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BLOCKCHAIN-BASED TRACEABILITY GOVERNANCE MODEL FOR ENHANCING SUPPLY CHAIN TRANSPARENCY AND DIGITAL AUDITABILITY OF LOCAL RETAIL PRODUCTS

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ABSTRACT

Local retail products often lack integrated records of product origin, distribution, and certification, limiting transparency and independent verification. This study designs a blockchain-inspired traceability governance model for local retail products in Padang City, Indonesia. Using Design Science Research (DSR), the study developed the Padang LocalTrace System (PLTS), a web-based prototype connecting product identities, sequential supply-chain events, digital certificate metadata, QR-based public lookup, and a simulated transaction-hash ledger. The prototype represents four stakeholder roles: producers, distributors, retailers, and consumers. A preliminary module-status checklist reports successful operation of seven functions, including product management, distribution recording, certificate generation, and public verification. An illustrative certificate record links a product and producer to a certificate identifier, status, and transaction-hash value. These observations establish design feasibility and reported functional coverage, but do not independently demonstrate blockchain immutability, security, scalability, usability, or improved consumer trust. The contribution is a governance-oriented prototype architecture that makes actor responsibilities and product information accessible within one workflow. Future work should validate test cases independently, deploy an actual distributed ledger where appropriate, and evaluate adoption and outcomes with local enterprises.

Keywords: *Blockchain, traceability governance, digital certification, supply chain transparency, local retail products.*

INTRODUCTION

Local retail products have become an important component of regional economic development by supporting community-based entrepreneurship, cultural identity, and inclusive economic growth. In Indonesia, various local products, particularly those produced by micro, small, and medium enterprises (MSMEs), have significant potential to expand into wider markets through effective downstreaming strategies. However, the competitiveness of local products is not only determined by production capacity and marketing activities but also by the ability of businesses to provide reliable information regarding product origin, quality assurance, certification status, and supply chain history. Increasing consumer awareness regarding authenticity, safety, and transparency has

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created a growing demand for traceability mechanisms that can strengthen trust between producers, retailers, and consumers (Queiroz et al., 2021).

Despite this potential, many local retail ecosystems still experience challenges related to fragmented supply chain information, limited documentation practices, and weak product verification mechanisms. Local producers commonly rely on conventional records or informal communication channels, resulting in limited visibility regarding product movement from production to final consumption. This condition creates information asymmetry among supply chain actors, where producers and intermediaries may possess more information regarding product characteristics than consumers. From a business governance perspective, such information gaps may reduce consumer confidence, limit market expansion opportunities, and weaken the accountability of local product value chains (Treiblmaier, 2018; Cole et al., 2019).

Traceability has therefore become an important mechanism in improving supply chain transparency and governance. Previous studies have demonstrated that effective traceability systems enable organizations to monitor product origins, distribution activities, and quality-related information while improving coordination among supply chain participants. In management and accounting perspectives, traceability also provides reliable evidence for accountability, auditability, and decision-making because stakeholders can access consistent records related to business processes. However, conventional traceability systems frequently depend on centralized databases and manual documentation, which may create challenges related to data integrity, accessibility, and trust among independent supply chain actors (Saberi et al., 2019; Centobelli et al., 2022).

Recent studies have highlighted blockchain technology as a potential solution for improving supply chain transparency and information reliability. Blockchain provides decentralized data recording, immutable transaction history, and verification mechanisms that enable multiple stakeholders to share trusted information without relying on a single authority. Research conducted over the last decade indicates that blockchain applications in supply chains can improve product authentication, reduce information manipulation risks, and enhance stakeholder confidence. Saberi et al. (2019) emphasized that blockchain technology contributes to sustainable supply chain management by improving transparency and trust among supply chain participants. Similarly, Casino et al. (2020) identified blockchain as an emerging technology capable of supporting traceability and verification processes across different business sectors.

