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Procedia Computer Science 277 (2026) 3817–3826

Procedia Computer Science

www.elsevier.com/locate/procedia

7th International Conference on Industry of the Future and Smart Manufacturing
(former International Conference on Industry 4.0 and Smart Manufacturing)

Perceptions of Blockchain's Role in Food Supply Chain Quality Management: A Comparative Analysis Across Global, Alternative, and Mixed Structures

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Abstract: The growing demand for transparency in food supply chains has positioned blockchain technology as an enabler for enhancing quality management. However, the structures of food systems and their supply chain networks, from large-scale global systems to localised alternative food networks (AFNs), suggest that the application and impact of blockchain are not uniform. This paper examines how blockchain is perceived to improve supply chain quality across various food network typologies. Adopting a qualitative approach, this study analyses responses from 59 food supply chain practitioners and experts who self-identified their operational context as solely global, solely alternative, or a mix of both. The findings show that the role of blockchain is context-dependent. Stakeholders in global food supply chains perceive it as a tool for standardisation, compliance, and managing complexity. Those in alternative networks view it as a mechanism to verify trust, enhance transparency around values-based attributes, and communicate their unique story. For stakeholders in mixed (global and alternative) supply chains, blockchain is viewed as a technology for integrating disparate systems and creating a unified, accountable framework. The research concludes that a one-size-fits-all approach to blockchain implementation is ineffective. Instead, "fit-for-purpose" solutions are required that align with the specific governance structures, values, and operational realities of each supply chain type.

Keywords: Digitalisation, Sustainable Food Supply Chain; Food System; Food Supply Chain

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1. Introduction

The global food system is undergoing a period of transformation, driven by pressure from consumers, governments, and foresight-driven businesses. These pressures are motivating a shift away from conventional, industrialised models towards more sustainable, transparent, and equitable methods [1]. However, the conventional, industrialised models still dominate the market share. The transformation is a response to the well-documented weaknesses of the current global food system approach, where decades of globalisation and industrialisation have led to a focus on economic performance and efficiency rather than other quality and sustainability criteria, such as soil health and social responsibility, along with other important indicators. The emphasis on economic performance and mass production reduces consumer trust due to food safety incidents, quality concerns, food fraud, and a lack of transparency that obscures the journey of food from farm to fork [2–4]. One response to the global food system is the increase of Alternative Food Networks (AFNs), as people seek products with alternative quality and sustainability performance attributes. [5,6]. Supply chains, both under global and alternative systems and networks, are reinforced by the principles and practices of Supply Chain Quality Management (SCQM), which involves coordinating all activities to systematically improve processes and products, thereby meeting and exceeding consumer needs.

Although alternative food networks (AFNs) present a promising way forward, managing supply chain quality remains a challenge. As the supply chains and AFNs expand their market reach, they transition from a highly local and direct relationship model between producers and consumers, where trust and quality are handled through personal interactions, to a structure where direct contact is often impractical. In indirect producer-to-consumer supply chains, AFNs must rely on abstract guidance, such as certificates and labels, to communicate value to consumers who are further away [7]. This presents challenges for supply chain quality management (SCQM), particularly in terms of trust. In AFNs, trust has traditionally been built on credibility, integrity, and benevolence through direct relationships [8]. As AFNs scale to new markets, it is necessary to reinforce trust to avoid misleading consumers and instil unwarranted confidence in products advertised through alternative channels. Additionally, inherent information asymmetries between producers and consumers complicate matters [9]. Conflicting governance pressures arise from top-down food safety regulations and the bottom-up relational quality conventions of the network itself [10]. To tackle these challenges, there is a need for “fit-for-purpose” solutions that are tailored to the unique scale, values, and capacities of AFNs.

Alongside these social transformations, digital technologies are presented as enablers for enhancing transparency and trust in supply chains [11,12]. Blockchain technology shows potential to support SCQM by providing a secure, immutable, and transparent digital ledger. Its ability to enhance traceability allows it to reinforce consumer confidence in intangible but highly valued quality attributes such as ethnicity, authenticity, traditional production methods, and the locality of raw materials. This capability shifts the quality paradigm from a passive "trust us, we are certified" model to "we will show you the data and the story" model. However, the successful implementation of such a technology is not solely a technical challenge, as it is influenced by the perceptions of the stakeholders who will use it. Stakeholder perceptions of a technology are often rooted in prior experiences. These experiences shape the design, adoption, and utility of the system, which may not always align with the technology's objective capabilities. The divergence between the perceived potential of blockchain and its practical realities highlights the importance of understanding stakeholder viewpoints from the outset. Despite the potential of blockchain, a knowledge gap exists. The unique, value-driven structures of food supply chains, ranging from direct, face-to-face networks to more extended, intermediated models, and fully global supply chains, suggest that how blockchain enables supply chain quality differs based on the structure of the supply chain network.

While research and application have revealed blockchain's potential, there is a lack of frameworks that analyse how its application and impact vary across these different supply chain typologies. Addressing this gap is meaningful to understanding how the technology can be used most effectively. This project aims to address the gap in understanding how supply chain managers perceive the role of blockchain technology in enhancing supply chain quality management across different food supply chain structures. The aim is to investigate and compare the perceptions of managers in global, alternative, and mixed food supply chains regarding the enabling role of blockchain technology in various aspects of supply chain quality management. To answer the aim, the research question is: How do managers' perceptions of blockchain technology's enabling role in supply chain quality management differ across global, alternative, and mixed food supply chain structures?

