

Business Ethics in Organic Agri-Food Supply Chains: Opportunities and Challenges of Digital Product Traceability

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ABSTRACT

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The growing market for organic agricultural products has intensified attention to sustainability, transparency, and business ethics within agri-food supply chains. Digital product traceability is increasingly recognized as a strategic instrument to address these demands. However, existing studies remain fragmented and provide limited systematic synthesis of the opportunities and challenges of digital traceability from a business ethics perspective, particularly in organic agri-food supply chains involving smallholder farmers. This study conducts a systematic literature review to examine the opportunities and challenges of implementing digital product traceability in support of business ethics within organic agri-food supply chains. Following PRISMA guidelines, the review analyzes 22 relevant articles retrieved from Scopus, Web of Science, and Google Scholar using thematic synthesis. The findings indicate that key opportunities associated with digital product traceability include enhanced transparency and accountability across supply chains, strengthened consumer trust and certification compliance, and improved efficiency and visibility of agri-food supply chain processes. Conversely, major challenges persist, particularly in smallholder-based supply chains, including high technology adoption costs, limited digital infrastructure and literacy, and risks of inequality and exclusion. Overall, this review highlights that digital product traceability holds significant potential to strengthen business ethics and sustainability in organic agri-food supply chains. However, the realization of these benefits is highly conditional upon inclusive implementation approaches, such as capacity building in digital literacy, supportive institutional frameworks, and the adoption of traceability technologies that are affordable, user-friendly, and aligned with local socio-cultural contexts.

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1. Introduction

Growing global demand for organic and high value-added food products has intensified attention to sustainability, transparency, and business ethics within agri-food supply chains. Previous studies indicate that consumers and international stakeholders increasingly expect credible information regarding production processes, product origin, and ethical practices embedded in food systems, particularly in the context of sustainable and organic agri-food markets [1].

Organic agri-food supply chains are generally characterized by high levels of complexity due to the involvement of certification standards, traceability requirements, and multiple actors operating at different scales. This complexity increases the risk of information asymmetry, weak coordination, and limited oversight of business practices along the supply chain. Tort et al. [2] highlight that such conditions can undermine transparency and accountability, thereby creating vulnerabilities to unethical practices within sustainable food supply chains. Smallholder farmers play a critical role in

organic and sustainable agri-food systems, contributing significantly to production while often facing structural disadvantages within supply chain governance. Limited access to information, weak bargaining power, and asymmetric relationships with downstream actors frequently constrain their participation in decision-making processes. Kersten et al. [3] argue that persistent information asymmetry within agri-food supply chains can negatively affect trust, fairness, and ethical business conduct among supply chain participants.

Business ethics challenges in organic agri-food supply chains are further reflected in the limited availability of reliable and transparent product information. Ellahi et al. [4] note that the absence of robust traceability systems can reduce product credibility and weaken accountability, particularly for products carrying sustainability or organic claims. In this context, product traceability has emerged as a critical mechanism for ensuring information integrity and strengthening ethical practices across agri-food supply chains. Anwar et al. [5] emphasize that well-designed traceability systems can enhance transparency, foster market trust, and protect small-scale producers from unfair business practices.

Recent advancements in digital technologies have opened new opportunities for strengthening product traceability in agri-food supply chains. Blockchain-based systems, Internet of Things (IoT) applications, and digital data integration platforms have been shown to improve data reliability, transparency, and real-time information sharing [6]. However, the implementation of such technologies also presents significant challenges, particularly for smallholder-based supply chains. Sundarakani and Ghose [7] highlight that limited infrastructure, financial constraints, and low levels of digital literacy remain major barriers to the adoption of digital traceability systems among small-scale producers.

Despite a growing body of literature addressing digital technologies and product traceability in agri-food supply chains, existing studies remain fragmented and predominantly focus on technical or operational aspects. There is still a lack of systematic synthesis that explicitly examines the opportunities and challenges of digital product traceability from a business ethics perspective, particularly within organic agri-food supply chains involving smallholder farmers. To address this gap, this study conducts a systematic literature review to synthesize existing research on digital product traceability in organic agri-food supply chains through the lens of business ethics. Specifically, this study aims to identify key opportunities associated with digital product traceability, analyze ethical challenges and risks arising from its adoption, particularly for smallholder farmers, and examine its implications for strengthening ethical governance in organic agri-food supply chains.

2. Method

This study employs a Systematic Literature Review (SLR) to synthesize existing research on digital product traceability in organic agri-food supply chains from a business ethics perspective. The review follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure a transparent, rigorous, and replicable process of literature identification, screening, and selection.

