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BLOCKCHAIN-ENABLED SUPPLY CHAIN GOVERNANCE FOR MSME MARKET INTEGRATION: A DIGITAL TRANSFORMATION MODEL FOR MODERN RETAIL DISTRIBUTION

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ABSTRACT

Micro, small, and medium enterprises (MSMEs) seeking access to modern retail channels face persistent distribution governance problems arising from fragmented records, limited shipment visibility, and weak product traceability. This study develops a blockchain-enabled digital supply chain governance model and implements it through SerangChain, a web-based prototype designed for MSME-to-retail distribution in Serang, Banten, Indonesia. A Design Science Research approach was employed, covering problem identification, requirement analysis, conceptual model design, prototype development, functional testing, and initial evaluation. The proposed model integrates three layers: supply chain management, a private blockchain-inspired ledger for transparent and verifiable transaction recording, and an analytics layer for monitoring distribution performance. The prototype supports MSME, modern-retail, and administrator roles and includes product management, retail requests, distribution transactions, blockchain ledger records, and analytical dashboards. Functional testing showed that all core modules operated according to the designed workflow, while the ledger simulation generated linked transaction records containing transaction IDs, block IDs, timestamps, previous hashes, and verification status. The findings indicate that a lightweight blockchain-inspired architecture can strengthen information transparency, traceability, and digital accountability without requiring a complex public blockchain infrastructure. Because field-based User Acceptance Testing and full impact measurement are still ongoing, claims regarding efficiency improvement remain preliminary. The study contributes a governance-oriented digital transformation model that can support MSME market integration with modern retail and provides a practical foundation for subsequent empirical validation.

Keywords: *Blockchain, digital supply chain, supply chain governance, MSMEs, modern retail.*

INTRODUCTION

Micro, small, and medium enterprises (MSMEs) play an important role in economic development, employment generation, and the sustainability of local business ecosystems. However, their integration into modern retail distribution networks requires reliable product information, coordinated supply chain activities, accurate transaction documentation, and effective shipment monitoring. Recent research indicates that supply

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chain transparency, information-sharing capabilities, and organizational adaptability are important factors influencing digital technology adoption and supply chain performance among SMEs (Iranmanesh et al., 2023; Wong et al., 2024). These findings highlight the importance of developing integrated digital systems that can support MSMEs in meeting increasingly structured distribution requirements.

In Serang, Banten, Indonesia, the preliminary assessment conducted for this study identified several operational challenges in MSME-to-retail distribution, including fragmented product records, limited shipment visibility, inconsistent transaction documentation, and dependence on direct communication between suppliers and retailers. These conditions indicate a need for improved coordination and information governance. Previous research has demonstrated that supply chain connectivity, transparent information exchange, and technological compatibility can support inter-organizational coordination and supply chain performance (Iranmanesh et al., 2023; Wong et al., 2024). Consequently, addressing fragmented distribution information requires not only technological innovation but also clearly defined operational responsibilities and verification procedures.

Digital supply chain management emphasizes the integration of information systems, business processes, and organizational relationships to improve visibility and coordination across supply chain activities. In particular, supply chain transparency and agility have been identified as significant factors influencing blockchain adoption among SMEs (Iranmanesh et al., 2023). Furthermore, Wong et al. (2024) demonstrated that supply chain connectivity, information sharing, and visibility are relevant to blockchain-enabled supply chain performance. These findings suggest that integrated digital governance mechanisms may provide MSMEs with a foundation for improving transaction documentation, distribution monitoring, and coordination with modern retail partners.

Blockchain technology has attracted increasing attention as a potential mechanism for improving supply chain transparency, transaction integrity, and product traceability. Its linked transaction records can facilitate the reconstruction of product movements and support the verification of supply chain events. Ahmed and MacCarthy (2023) emphasized that blockchain-enabled traceability depends on the scope and granularity of information recorded across supply chain stages. Similarly, Iranmanesh et al. (2023) identified transparency and agility as important factors associated with blockchain adoption among SMEs. Nevertheless, implementing blockchain solutions requires consideration of organizational resources, technical complexity, and infrastructure readiness, particularly in resource-constrained MSME environments (Wong et al., 2024; Paliwal et al., 2024).

Despite growing interest in blockchain-enabled supply chain management, several research challenges remain. Existing studies have examined determinants of blockchain adoption, technological suitability, organizational readiness, and traceability requirements. Iranmanesh et al. (2023) investigated the influence of supply chain transparency, alignment, adaptability, and agility on blockchain adoption among SMEs.