Furthermore, the integration of smart contract mechanisms provides additional opportunities for improving digital certification processes. Smart contracts allow predefined business rules to be executed automatically when specific conditions are fulfilled, enabling more reliable and transparent certification mechanisms. In the context of local retail products, smart contract-based certification can support product authenticity verification by linking product identity, certification status, and transaction records within a digital environment (Casino et al., 2020; Wang et al., 2019).

Although previous studies provide valuable insights into blockchain-based traceability, several limitations remain. First, existing research predominantly focuses on

large-scale industrial supply chains, agricultural commodities, and international logistics networks. Limited studies have explored blockchain traceability implementation in local retail ecosystems involving MSMEs and regional products. Second, many previous studies emphasize technological capabilities, such as blockchain architecture and transaction security, while the role of blockchain as a business governance mechanism that supports accountability, auditability, and trust development remains less explored. Third, research regarding digital certification integrated with traceability mechanisms for local products remains limited, particularly in emerging regional economies such as Indonesia.

The proposed design novelty is the Padang LocalTrace System (PLTS), which brings together actor-linked product histories, certificate metadata, QR-based public lookup, and a simulated transaction-hash ledger in one local-retail governance workflow. The contribution is the integration and allocation of governance responsibilities within the prototype, rather than a novel blockchain consensus algorithm. Because the ledger is simulated rather than deployed across independent nodes, immutability and decentralization have not been demonstrated.

These limitations indicate an opportunity to investigate how blockchain-inspired traceability systems can be designed as a governance mechanism for strengthening local product downstreaming. Rather than positioning blockchain merely as a technological infrastructure, this study views blockchain-based traceability as a strategic business mechanism that connects product identity, supply chain transparency, certification reliability, and consumer trust. This perspective is particularly relevant for local retail ecosystems where strengthening credibility and information transparency is essential for improving competitiveness.To address this research gap, this study aims to develop a blockchain-based traceability and digital certification model for local retail products in Padang City, Indonesia. The study applies a Design Science Research (DSR) approach to design and evaluate a technological artifact in the form of the Padang LocalTrace System (PLTS). The proposed system integrates digital product identity, traceability records, digital certification, QR-based verification, and blockchain ledger simulation to represent the product journey from producers to consumers.

This study contributes to both academic and practical perspectives. Academically, it extends previous blockchain traceability research by proposing a governance-oriented model that emphasizes transparency, accountability, and trust within local retail supply chains. Practically, the developed prototype provides an initial digital infrastructure that can support local businesses in improving product credibility, strengthening market confidence, and enhancing downstreaming capabilities. Therefore, this research provides insights into how emerging digital technologies can be utilized to support sustainable development of local product ecosystems.

Supply chain governance has become an important perspective for understanding how organizations coordinate activities, manage relationships, and ensure accountability among multiple actors involved in value creation processes. In contemporary business environments, supply chains are no longer viewed merely as operational networks but as

governance structures that require effective coordination, information sharing, monitoring mechanisms, and trust among participating actors. According to governance theory, effective supply chain management depends on the ability of organizations to establish coordination mechanisms that reduce uncertainty, improve collaboration, and align the interests of different stakeholders.

In local retail ecosystems, supply chain governance becomes particularly challenging because products often involve multiple independent actors, including producers, distributors, retailers, and consumers. Unlike vertically integrated supply chains, local product ecosystems are generally characterized by fragmented ownership structures and limited technological integration. These conditions may create difficulties in monitoring product movement, verifying product authenticity, and ensuring consistency of information across supply chain stages. Consequently, governance mechanisms that facilitate transparency and accountability are required to strengthen coordination among supply chain participants.

From a management perspective, traceability represents an important governance instrument because it enables organizations to monitor the history, location, and transformation process of products throughout the supply chain. A robust traceability system provides visibility regarding product origin, handling processes, distribution activities, and certification status. Previous studies have emphasized that supply chain transparency contributes to improved operational control, risk management, and stakeholder confidence because organizations are able to access reliable information regarding product flows.