This paper is structured into six sections. Section 2 provides an overview of related work on supply chain quality and the use of blockchain in food supply chains. Section three covers the methodology, followed by the results in

Section 4. Section 5 presents the discussion, and Section 6 concludes, offering insights into the work's limitations and future directions.

2. Background and Related Work

2.1 Managing Supply Chain Quality in Food Supply Chains

A divergence between supply chain models characterises the food system. In this paper, the supply chains of the conventional global food systems and the Alternative Food Network (AFN) are studied. Supply chains in global food systems are products of decades of technological advancements and competitive strategies, and are characterised by their economies of scale, long-distance trade, and the dominance of large processing and retail corporations [13,14]. The conventional global food system structures are often linear and supply-driven, optimised for efficiency and cost reduction. On the other hand, the supply chains of AFNs represent a response to the perceived social and environmental failings of the global model [6]. Their objectives are to reduce the physical and social distance between producers and consumers, provide enhanced information, and provide alternative product offerings compared to what is being offered in their conventional, global counterparts [15]. The main differences between their supply chains include the configuration of the chain, the nature of relationships within the network, the way quality and sustainability are perceived and managed, in addition to the primary interests of the stakeholders involved [16]. Many participants in this study operate within this duality.

Supply Chain Quality Management (SCQM) has evolved as a discipline, integrating the principles of quality management with the complexities of supply chain management [17]. In its essence, SCQM represents the strategic coordination and integration of all supply chain activities and stakeholders to systematically monitor, analyse, and continually improve services, processes, and products, with the ultimate goal of adding value to meet and exceed consumer needs [18]. The core aims of SCQM are to elevate quality performance, foster deep integration among supply chain members, and enable a consumer-driven value creation process through strong upstream and downstream linkages [19,20].

Within the food industry, SCQM is not only beneficial but also indispensable [21]. The adoption of SCQM principles enables food companies to enhance their performance through tangible outcomes, including increased food safety, improved brand reputation, more effective recall procedures, reduced quality risks, and enhanced consumer perceptions of quality [22,23]. There is a necessity for SCQM in all types of food systems, which encompass the vast network of people and activities required to grow, transport, and consume food [24]. However, it is increasingly clear that the nature of consumer trust, a foundation of quality perception, differs across these food systems [25]. In the supply chains of conventional global food systems, consumer trust has been systematically eroded by intentional and unintentional food incidents, including food fraud, the proliferation of foodborne pathogens, and pervasive quality risks [26]. In contrast, Alternative Food Networks (AFN) are increasing consumer trust, which can be attributed to the interactions and close, transparent relationships they foster between stakeholders [27]. An AFN is explicitly designed to address the systemic failures of global food systems and is fundamentally driven by consumer demands for higher quality and greater sustainability [28]. These systems incorporate initiatives known as Sustainable and Alternative Food Networks (AFNs), which aim to restructure their organisation and supply chains by reducing both physical and social distances [29,30].

Within AFNs, quality and sustainability are the two pillars of value creation [31]. This creates a divergence in how quality is managed compared to global systems, i.e., where quality is prescribed by large-scale, industrialised quality organisations like GlobalG.A.P., the International Standards Organisation (ISO), and the International Food Standard (IFS). These top-down systems are challenging and sometimes incompatible for the small-to-medium enterprises (SMEs) that dominate AFNs [32]. Quality in AFNs is predicated on the (re)connection between producer and consumer and the (re)establishment of trust. This places their practices outside the scope of institutionalised quality management systems, leading to potential barriers such as limited market entry and risks of non-compliance [32]. Some AFNs use Participatory Guarantee Systems (PGS), which depend on stakeholder involvement and trust for producer certification. This variation in quality assurance calls for an investigation into adapting blockchain technology for these models.

2.2 Blockchain as an Enabler of Food Supply Chain Quality

Blockchain technology is being explored to improve quality, transparency, and trust in food supply chains, ranging from general agri-food systems to specific short and alternative networks. Table 1 summarises literature on different supply chain types and how blockchain can enhance quality and performance in these systems.