2.1. Literature Search Strategy

The literature search was conducted using three major academic databases, namely Scopus, Web of Science, and Google Scholar, to ensure comprehensive coverage of peer-reviewed studies relevant to digital traceability, agri-food supply chains, and business ethics. The search focused on publications issued between 2015 and 2025, reflecting recent developments in digital technologies and traceability systems within agri-food contexts. A combination of keywords related to digital traceability (such as blockchain and Internet of Things), organic and agri-food supply chains, and ethical and sustainability considerations was applied. This search process yielded a total of 328 articles, comprising 72 articles from Scopus, 46 from Web of Science, and 210 from Google Scholar.

2.2. Screening and Selection of Studies

Following the identification stage, all retrieved records were combined and subjected to a deduplication process, which resulted in the removal of 48 duplicate articles. The remaining 280 articles were then screened based on their titles and abstracts to assess their relevance to the research focus on business ethics, organic agri-food supply chains, and digital product traceability. During

this stage, 19 articles were excluded due to limited relevance. Subsequently, full-text screening was conducted on 82 articles, of which 6 articles were excluded because the full texts were not accessible. The remaining 76 articles were assessed against predefined inclusion and exclusion criteria, leading to the exclusion of 54 articles. Ultimately, 22 articles were selected for thematic analysis. The overall selection process is illustrated in Figure 1, which presents the PRISMA flow diagram.

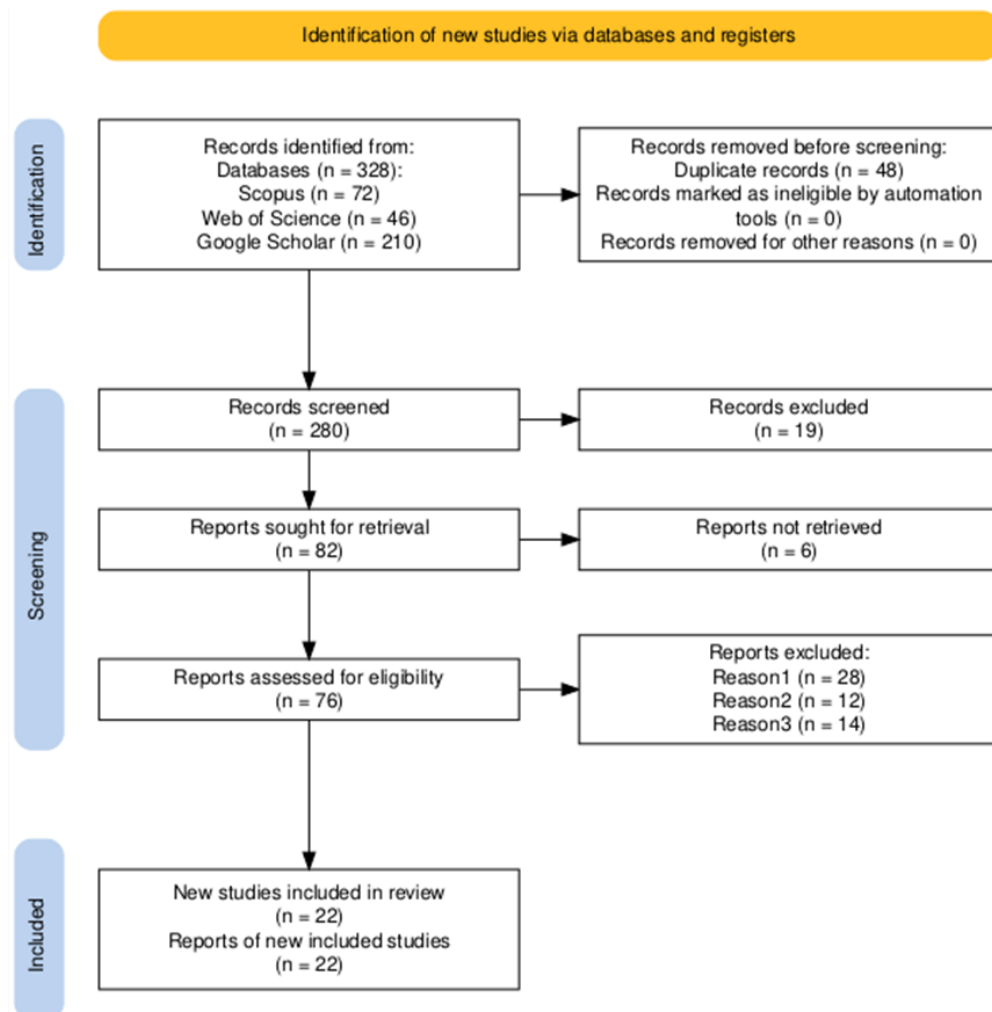


Figure 1. The PRISMA flow diagram detailing the screening and selection process of literature

2.3. Inclusion and Exclusion Criteria

The inclusion and exclusion of articles were guided by their relevance to the objectives of this study. Articles were included when they addressed digital product traceability or the application of digital technologies within agri-food supply chains, incorporated considerations of business ethics, sustainability, governance, or transparency, and examined organic agri-food systems or supply chains involving smallholder farmers. Articles were excluded when they focused exclusively on technical system design without ethical or governance implications, examined non-agri-food sectors, or lacked sufficient relevance to the research objectives.