Information asymmetry theory, initially introduced by Akerlof (1970), explains situations where different parties involved in an economic transaction possess unequal levels of information. In markets characterized by information asymmetry, sellers generally have more knowledge regarding product quality, origin, and production processes than consumers. This imbalance may create uncertainty, reduce consumer confidence, and negatively influence market efficiency.

The issue of information asymmetry is highly relevant in local retail product ecosystems. Many local products possess unique cultural and geographical characteristics; however, consumers often experience difficulties in verifying product authenticity, production processes, and certification validity. The absence of accessible and reliable product information may limit the ability of local businesses to differentiate their products from competitors and obtain greater market recognition.

From an accounting and business management perspective, reliable information availability is essential for decision-making, accountability, and control. Similar to financial reporting systems that require accurate and verifiable information, supply chain ecosystems require trustworthy product-related data to support stakeholder decisions. Inaccurate or incomplete product information may reduce transparency and weaken trust between producers, retailers, and consumers.

Digital traceability systems provide a mechanism to reduce information asymmetry by enabling stakeholders to access consistent and verifiable product information. Through

traceability mechanisms, consumers can obtain information regarding product origin, production history, distribution activities, and certification status. For businesses, traceability provides evidence of operational compliance and strengthens their ability to demonstrate product credibility.

Blockchain technology further enhances the role of traceability systems by providing immutable records and distributed verification mechanisms. Unlike conventional databases where information modification may occur without transparent verification, blockchain enables transaction records to be securely maintained through cryptographic mechanisms. Therefore, blockchain-based traceability can reduce information asymmetry by improving information availability, reliability, and transparency across supply chain networks.

In this research, information asymmetry theory explains why local retail products require enhanced digital traceability mechanisms. The PLTS prototype addresses this challenge by providing a digital product identity and verification mechanism that allows stakeholders to access reliable product information throughout the supply chain.

Trust represents a fundamental element in business relationships because economic exchanges frequently occur under conditions of uncertainty. Institutional trust theory suggests that trust is not only developed through interpersonal relationships but also through the existence of reliable systems, rules, and institutional mechanisms that ensure predictable and accountable interactions among stakeholders.

In retail ecosystems, consumer trust is strongly influenced by the credibility of product information, certification mechanisms, and the ability of businesses to demonstrate authenticity. For local products attempting to expand beyond regional markets, establishing trust becomes a strategic requirement because consumers outside the local community may have limited knowledge regarding product origins and production practices.

Based on the theoretical perspectives discussed above, this study proposes that blockchain-based traceability can function as a digital governance mechanism that connects technological capability with business outcomes. The conceptual relationship is illustrated as follows:



Figure 1. Blockchain-Based Traceability Governance Framework

RESEARCH METHOD

Research Design

Figure 1 presents the conceptual relationship among supply-chain actors, traceability functions, and the anticipated governance outcomes; these outcomes remain conceptual rather than empirically demonstrated. This study employed a Design Science Research (DSR) approach to develop and evaluate a technological artifact for addressing traceability and certification challenges in local retail product supply chains. DSR was selected because the objective of this research was not only to analyze an existing phenomenon but also to design, implement, and evaluate a practical solution in the form of a blockchain-based traceability system.

The evaluation framework distinguishes four dimensions: (1) functional completeness, assessed through specified module operations; (2) traceability integrity, assessed through the continuity of product identifiers and ordered events; (3) verification correctness, assessed by matching QR-based queries to the intended certificate and product records; and (4) usability, assessed through task completion and user feedback. In the present study, the available evidence consists of a preliminary functional-status checklist. Accordingly, dimensions (2)–(4) are proposed evaluation criteria rather than independently verified results. The authors should report the testing environment, sample records, test-case identifiers, expected and observed outputs, execution dates, evaluator roles, and any failed or repeated tests before claiming systematic validation.