Table 1. Examples of Literature on Blockchain Technology in Food Supply Chains

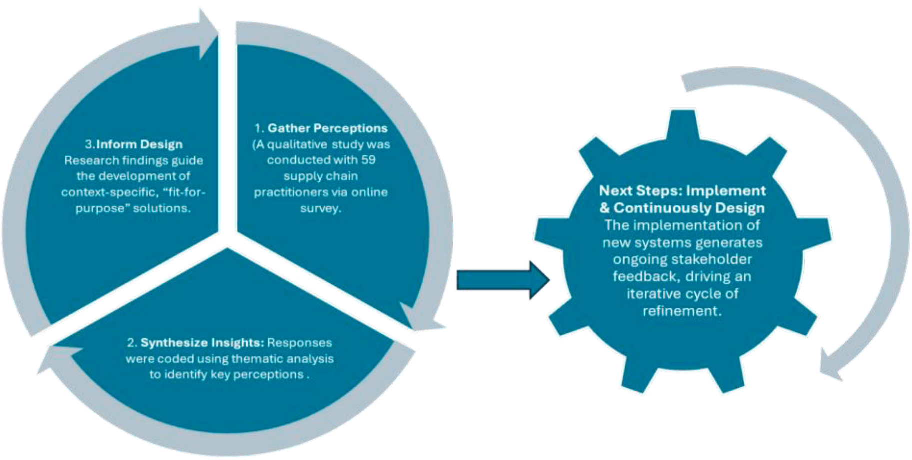
Source	Scope and Supply Chain Type	How Blockchain Enables Food Supply Chain Quality
[33]	General Agri-food Supply Chain: A qualitative study based on expert interviews exploring blockchain adoption through the lens of operational capability.	Enables quality through five core capabilities: Traceability (tracking origin to avoid disruptions), Transparency (increasing visibility to improve system efficiency), Information Security (securing data immutably), Transactions (automating processes via smart contracts to reduce costs), and Trust & Quality (establishing trust between parties to maintain food quality).
[34]	Sustainable & Alternative Food Supply Chains (AFSCs): A mixed-methods study to identify and prioritise stakeholder information needs for transparency.	Enables quality by addressing the "information deficit" in extended AFSCs. It supports informed consumer decision-making by providing verifiable, end-to-end information focused on stakeholder priorities (quality & safety, origin, nutrition). It facilitates a shift from top-down labels to more dynamic and participatory information sharing.
[35]	Short Food Supply Chains (SFSCs) & (Re) localised Systems: Proposes a multi-level blockchain architecture designed specifically for the quality management requirements of SFSCs.	Enables quality by supporting the unique requirements of SFSCs, such as fairness, locality, authenticity, and freshness. The proposed architecture combines IoT for data collection with a blockchain layer for immutable data storage, a trust layer to manage reputation with incentives, and an application layer for quality management functions.
[33,36]	General Food Supply Chain: A systematic literature review and bibliometric analysis of blockchain research.	The literature shows that blockchain enables quality by improving transparency, traceability, food safety, and food quality. It is a promising technology to build trust among actors, reduce intermediaries, and provide a secure platform for fair trade.
[37]	General Food Supply Chains: Proposes a traceability system framework that deeply integrates blockchain (Hyperledger Fabric) with RFID technology at the packaging level.	Enables quality by providing a decentralised traceability system. It guarantees data security and simplifies tracking by creating a blockchain data structure directly within the RFID tag. Information is recorded on the tag and simultaneously on the leading platform, creating a robust and scalable system for industrial use.

Many studies have explored blockchain technology's impact on food supply chains, but research on its role in enhancing supply chain quality across various companies in alternative, global, and mixed food systems is limited.

3. Methodology

The findings presented in this paper are derived from the qualitative component of a larger, ongoing mixed-methods research project. The research employed open-ended survey questions to capture the perspectives of experienced supply chain stakeholders regarding blockchain technology in SCQM. Figure 1 shows the approach adopted for the research presented in this paper. An online questionnaire was used to collect the data. Participants were recruited from a professional network, targeting individuals with demonstrable experience in the food industry. The selection criterion was active involvement in a food supply chain, ensuring that respondents possessed the necessary contextual knowledge to provide insightful answers. As part of the survey, participants were asked to self-identify the primary structure of their supply chain, categorising it as either "Solely alternative (e.g., short and local)," "Solely global," or a "Mix of global and alternative." This categorisation allowed for a comparative analysis of perspectives across different network types. This paper focuses specifically on the qualitative data collected from an open-ended question within the larger questionnaire: "Concerning supply chain quality management, in your view, how could blockchain technology enable you to achieve your organisation's key success factors?".

Figure 1: Research Approach



The written responses were analysed using an inductive thematic analysis approach. This involved an iterative process of: i) Familiarisation with the data through repeated reading of participant quotes. ii) Coding of keywords and ideas to identify patterns. iii) Grouping of codes into broader, overarching themes that emerged from the data. iv) Reviewing and refining themes to ensure they accurately capture the essence of the participant perspectives. v) Normalising the frequency of mentions per group (mixed, alternative, global) creates a comparative illustration of how stakeholders within the systems perceive blockchain as an enabler.

4. Results

4.1. About the participants and supply chains

This section describes the study participants and their respective organisations, followed by a thematic analysis of their perceptions of blockchain technology as a facilitator for supply chain quality success factors. The analysis is based on the 59 responses collected. The participants represented a range of experience with blockchain technology (From Novice to Expert). To ensure an understanding for those less familiar with blockchain, the questionnaire presented foundational concepts of blockchain's application in supply chains. The experience is illustrated in Figure 2. The participants came from diverse professional backgrounds within the food and agriculture sector. Many held multiple roles, reflecting the multifaceted nature of their work. Figure 3 shows the primary functions represented in the study. The participants could select more than one function, as some were engaged across several professional backgrounds.