2.4. Data Analysis and Synthesis

The selected articles were analyzed using a thematic synthesis approach, which enabled the identification of recurring patterns and key themes related to the opportunities and challenges of digital product traceability in organic agri-food supply chains, as well as their ethical implications for smallholder farmers. This study did not apply a quantitative methodological quality appraisal using standardized scoring tools. Instead, it emphasized conceptual relevance and thematic consistency across the selected literature. All included articles were published in reputable academic journals and met the predefined inclusion criteria, which was considered sufficient to support a rigorous and meaningful thematic synthesis aligned with the objectives of this systematic literature review.

3. Results and Discussion

3.1. Overview of the Reviewed Studies

The analysis of the 22 selected articles indicates that research on digital product traceability and business ethics in organic agri-food supply chains is predominantly conducted in developing country contexts and largely focuses on smallholder-based systems. The reviewed literature applies diverse methodological approaches, including empirical studies, qualitative case studies, conceptual analyses, and systematic literature reviews. Overall, these studies provide a comprehensive empirical and conceptual foundation for examining how digital product traceability intersects with ethical issues in organic agri-food supply chains, particularly in relation to transparency, governance, and the position of smallholder farmers. The findings from this body of literature form the basis for identifying key ethical opportunities and implementation challenges discussed in the following sections.

3.2. Business Ethics in Organic Agri-Food Supply Chains

The literature consistently demonstrates that the implementation of business ethics in organic agri-food supply chains continues to face structural challenges, particularly in relation to weak bargaining positions of smallholder farmers and limited transparency of information. These conditions contribute to unfair value distribution and restricted participation of farmers in decision-making processes, as documented in several studies focusing on organic and smallholder-based agri-food supply chains [8],[9]. Within smallholder-based organic agri-food supply chains, the adoption of digital product traceability carries significant ethical implications. Several studies emphasize that, in the absence of inclusive implementation designs, traceability technologies may reinforce existing power imbalances and increase the risk of digital exclusion among smallholder farmers [10],[11]. Conversely, when designed using participatory approaches and supported by appropriate policy frameworks, digital traceability systems can function as empowerment tools by improving access to information, enhancing price transparency, and protecting smallholders from unfair business practices [8],[9].

3.3. Opportunities of Digital Product Traceability

The reviewed literature identifies digital technologies, such as blockchain and the Internet of Things (IoT), as key enablers of improved product traceability in organic agri-food supply chains. Through integrated and tamper-resistant data recording systems, digital traceability enhances the reliability and credibility of information across supply chain stages, thereby strengthening accountability and supporting certification compliance [12],[13]. From a business ethics perspective, digital traceability is widely associated with the reduction of information asymmetries between smallholder farmers and other supply chain actors. Increased transparency regarding product origin, quality standards, and pricing contributes to fairer value distribution and creates more favorable conditions for strengthening farmers' bargaining positions [8],[9]. In addition, enhanced transparency functions as a form of social control that can deter unethical business practices.

Beyond governance considerations, several studies highlight the role of digital traceability in expanding market access for smallholder farmers, particularly in premium organic markets that require high levels of transparency and traceability. In this sense, digital product traceability is not merely framed as a technical innovation but as a governance instrument that can support inclusivity, fairness, and sustainability in organic agri-food supply chains when aligned with participatory design principles and supportive policy environments [10],[11].

3.4. Implementation Challenges and Ethical Implications

Despite its potential benefits, the literature consistently reports significant challenges in implementing digital product traceability within smallholder-based agri-food supply chains. Frequently identified barriers include high technology implementation costs, limited digital infrastructure, and low levels of digital literacy and readiness among supply chain actors [14].