The DSR approach enables researchers to produce innovative artifacts through systematic design, development, and evaluation processes (Hevner et al., 2004; Peffers et al., 2007). In this study, the artifact developed was the Padang LocalTrace System (PLTS), a web-based prototype designed to improve product transparency, digital certification, and accountability among local retail supply chain actors.

The research process consisted of five main stages:

a. Problem identification and requirement analysis;
b. Traceability governance model design;
c. Prototype development;
d. Functional evaluation;
e. Analysis of business implications.

The research stages were adapted to the research objectives and are illustrated in Figure 1.

Figure 2 illustrates the five-stage Design Science Research workflow adopted to organize the development and preliminary evaluation of PLTS.

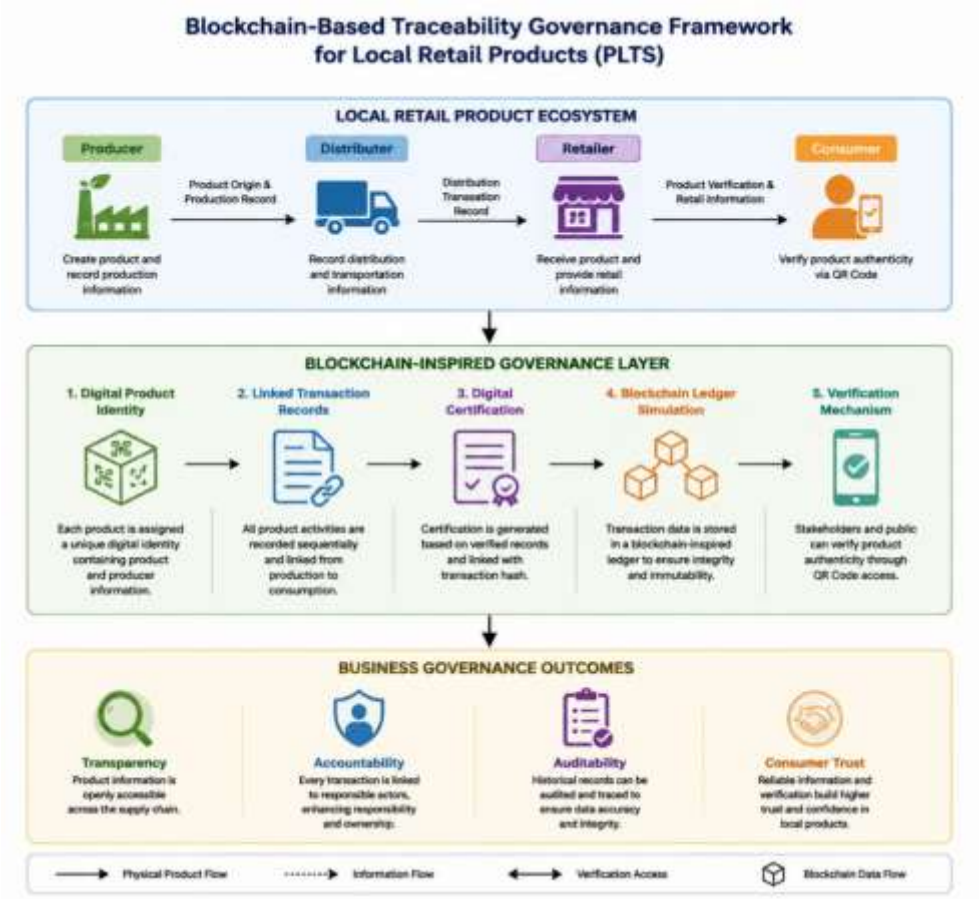


Figure 2. Research Framework Based on Design Science Research Approach

Problem Identification and Requirement Analysis

The first stage involved identifying practical problems related to local retail product supply chains. The analysis focused on several challenges, including:

a. limited availability of product origin information;
b. fragmented documentation among supply chain actors;
c. difficulties in verifying product authenticity;
d. limited digital certification mechanisms.