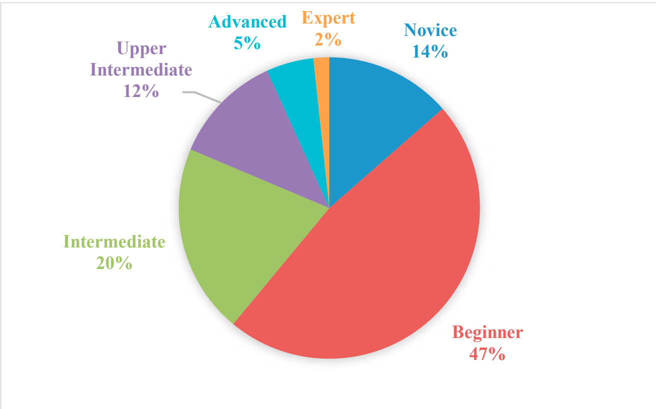


Figure 2: Participant Blockchain Understanding

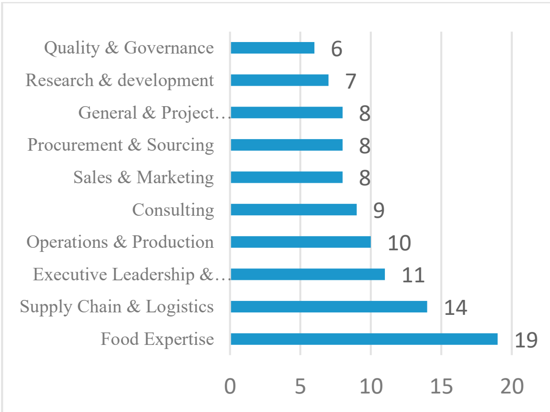


Figure 3: Participant Professional Function

The participants were asked to select the supply chain structure in which they perceive their main operations. The study encompassed a variety of supply chain structures. A significant portion of participants (26) were involved in a mix of global and alternative food supply chains (e.g., short and local). 19 operated solely within global supply chains, while 14 focused on alternative, exclusive models. The diversity within these categories is best understood through specific examples that highlight the range of actors, from consultants involved in multiple projects to producers. The Mixed (Global & Alternative) Supply Chains group was the largest, dealing with experiences in both global and alternative operations. For instance, Participant 24, a consultant who also helps operate their family's farm, manages a diverse operation including dairy cattle for the provincial supply board (local) and lowbush blueberries sold to a large packer for national and international distribution. This demonstrates the reality for producers who serve multiple market types simultaneously. Participant 19, a procurement manager for a dairy processor, described having a dedicated "Farm to Table" supply chain that accounts for over 70% of their operation within the Netherlands, alongside a separate, international supply chain for global markets. Participants in the Solely Alternative Supply Chains category focused on short, local, or specialised models that fall outside of the typical global structures. For example, Participant 33, a manager at a food processor, works within a Short Food Supply Chain (SFSC) by ordering vegetables directly from local farmers for processing and delivery. Participant 30, a farmer and CEO, operates a traditional, trust-based system for their beet, wheat, and chicory crops, which are harvested for processing at local plants. Their international scale and complexity characterised those in global supply chains. For example, Participant 48, a Supply Chain Manager for a large dairy company, describes a process that takes milk from the cow and turns it into powdered products in cans and bags for global use, either as a final product or as an ingredient for other food producers. Further down the chain, Participant 51 oversees a detailed global cheese operation that sources milk from multiple countries for processing and then distributes a wide range of products worldwide.

A range of products were covered across the represented experiences, from primary agricultural commodities to processed consumer goods. Figure 4 shows the number of organisations involved with specific product categories, while Figure 5 details their primary operational functions within the supply chain.

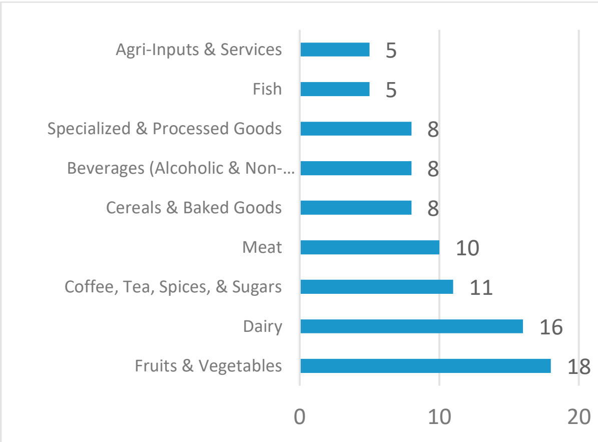


Figure 4: Supply Chain Involvement by Product Type

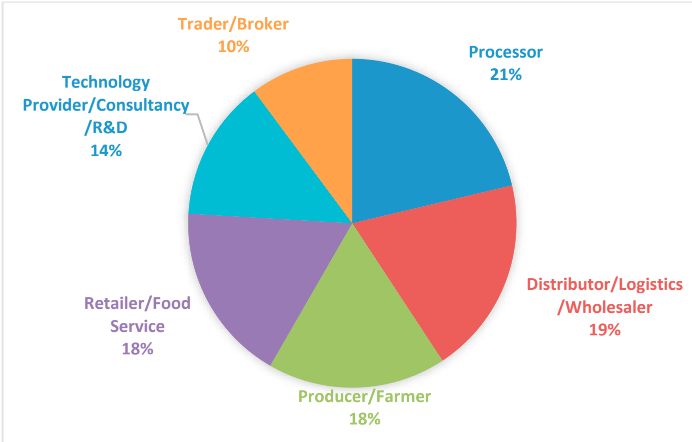


Figure 5: Supply Chain Involvement by Organisation Focus

4.2. Thematic Analysis of Blockchain Enablers

This section highlights the results on how blockchain can support supply chain quality management from managers in mixed food supply chains, alternative food supply chains, and global food supply chains. In mixed supply chains, respondents view blockchain as a foundational technology that enables a transparent, integrated, and accountable system. The benefit is providing a "secure, transparent, and verifiable foundation for supply chain operations," allowing a business to "demonstrate the entire supply chain." This foundation supports numerous quality and business objectives, providing "evidence of product credentials," which enhances "supplier accountability" and allows for the "monitoring of product quality in transit." The goal is to create a system where "data sharing along the supply chain leads to feedback," which in turn implements "practice change to better chase new pricing models." This integrated data environment facilitates a "shift away from the silo's of information that have existed in our industry," where nearly every processor has a "bespoke ERP system." By enabling "faster info sharing" and making "good and useful data readily available," blockchain leads to "better decision making" and helps "reduce unnecessary human mistake costs." This value extends beyond simple traceability to include tangible economic benefits, such as enabling "direct payment to farmers," strengthening "branding of product (oysters)," and reducing "liability in INCO terms if there is a discrepancy on a shipment." While some express concern over the "carbon footprint of data centers" and believe adoption depends on "customer demand," the overarching view is that blockchain is an enabler for transparency, performance, accountability, and trust.