Table 1. Synthesis of ethical opportunities and implementation challenges of digital product traceability in organic agri-food supply chains

Author (Year)	Method	Identified Opportunities	Identified Challenges
Cuellar et al. (2022)	Empirical study	Data transparency; increased consumer trust; information integrity across supply chains	High implementation costs; technological system readiness
Ekawati et al. (2021)	Case study	Digital record-keeping; enhanced accountability; certification support	Low digital literacy; high initial investment
Indrayanto et al. (2023)	Qualitative study	Supply chain actor mapping; transparency; price fairness; equitable value distribution	Weak farmer bargaining power; information asymmetry
Kshetri (2021)	Conceptual analysis	Strengthening business ethics; digital accountability; data governance	Institutional readiness; immature regulatory frameworks
Relawati et al. (2024)	Empirical study	Certification compliance; increased market trust; access to export markets	Standard complexity; compliance costs
Samoggia et al. (2021)	Systematic literature review	Supply chain efficiency; product information transparency; consumer trust	Technology integration challenges; actor heterogeneity
Tort et al. (2022)	Systematic literature review	Improved supply chain coordination; sustainable governance	Multi-actor complexity; persistent information asymmetry
Ellahi et al. (2023)	Systematic literature review	Transparency and traceability; enhanced accountability	Technology costs; system interoperability issues
Anwar et al. (2022)	Systematic literature review	Protection of small-scale producers; transparency of organic data	Actor readiness; information model complexity
Kersten et al. (2024)	Conceptual analysis	Supply chain governance; circular economy integration; transparency	Value distribution inequality; coordination challenges
Sundarakani and Ghouse (2024)	Systematic literature review	Food safety; supply chain efficiency	Digital infrastructure limitations; low technological literacy
Vasileiou et al. (2025)	Systematic literature review	Data reliability; blockchain-based transparency	Infrastructure readiness; high implementation costs

Oruma et al. (2021)	Empirical study	Operational efficiency; Agriculture 4.0 adoption; supply chain visibility	Limited infrastructure; technological capability gaps
Frontiers in Blockchain study (2020a)	Empirical study	Transparency and accountability; data integrity	Adoption costs; system scalability limitations
Frontiers in Blockchain study (2020b)	Conceptual analysis	Cross-actor traceability; data trust	Interoperability issues; data governance challenges
Frontiers in Sustainable Food Systems (2020)	Conceptual analysis	Supply chain inclusion; sustainability orientation	Risk of smallholder exclusion; access gaps
Applied Sciences study (2024)	Empirical study	Automated record-keeping; process efficiency	Technology costs; system maintenance requirements
Agriculture study (2023)	Empirical study	SME digitalization; competitiveness improvement	Digital literacy limitations; actor readiness
Sustainability study (2015)	Conceptual analysis	Organic supply chain sustainability	Actor fragmentation; weak coordination
Steiner (2024)	Conceptual analysis	Ethical awareness; strengthened consumer trust	Ethical implementation challenges; actor resistance
Food Ethics study (2021)	Conceptual analysis	Ethics and transparency; supply chain governance	Regulatory framework gaps; unequal benefit distribution
Journal of Cleaner Production study (2019)	Empirical study	Supply chain governance and ethics	System complexity; compliance costs

As summarized in Table 1, these technical and institutional challenges are closely interconnected and recur across different empirical and conceptual contexts. Several studies emphasize that high initial investments and system complexity disproportionately affect smallholder farmers and small-scale enterprises, particularly in settings with limited institutional capacity and insufficient regulatory readiness.

In addition to these constraints, the literature highlights persistent ethical concerns related to unequal power relations and the risk of smallholder exclusion. When traceability systems are controlled by actors with greater technological and financial resources, smallholder farmers may be marginalized from decision-making processes and from the distribution of technological benefits [10],[11]. These findings indicate that, while transparency and efficiency are central objectives of digital traceability, they may conflict with principles of fairness and inclusivity if disparities in capacity and bargaining power are not adequately addressed. Accordingly, the literature underscores that digital product traceability should be understood as a conditional ethical governance instrument, whose effectiveness depends on supportive policy frameworks, inclusive governance arrangements, and context-sensitive implementation strategies. This understanding provides the analytical foundation for the conclusions of this study [20].

4. Conclusion

Based on a systematic literature review of 22 scholarly articles, this study demonstrates that digital product traceability constitutes an important instrument for strengthening business ethics and

governance in organic agri-food supply chains. The reviewed literature consistently frames digital traceability not merely as a technical solution, but as a governance mechanism with the potential to enhance transparency, accountability, and trust among supply chain actors.

However, these ethical benefits are not automatically realized. In smallholder-based supply chains, traceability technologies may reinforce existing structural inequalities when disparities in capacity, technological access, and bargaining power are not adequately addressed during system design and implementation. From a theoretical perspective, this study contributes to the literature by conceptualizing digital product traceability as a conditional ethical governance mechanism shaped by institutional contexts, power relations, and the degree of smallholder participation. When implemented through inclusive and participatory governance frameworks, digital traceability can function as a strategic instrument for strengthening business ethics and supporting the long-term sustainability of organic agri-food supply chains.

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Data and Software Availability Statements

The data supporting this study are derived from published literature included in the systematic review. No new datasets or software were generated.

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