Based on the identified problems, the researchers analyzed the information requirements needed to develop a traceability governance system. The requirement analysis focused on defining actors, information flows, product records, and verification mechanisms.

Table 1. Four Main Actors

Actor	Role in PLTS
Producer	Records initial product information and production activities
Distributor	Records product movement and distribution activities
Retailer	Provides product availability and retail verification
Consumer	Performs product authenticity verification

Design of Blockchain-Based Traceability Governance Model

The second stage focused on designing the conceptual model of product traceability governance. The model was developed by integrating supply chain governance principles with blockchain characteristics, including transparency, data integrity, and transaction verification.

The designed model consists of Table 1 identifies the four stakeholder roles and their respective responsibilities within the proposed PLTS workflow.

1. Digital Product Identity
   Each product receives a unique identity containing product information, producer information, and certification attributes.
2. Linked Transaction Record
   Product activities are recorded sequentially from production, distribution, retailer acceptance, and consumer verification.
3. Digital Certification Mechanism
   Certification information is generated based on verified product records and connected with transaction hash identification.
4. Public Verification Mechanism
   Consumers can verify product authenticity through QR Code-based access.

This design stage produced the conceptual architecture of PLTS, which represents the relationship between supply chain actors and digital verification processes. The model follows blockchain principles of transparency and immutable information recording, although implemented as a prototype blockchain ledger simulation.

Data Analysis

The collected results were analyzed descriptively by comparing the developed artifact with the initial research objectives. The analysis focused on:

a. capability of the system to represent product traceability;
b. ability to generate digital certification;
c. effectiveness of verification mechanisms;
d. potential contribution to supply chain transparency and business accountability.

The findings were interpreted by connecting prototype results with previous research on blockchain-based supply chain management and digital traceability.

RESULTS AND DISCUSSION

Blockchain-Based Product Traceability Governance Model

The first research finding is the development of the Blockchain-Based Product Traceability Governance Model implemented in PLTS. The model establishes a digital relationship among four supply chain actors: producers, distributors, retailers, and consumers.

Figure 3 displays the PLTS home interface as evidence of the prototype user-facing design, rather than proof of a deployed distributed blockchain. The model addresses the fundamental problem identified in the introduction, namely the lack of transparent

information flow among local product supply chain actors.

In conventional local retail ecosystems, product information is generally distributed separately among actors. Producers maintain production information, distributors manage transportation records, and retailers provide sales information. However, these records are often not connected into a unified information system.

The proposed governance model integrates these activities through linked transaction records. Each product activity is recorded sequentially, creating a digital product journey from production to consumption.