In solely alternative food supply chains, respondents view blockchain as a tool to enhance transparency, improve data management, and build consumer trust. The technology is seen as a way to solve operational inefficiencies, with one respondent noting it can make their transparency more "traceable and organised," which is needed because "Right now, we input a lot of information manually and it is quite cumbersome." The objective is to achieve better "inter-departmental information sharing across the supply chain," allowing stakeholders to "produce, track and deliver our product in its highest quality and on time." This improved data management is directly linked to building credibility with partners and customers. Stakeholders aim to "provide reliable data to client's" and give customers "full access to transparent data management." The ultimate commercial benefit is clear: by providing a "transparent overview of what's going on in each node," they can "create trust with the consumer, therefore creating more sales opportunities." A counter-narrative emerged in the alternative supply chains, expressing scepticism towards the technology's complexity and fit. One respondent stated it would be "overly complex in a farm setting. It’s best to keep things simple and based on trust and motivation, rather than administration or control." This highlights a central tension in alternative networks between leveraging technology for verifiable trust and preserving the simplicity of traditional, relationship-based systems.

For stakeholders in solely global food supply chains, the perception of blockchain as an enabler shifts towards organising chaos and ensuring end-to-end traceability, managing compliance, and enabling strategic communication. The technology is seen as a way to "improve traceability from grass to glass," providing the "clear historical data" needed for robust quality control and to "continuously find new and more efficient ways for production and product improvements." A driver is managing the complexities of international certification, where blockchain could "guarantee a transparency of information, something is very needed when we are dealing with so many controls on certificates." The ability to share this verified information with a "click" would save significant time. However, a tension exists between the ideal of radical transparency and the commercial realities of global trade. One respondent from a trading company stated plainly that full disclosure "would not be possible in our company, as we are a trading company and therefore cannot disclose too much information about the origin/manufacturer." This suggests that for some global actors, blockchain is valued not for transparency, but for its ability to provide "a consistent storyline of the raw material without needing to inform all production details," thereby helping to "maintain contact with disconnected consumers" in a controlled manner while ensuring "transparency and data security." Despite this, there is an acknowledgement that the technology has "a lot of potential, but still baby steps to explore."

Table 2 highlights the key themes mentioned by participants and the frequency of those mentions across the different supply chain types. For comparison (in percentage), the responses have been normalised to the population of each group, global, alternative and mixed supply chains.

Table 2. Final Results Table Summarising Themes and Frequencies per Supply Chain Type

Main Theme	Mixed Supply Chains (n=26)	Alternative Supply Chains (n=14)	Global Supply Chains (n=19)	Total Mentions
Transparency & Information Sharing	11 (42%)	5 (36%)	8 (42%)	**24**
Operational Efficiency & Economic Performance	8 (31%)	5 (36%)	3 (16%)	**16**
Traceability & Provenance	7 (27%)	4 (29%)	5 (26%)	**16**
Data Governance & Integrity	7 (27%)	4 (29%)	5 (26%)	**16**
Trust & Supply Chain Relationships	6 (23%)	5 (36%)	1 (5%)	**12**
Consumer Empowerment	5 (19%)	3 (21%)	2 (11%)	**10**
Accountability & Compliance	5 (19%)	0 (0%)	3 (16%)	**8**
Scepticism & Adoption Barriers	1 (4%)	1 (7%)	1 (5%)	**3**

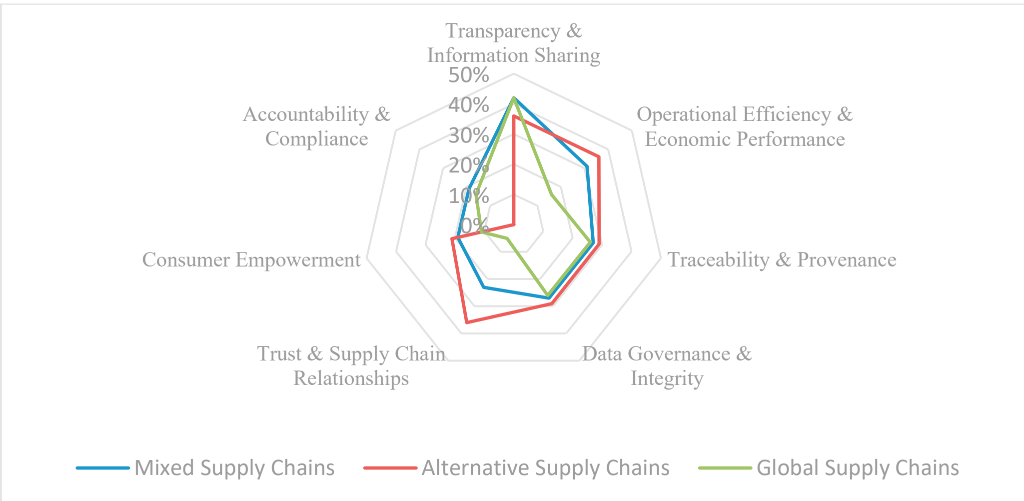


Figure 6. Spider Plot Comparing Perceptions of Blockchain as an Enabler for Supply Chain Quality

Figure 6 illustrates how participants perceive blockchain as an enabler. Transparency and information sharing remain a consistently high priority across all groups, mentioned by 42% of global, 42% of mixed, and 36% of alternative chain stakeholders. Other priorities, however, show notable divergence. For example, "Trust & Supply Chain Relationships" is a theme that is particularly relevant for stakeholders in alternative (36%) and mixed (23%) chains, but it is scarcely mentioned by those in global chains (5%). Conversely, themes such as "Accountability & Compliance" are essential in global (16%) and mixed (19%) settings but are not mentioned at all by stakeholders in alternative networks (0%).

