheless, managers must possess a comprehensive understanding of the interoperability and scalability challenges associated with different BCs to effectively manage their technological choices, both internally and within the supply chain context, particularly concerning the potential for connectivity with other entities belonging to the same supply chain as well as the reputational risks associated with technology misalignment or poor public engagement (Hardjono *et al.*, 2019; Blanco-González-Tejero *et al.*, 2024).

Third, this study demonstrates the need for managers to be cognisant of the advantages technology offers on different sides. While adopting a BC appears promising for all companies, certain aspects must be considered to maintain the firm's sustainability goals. Despite the importance of fostering an organizational environment conducive to the utilization of new technologies through the promotion and development of specific knowledge and skills regarding the advantages and methods of implementing new technologies, the results indicate that the role of factors related to the penetration of technology into business processes or the development and strengthening of business relationships are essential for companies to achieve these goals. This aspect explains why BC may appear promising for all companies, but its effects and benefits are sometimes of different scope and significance (Aslam *et al.*, 2023). Cultural transformation, the capacity to invest in the digitisation of processes or to improve supply chain management, necessitates engaging stakeholders, including regulators, industry partners, and customers, to construct a supportive network that facilitates BC adoption and optimisation. These aspects highlight managers' roles in driving technological transformation in firms by extending beyond the availability of promising technologies ready to be adopted in the market, to include active shaping of trust and legitimacy through strategic stakeholder engagement and transparency practices (Blanco-González-Tejero *et al.*, 2024).

Additionally, by illustrating how BC enhances these dimensions, especially in contexts with low standardisation of non-financial reporting, our results offer actionable insights for managers to respond to ongoing calls for greater transparency, legitimacy, and stakeholder accountability in sustainability reporting (Arianpoor *et al.*, 2023; Zimon *et al.*, 2022). This study emphasises the importance of comprehensive sustainability measurements and their interrelations (Arianpoor and Salehi, 2021), reinforcing the need for integrative frameworks that can accommodate both the financial and non-financial dimensions. Blockchain has emerged as a promising mechanism to support such integration by enhancing transparency, traceability, and stakeholder accountability within sustainability reporting systems.

6.3 Further research

The findings and contributions of this study offer several avenues for further research.

First, further research might enhance the understanding of the role of BC-related benefits in various specialised sustainability practices, such as circular ones. BC may play a crucial role in facilitating supply chain circularity by enabling the tracing of materials across the supply chain and ensuring transparency and provenance. Further investigation into this element may facilitate adaptation or expansion of the framework to include these specificities. Moreover, future investigations may include different or additional antecedents to explore their contribution to achieving strategic goals such as sustainability.

Second, the findings underscore the importance of interactions between BC-related benefits in generating strategic effects. For instance, this study showed that specific relationships are critical when coupled with enhanced technical and technological competencies. This alignment fortifies inter-organisational ties and generates broader market impacts, illustrating BC's potential as a transformative enabler of sustainability goals. In this regard, additional research could go beyond the tier-one strategy utilised in this study, focusing on including agri-food enterprises and their technology providers in the empirical analysis. Future studies should include participants at other supply chain levels. This extension may reveal more about the use of BC in the supply chain, including indirect factors, to augment the findings. Future research could expand the conceptual framework to different organizational contexts and/or industries, uncover essential modifications according to other scenarios, and develop a deep understanding of various business contexts.

Third, technology-driven, process-driven, and value-driven approaches offer scholars a continuum to examine BC's transformative potential. This categorization provides scholars with a structured lens to investigate the various pathways that companies pursue when aligning BC implementation with sustainability objectives and organisational contexts (Sezer *et al.*, 2024). In a dynamic perspective, further longitudinal studies should examine how the adoption of BC evolves in response to different contextual conditions such as improved technological competences, changing regulations, or economic conjuncture. In addition, studies could explore how reputational risks and narrative-building influence the sustainability outcomes of different adoption paths over time (Blanco-González-Tejero *et al.*, 2024).

About the authors

Tiziana Russo-Spena, Ph.D., is Full professor of Business Management and Coordinator of PhD in Management at University of Naples Federico II. He is the elected Member of Reser–European Research Network on Services (www.Reser.net) and a Member of the Board of Directors of C.A.I.S.I.A.L. (Center for Innovation and Development of the Agri-food Industry of the Federico II University of Naples). She has been involved as local unit coordinator of many scientific projects on innovation and technology transfer. Her main areas of interest are service innovation and digital transformation. She has co-authored over 100 refereed articles six books on innovation topics and international *Journals, including the Industrial Marketing and Management, Journal of Business Ethics, Journal of Service Management, Journal of Business Research, Journal of Service Theory and Practices*.

Nadia Di Paola, PhD is Associate Professor of Business Management, Blockchain Management, and Operations and Logistics Management at the Department of Economics, Management, Institutions (DEMI), University of Naples "Federico II", Italy. She has authored and co-authored more than 80 peer-reviewed research articles, book chapters and proceedings and published 6 books in the fields of Business and Technology Management, Entrepreneurship, *Supply Chain and Operations Management. She serves as Editorial Board member of international scientific journals.*

Cristina Mele, Ph.D., is a Full Professor in the Department of Economics, Management, and Institutions at the University of Naples "Federico II." She is responsible for the Innovation and Technology Transfer research area at LUPT and is a member of the Executive Committee of Federica Weblearning–University Center for Innovation, Experimentation, and the Promotion of Multimedia Teaching. She serves as an Ambassador of ISSIP.org (International Society of Service Innovation Professionals) and is co-chair of the Naples Forum on Service. An expert in service innovation, smart technologies, markets, service ecosystems, and value co-creation, she has authored approximately 300 national and international publications, including contributions to J*ournal of The Academy of Marketing Science, Journal of Business Research, Industrial Marketing Management, Journal of Service Management, Journal of Retailing and Consumer Services, Journal of Business Market Management, Service Science, International Journal of Quality and Reliability Management*.

Appendix

Table A1. Firms included in the study.

Main product typology	N. Firms	N. Interviewees	Roles of interviewees
Beverage	2	3	Two quality managers One ICT manager
Blockchain solutions	3	3	Three project managers
Bran	2	2	One CEO One product manager
Cheese	1	1	One product manager
Coffee	1	2	One owner One quality manager
Cured meat	3	3	One CEO One quality manager One product manager
Fish	1	1	One e-supply chain manager
Food IT solutions	7	7	Seven project managers
Food preparations	3	5	One owner One CEO One marketing manager
Frozen food	1	1	One ICT manager
Fruit and vegetables	2	2	One technology manager One product manager
IT services and consultancy	3	3	Three project managers
IT solutions	7	7	Seven project managers
Meat	3	3	One CEO Two marketing managers

(*continued*)

Table A1. Continued

Main product typology	N. Firms	N. Interviewees	Roles of interviewees
Olive oil	5	9	Three CEO Two product managers One sales manager One logistics manager One quality manager One ICT manager
Pasta	3	3	Three product quality managers
Rice and cereals	2	2	Two product quality managers
Wine	3	5	One CEO Two quality managers One ICT manager One export manager

Source(s): Authors' own work

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Corresponding author
Tiziana Russo-Spena can be contacted at: russospe@unina.it