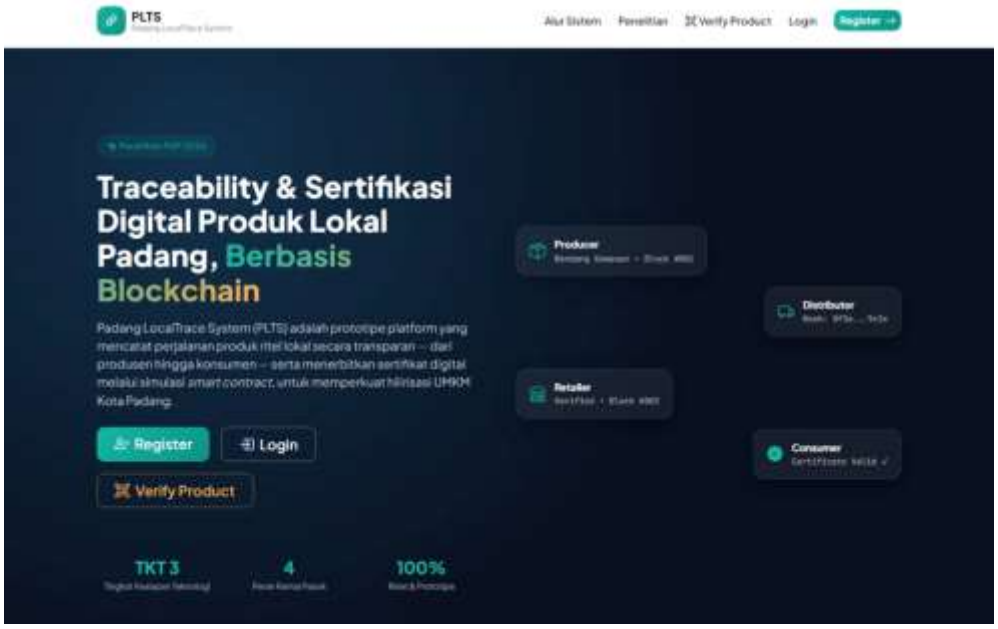


Figure 3. Home of PLTS System
(https://plts-padang-localtrace.onrender.com/index.php)

This mechanism supports three important governance functions:

1. Transparency
   The system enables stakeholders to access consistent product information throughout the supply chain.
2. Accountability
   Each activity is associated with responsible actors, creating clearer responsibility ownership.
3. Auditability
   Historical product records can be reviewed through transaction information and certification records.

Table 2 provides an illustrative digital certificate record and its associated transaction-hash string. This finding supports previous research suggesting that blockchain technology can improve supply chain transparency by enabling secure and

verifiable information exchange among multiple stakeholders (Saberi et al., 2019; Kshetri, 2018).

Figure 4 illustrates the certificate display and QR-based verification interface generated by the prototype.

Digital Certification Mechanism

The design contribution is the integration of product identity, sequential supply-chain event records, digital certification metadata, QR-based public lookup, and transaction-hash ledger simulation into a single governance-oriented workflow for local retail products. PLTS explicitly organizes record creation and verification around the responsibilities of producers, distributors, retailers, and consumers. This integration distinguishes the proposed artifact at the design level; comparative advantages, cryptographic immutability, and real-world trust effects have not been empirically established.

Table 2. The PLTS prototype successfully generated digital certificates

Parameter	Implementation Result
Certificate ID	CERT-PLTS-2026-0001
Product	Rendang Kemasan
Producer	UMKM Rendang Uni Siti
Location	Padang, Sumatera Barat
Status	Active
Transaction Hash	fe877e6ed9daa9857c08d228...

The illustrative digital certificate links a product identifier to certificate metadata and a transaction-hash string, enabling a user to inspect the associated record. This mechanism provides a prototype verification interface; it does not, by itself, establish independent certification authority, authenticity of physical goods, or tamper-proof ledger storage.



Figure 4. Digital Certification Data Generated by PLTS

The prototype is designed to make certificate records accessible through a QR-based interface and to connect them to product-event histories. These features may

improve ease of lookup and information linkage relative to disconnected paper records; no controlled comparison with conventional certification was conducted.

1. Easier verification;
2. Improved accessibility;
   Table 3 summarizes the seven main functional modules included in the PLTS architecture.
3. Stronger information linkage between products and supply chain records.

The implementation supports previous findings that blockchain-based systems can enhance product authenticity and reduce uncertainty by providing reliable digital records (Casino et al., 2020).

The current implementation remains a prototype-level certification mechanism with a simulated ledger. Smart contracts have not been shown to execute on a deployed blockchain. Any future production deployment would require assessment of data provenance, credential issuance authority, access controls, privacy, security, infrastructure costs, and applicable regulatory requirements.

Prototype Implementation of Padang LocalTrace System (PLTS)

The developed PLTS prototype demonstrates the practical implementation of the proposed governance model.