5. Discussion

The analysis reveals that stakeholder perceptions of blockchain's role in supply chain quality management are not uniform, but somewhat shaped by the unique structural and normative context in which they operate. The findings illustrate the apparent divergence in priorities across the three supply chain types: global stakeholders prioritise applications related to compliance, traceability, and control; alternative stakeholders focus on trust, transparency, and efficiency; and those in mixed systems see value in integration, accountability, and performance. However, the figure also highlights the common ground, showing that the foundational needs for better information sharing and data integrity are universally recognised.

The spider diagram offers an overview of supply chain managers' perceptions regarding the enabling role of blockchain technology in supply chain quality management, revealing that this perception is not uniform across supply chain structures. Instead, it is shaped by the unique structural and normative context in which stakeholders operate. This differentiation in perception highlights several points for discussion, underscoring the technology's application in food SCQM.

A universal belief in blockchain's capacity to enhance "Transparency & Information Sharing" is evident, ranking as a high priority across all three groups (42% for both Mixed and Global, 36% for Alternative). This, along with similar perceptions for "Traceability & Provenance" and "Data Governance & Integrity," indicates a shared understanding of blockchain's core value in creating a secure and verifiable ledger. This aligns with foundational literature that identifies immutability and distributed ledgers as primary enablers for mitigating fraud and building confidence [33,36]. For Global Supply Chains, the need for such systems is intuitive, given their inherent complexity and the multitude of intermediaries involved. However, the data shows that even in the shorter, more direct supply chains of AFNs, the desire for verifiable product journeys remains strong [34].

However, a more nuanced picture emerges when examining other dimensions of quality management. The opposing themes of trust and compliance best illustrate a divergence in strategic motivation. For stakeholders in Alternative Supply Chains, the primary driver is enhancing "Trust & Supply Chain Relationships," which was a major focus (36%). In contrast, "Accountability & Compliance" was not mentioned at all (0%). This finding strongly reinforces that AFNs operate on a logic of relational quality [8], where technology is seen not as a tool for enforcement, but as a mechanism to verify and scale the trust that already underpins their value proposition. It allows them to communicate unique attributes and foster a direct, "personalised trust" with consumers [7], which can border on a "make-believe trust" rooted in feelings and stories, rather than solely in empirical data.

In comparison, global supply chains, the focus of blockchain adoption aligns more with risk management. Stakeholders in Global Supply Chains perceive blockchain's value through the lens of "Accountability & Compliance" (16%), while placing little emphasis on "Trust & Supply Chain Relationships" (5%). This reflects the operational reality of large, impersonal systems, where managing risk, ensuring regulatory compliance, and standardising processes across vast networks are paramount [14,38]. For these actors, transparency is often more strategic, i.e. a tool to prove compliance and manage the "information deficit" in extended chains without revealing sensitive commercial details. It becomes a way to provide a "consistent storyline" and manage certifications without necessarily fostering direct, personal trust. The data also presents a more nuanced picture of efficiency, with "Operational Efficiency & Economic Performance" being a significantly higher priority for Alternative (36%) and Mixed (31%) chains than for Global ones (16%), suggesting the direct economic benefits are a primary motivator for smaller, more agile networks. This also highlights the issue of blockchain as a double-edged sword for the competitive priorities of global food systems.

Furthermore, barriers to adoption remain, which are also context-dependent. A critical challenge for all chain types is the pervasive "garbage-in, garbage-out" problem. An immutable record of incorrect data is a significant liability, underscoring that a purely technical solution is insufficient. This necessitates a socio-technical approach, such as the "trust layer" with incentives proposed by [11,35], to ensure data accuracy. Furthermore, the barriers are deeply ingrained in existing business models. In alternative chains, there is a palpable scepticism that the technology is "overly complex," potentially undermining the simplicity of their relationship-based trust. Conversely, in global chains, a more structural barrier exists where the business models of many intermediaries rely on information asymmetry, making the radical transparency offered by blockchain a direct threat to their value proposition.

These findings strongly support the need for a socio-technical framework when considering blockchain implementation. Drawing on concepts from structuration theory, which posits that technology (structure) and human action (agency) mutually shape one another, it is reflected that a technical approach alone, is insufficient. The perceptions of stakeholders are not passive opinions, but are central to this process of mutual development. For an implementation to be successful, the technical system must be designed to align with the perceived benefits and operational desires of its users. This study reveals a divergence in these perceptions. AFNs prioritise technology that reinforces relational trust, while global food networks seek tools for enforcing compliance. A successful implementation, therefore, cannot simply impose a technical solution but must co-design the system with the unique social structures, values, and priorities of the stakeholders (the 'social'). This synthesis highlights that the challenge is not just implementing blockchain, but aligning it with the socio-technical reality of each supply chain.

Ultimately, the results reveal distinct and divergent priorities across various supply chains when considering the role of blockchain. These fundamental differences highlight that blockchain solutions for supply chain quality management cannot be a one-size-fits-all proposition; they must be carefully tailored to reflect the unique values, operational logic, and strategic priorities of each specific supply chain type, necessitating a move beyond generic blockchain solutions towards context-specific, socio-technical designs that honour the unique ethos of each supply chain.

6. Conclusion

This paper investigates how stakeholders across global, alternative, and mixed food supply chains perceive the role of blockchain in quality management, providing empirical evidence that its application is highly context-dependent. The main contribution is demonstrating that a "one-size-fits-all" approach is ineffective, as global stakeholders view blockchain as a tool for compliance and standardisation. At the same time, those in alternative networks see it as a mechanism for verifying trust and communicating their unique story. Stakeholders in mixed systems, in turn, perceive it as a foundational technology for integration. At the same time, this qualitative study highlights these divergent views, its limitations as part of a larger mixed-methods project point to the need for future research. Key areas for further investigation include developing socio-technical solutions to ensure data accuracy before it is recorded on-chain and creating governance models to overcome the business and structural barriers to adoption.

This study highlights several limitations regarding approach and technology, suggesting future research directions. One issue is data veracity, as blockchain cannot verify the accuracy of input data, indicating a need for third-party audits and community-based models to ensure data integrity. Additionally, findings based on 59 practitioners may not be applicable to the entire food industry. The research also does not compare blockchain to other technologies that enhance transparency and traceability. Treating "blockchain" as a single concept ignores the unique features like decentralisation and smart contracts that may be relevant in various supply chains. Future studies should analyse these aspects for a deeper understanding. Effective stakeholder training is crucial for bridging the gap between the perceived benefits of blockchain and its actual capabilities. Ultimately, a contextual analysis of a supply chain's socio-technical requirements is essential before selecting technology; future work should focus on developing frameworks for successful blockchain implementation and governance.

References

[1] A. Hariharasudan, S. Kot, J. Sangeetha, The decades of research on SCM and its advancements: Comprehensive framework, Acta Logistica 8 (2021) 455–477.

[2] E.K. Ling, S.N. Wahab, Integrity of food supply chain: Going beyond food safety and food quality, International Journal of Productivity and Quality Management 29 (2020) 216–232. https://doi.org/10.1504/IJPQM.2020.105963.

[3] A.P.J. Mol, Governing China's food quality through transparency: A review, Food Control 43 (2014) 49–56. https://doi.org/https://doi.org/10.1016/j.foodcont.2014.02.034.