Table 3. Seven main modules of the PLTS prototype

System Component	Function
Authentication	Role-based access management
Product Management	Product data management
Traceability Timeline	Product journey recording
Digital Certificate	Certification generation
QR Verification	Consumer verification
Blockchain Ledger Simulation	Transaction integrity representation
Dashboard Analytics	Monitoring supply chain activities

The prototype was designed to represent the product journey from production to consumer verification. Table 4 summarizes seven modules marked “Successful” in the preliminary functional-status checklist. These entries should be interpreted as author-reported implementation status, not as independently reproducible test outcomes. The manuscript does not yet provide test-case identifiers, input datasets, expected-versus-actual outputs, execution logs, or third-party verification. The authors should add this evidence and clarify whether each status was established through a demonstration, manual inspection, or repeatable test.

Table 4. Preliminary author-reported functional status

Function	Status
User registration/login	Successful
Product management	Successful
Production recording	Successful

Distribution recording	Successful
Certificate generation	Successful
Public verification	Successful
Dashboard analytics	Successful

These preliminary functional-status reports suggest that the principal traceability and certification modules have been implemented. They do not establish the reliability of cryptographic integrity controls, resistance to tampering, system performance under load, user acceptance, or measurable changes in stakeholder trust. These outcomes remain hypotheses for future empirical assessment.

Business Implication of Blockchain-Based Traceability

Beyond the technical design, the prototype suggests several potential implications for local retail governance. A shared product record could reduce information fragmentation between producers, distributors, retailers, and consumers, while certificate metadata and QR lookup could make product claims easier to inspect. Actor-linked event histories may also support accountability by indicating which participant entered each record. However, these are anticipated benefits of the proposed design, not observed improvements in transparency, credibility, or market performance. Evaluation with actual local enterprises and consumers is necessary to establish whether these mechanisms produce the intended outcomes.

Second, digital certification can strengthen product credibility. For local products seeking broader market penetration, trustworthy certification information can become a competitive advantage. Third, the system supports improved accountability among supply chain participants. Each recorded activity creates digital evidence regarding product movement and verification history.

From an accounting and management perspective, the system contributes to the development of digital audit trails. Similar to accounting information systems that require reliable transaction evidence, traceability systems require accurate and verifiable product records. Therefore, blockchain-based traceability should not only be viewed as a technological innovation but also as a governance mechanism that supports transparency, accountability, and business trust.

The principal novelty of this study is the governance-oriented integration of product identity, actor-linked sequential event records, digital certificate metadata, QR-based public lookup, and a simulated transaction-hash ledger within a single workflow for local retail products. Rather than introducing a new consensus mechanism, PLTS specifies how producers, distributors, retailers, and consumers can participate in an auditable information process. This design-level contribution is consistent with recent research emphasizing blockchain adoption barriers and supply-chain governance considerations (Queiroz et al., 2021; Centobelli et al., 2022; Kshetri, 2021). However, comparative superiority, decentralization, cryptographic immutability, and real-world trust improvements have not been demonstrated.

The practical implication of PLTS is its potential to consolidate local product histories, clarify responsibility for recorded events, and facilitate public inspection of certificate metadata. These anticipated benefits align with recent discussions of blockchain adoption and supply-chain governance (Queiroz et al., 2021; Centobelli et al., 2022; Kshetri, 2021). However, benefits have not yet been empirically measured; future implementation requires source-data verification, credential issuance authority, access controls, privacy safeguards, usability evaluation, and cost assessment.

CONCLUSION

This study developed the Padang LocalTrace System (PLTS) using a Design Science Research approach to address fragmented product information and limited verification mechanisms in local retail supply chains. The resulting blockchain-inspired governance prototype integrates digital product identity, sequential actor-linked supply-chain events, certificate metadata, QR-based public verification, and a simulated transaction-hash ledger for producer, distributor, retailer, and consumer roles. A preliminary author-reported checklist indicates that seven principal modules were implemented, supporting prototype-level functional feasibility and the conceptual value of a shared traceability workflow. Nevertheless, the available evidence does not demonstrate actual distributed-ledger immutability, independently verified testing, enhanced consumer trust, or improved business performance. The study therefore contributes a preliminary governance architecture rather than a validated production blockchain solution; reproducible testing and field evaluation are required to establish operational effectiveness.

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