[4] J. Hoorfar, K.N. Jordan, F. Butler, R. Prugger, Food chain integrity: A holistic approach to food traceability, safety, quality and authenticity, Elsevier Ltd, National Food Institute, Technical University of Denmark, Mùrkhùj Bygade 28, Block H, DK-2860 Sùborg, Denmark, 2011. https://doi.org/10.1533/9780857092519.
[5] M. Kneafsey, L. Venn, U. Schmutz, B. Balázs, L. Trenchard, T. Eyden-Wood, E. Bos, G. Foster, M. Blackett, Short Food Supply Chains and Local Food Systems in the EU. A State of Play of their Socio-Economic Characteristics., 2013. https://op.europa.eu/en/publication-detail/-/publication/d16f6eb5-2baa-4ed7-9ea4-c6dee7080acc.
[6] H. Renting, T.K. Marsden, J. Banks, Understanding alternative food networks: exploring the role of short food supply chains in rural development, Environ Plan A 35 (2003) 393–411. https://doi.org/10.1068/a3510.
[7] S.C.O. Wertheim-Heck, G. Spaargaren, Shifting configurations of shopping practices and food safety dynamics in Hanoi, Vietnam: a historical analysis, Agric Human Values 33 (2016) 655–671. https://doi.org/10.1007/s10460-015-9645-4.
[8] A.-H. Prigent-Simonin, C. Hérault-Fournier, The role of trust in the perception of the quality of local food products: with particular reference to direct relationships between producer and consumer, Anthropology of Food (2005). https://doi.org/https://doi.org/10.4000/aof.204.
[9] C. Bai, J. Sarkis, A supply chain transparency and sustainability technology appraisal model for blockchain technology, Int J Prod Res 58 (2020) 2142–2162. https://doi.org/10.1080/00207543.2019.1708989.
[10] D. López-García, M. González de Molina, An Operational Approach to Agroecology-Based Local Agri-Food Systems, Sustainability 13 (2021) 8443.
[11] S. Malik, V. Dedeoglu, S.S. Kanhere, R. Jurdak, Trustchain: Trust management in blockchain and iot supported supply chains, in: 2019 IEEE International Conference on Blockchain (Blockchain), IEEE, 2019: pp. 184–193.
[12] S. Yele, R. Litoriya, Blockchain-based secure dining: Enhancing safety, transparency, and traceability in food consumption environment, Blockchain: Research and Applications 5 (2024) 100187. https://doi.org/https://doi.org/10.1016/j.bcra.2023.100187.
[13] M. Fonte, Introduction: Food relocalisation and knowledge dynamics for sustainability in rural areas, Naming Food After Places: Food Relocalisation and Knowledge Dynamics in Rural Development (2010) 1–35.
[14] G. Gereffi, J. Humphrey, T. Sturgeon, The governance of global value chains, Rev Int Polit Econ 12 (2005) 78–104.
[15] C. Paciarotti, F. Torregiani, The logistics of the short food supply chain: A literature review, Sustain Prod Consum 26 (2021) 428–442. https://doi.org/https://doi.org/10.1016/j.spc.2020.10.002.
[16] K.M. Thomé, G. Cappellesso, E.L.A. Ramos, S.C. de L. Duarte, Food Supply Chains and Short Food Supply Chains: Coexistence conceptual framework, J Clean Prod 278 (2021) 123207. https://doi.org/https://doi.org/10.1016/j.jclepro.2020.123207.
[17] S.T. Foster Jr, C. Wallin, J. Ogden, Towards a better understanding of supply chain quality management practices, Int J Prod Res 49 (2011) 2285–2300. https://doi.org/https://doi.org/10.1080/00207541003733791.
[18] C.J. Robinson, M.K. Malhotra, Defining the concept of supply chain quality management and its relevance to academic and industrial practice, Int J Prod Econ 96 (2005) 315–337. https://doi.org/10.1016/j.ijpe.2004.06.055.
[19] L. Fish, Supply Chain Quality Management, in: 2011. https://doi.org/10.5772/19973.
[20] S.T. Foster, Towards an understanding of supply chain quality management, Journal of Operations Management 26 (2008) 461–467. https://doi.org/https://doi.org/10.1016/j.jom.2007.06.003.
[21] I. Filipović, B. Njari, L. Kozačinski, Ž. Cvrtila Fleck, B. Mioković, N. Zdolec, V. Dobarnić, Quality management systems in the food industry, Meso 10 (2008) 465–468.
[22] H. Song, R. Turson, A. Ganguly, K. Yu, Evaluating the effects of supply chain quality management on food firms' performance: The mediating role of food certification and reputation, International Journal of Operations and Production Management 37 (2017) 1541–1562. https://doi.org/10.1108/IJOPM-11-2015-0666.
[23] M. Zhang, H. Hu, X. Zhao, Developing product recall capability through supply chain quality management, Int J Prod Econ 229 (2020) 107795. https://doi.org/https://doi.org/10.1016/j.ijpe.2020.107795.
[24] A. Espino, E. Monville-Oro, W.J. Barbon, C.D. Ruba, S. Gummadi, J. Gonsalves, Local Food Systems in Cambodia, Myanmar, and the Philippines: Perspective from the Local Communities, CCAFS Working Paper (2021).
[25] A.-H. Prigent-Simonin, C. Hérault-Fournier, The role of trust in the perception of the quality of local food products: with particular reference to direct relationships between producer and consumer, Anthropology of Food (2005). https://doi.org/https://doi.org/10.4000/aof.204.
[26] E.K. Ling, S.N. Wahab, Integrity of food supply chain: Going beyond food safety and food quality, International Journal of Productivity and Quality Management 29 (2020) 216–232. https://doi.org/10.1504/IJPQM.2020.105963.
[27] A. Carbone, M. Gaito, S. Senni, Consumers' buying groups in the short food chains: Alternatives for trust, 2007.
[28] R. Feagan, The place of food: Mapping out the "local" in local food systems, Prog Hum Geogr 31 (2007) 23–42. https://doi.org/10.1177/0309132507073527.
[29] J.R. Follett, Choosing a food future: Differentiating among alternative food options, J Agric Environ Ethics 22 (2009) 31–51.
[30] R. Michel-Villarreal, M. Hingley, M. Canavari, I. Bregoli, Sustainability in Alternative Food Networks: A Systematic Literature Review, Sustainability 11 (2019). https://doi.org/10.3390/su11030859.
[31] S. Jarzębowski, N. Bezat, Supply chain management according to the concept of short supply chain, Proceedings in Food System Dynamics (2018) 313–320.
[32] G. Heron, D. Oglethorpe, Testing the theory of constraints in UK local food supply chains, International Journal of Operations & Production Management 33 (2013) 1346–1367. https://doi.org/10.1108/IJOPM-05-2011-0192.
[33] A. Sharma, T. Bhatia, R.K. Singh, A. Sharma, Developing the framework of blockchain-enabled agri-food supply chain, Business Process Management Journal 30 (2024) 291–316. https://doi.org/10.1108/BPMJ-01-2023-0035.
[34] P.R. Burgess, F.T. Sunmola, S. Wertheim-Heck, Information Needs for Transparency in Blockchain-Enabled Sustainable Food Supply Chains, International Journal of Information Management Data Insights (n.d.).
[35] P. Burgess, F. Sunmola, S. Wertheim-Heck, Blockchain Enabled Quality Management in Short Food Supply Chains, Procedia Comput Sci 200 (2022) 904–913. https://doi.org/https://doi.org/10.1016/j.procs.2022.01.288.
[36] A. Sharma, A. Sharma, T. Bhatia, R.K. Singh, Blockchain enabled food supply chain management: A systematic literature review and bibliometric analysis, Operations Management Research 16 (2023) 1594–1618. https://doi.org/10.1007/s12063-023-00363-2.
[37] L. Wang, Y. He, Z. Wu, Design of a Blockchain-Enabled Traceability System Framework for Food Supply Chains, Foods 11 (2022). https://doi.org/10.3390/foods11050744.
[38] S.T. Foster, Towards an understanding of supply chain quality management, Journal of Operations Management 26 (2008) 461–467. https://doi.org/https://doi.org/10.1016/j.jom.2007.06.003.