Ahmed and MacCarthy (2023) developed an evidence-based framework for determining the scope and granularity of blockchain-enabled supply chain traceability. Wong et al. (2024) examined blockchain suitability and viability for SME supply chain performance, while Paliwal et al. (2024) explored blockchain adoption intentions in MSMEs through organizational, technological, and sustainability perspectives. Although these studies provide important insights, they do not directly evaluate the specific combination of role-based MSME-to-modern-retail distribution workflows, a lightweight blockchain-inspired transaction ledger, and integrated managerial analytics implemented in the present study.

To address this contextual and design-oriented research gap, the present study develops SerangChain, a web-based digital supply chain governance prototype designed to support MSME distribution to modern retail in Serang, Banten. The proposed architecture integrates three interconnected components: a supply chain management layer for operational coordination, a private blockchain-inspired ledger for recording and verifying distribution transactions, and an analytics layer for monitoring distribution activities. The development of this integrated architecture is informed by recent findings concerning transparency, traceability, information sharing, and organizational readiness in blockchain-enabled supply chains (Ahmed & MacCarthy, 2023; Iranmanesh et al., 2023; Wong et al., 2024).

The objective of this study is to design, implement, and functionally evaluate a blockchain-enabled digital supply chain governance model for MSME-to-modern-retail distribution. Specifically, the study examines how an integrated web-based prototype can support role-based coordination, transaction traceability, and distribution monitoring. Using a Design Science Research approach, the study focuses on artifact development and functional feasibility rather than establishing field-level improvements in distribution efficiency or organizational performance.

The expected contribution of this research is a governance-oriented digital transformation model that connects operational distribution activities with integrity-oriented transaction records and managerial analytics. Unlike studies primarily examining blockchain adoption intentions or general traceability frameworks, SerangChain operationalizes these components within a single prototype designed for local MSME-to-modern-retail distribution. This contribution builds on recent research emphasizing the importance of supply chain transparency, traceability design, technological suitability, and organizational readiness (Ahmed & MacCarthy, 2023; Iranmanesh et al., 2023; Paliwal et al., 2024; Wong et al., 2024). The proposed model therefore provides a preliminary foundation for subsequent empirical evaluation of user acceptance, interoperability, security, and measurable distribution performance.

Supply-chain governance concerns the coordination of activities, responsibilities, information exchange, and monitoring across participating organizations. Evidence from SMEs associates transparency, alignment, adaptability, and agility with blockchain adoption (Iranmanesh et al., 2023), while organizational fit and innovation diffusion influence blockchain's relevance to supply-chain performance (Wong et al., 2024). In this study, the governance challenge is operationalized as the assignment of recording and

verification responsibilities to MSMEs, retailers, and administrators; these are design choices rather than empirically established improvements.

The Supply Chain Operations Reference (SCOR) process perspective provides a conceptual lens for linking planning, sourcing, delivery, and returns with performance indicators. Within the present artifact, product management, retail requests, shipment updates, and receipt confirmation are translated into observable workflow events. The need to define traceability scope and data granularity for each event is consistent with Ahmed and MacCarthy (2023), while the importance of inter-organizational information sharing is supported by Wong et al. (2024).

Recent supply-chain research identifies transparency and traceability as relevant blockchain application objectives, while cautioning that information coverage and granularity must be tailored to the supply-chain setting (Ahmed & MacCarthy, 2023). SME studies additionally link blockchain adoption to transparency, agility, organizational fit, and information-sharing conditions (Iranmanesh et al., 2023; Wong et al., 2024). A sequential hash-linked audit trail can demonstrate how events are recorded and inspected, but a single-application ledger simulation does not by itself establish decentralized consensus, immutability against privileged database modification, or independently verified security.

For this study, blockchain is conceptualized as a governance mechanism rather than a cryptocurrency infrastructure. The SerangChain prototype uses a private blockchain ledger simulation in which each distribution transaction is represented by a transaction ID, block ID, timestamp, previous hash, and verification status. The design is intended to demonstrate how integrity-oriented records can support digital accountability between MSMEs and modern retail while remaining technically accessible for a prototype-stage environment.

The framework developed in this study connects three elements that emerged from the field problem and the literature: operational distribution activities, integrity-oriented transaction recording, and managerial analytics. As illustrated in Figure 1, these elements are organized into supply-chain, blockchain, and analytics layers, with anticipated governance outcomes of better transparency, traceability, accountability, and decision visibility. These outcomes are evaluated here at the level of artifact capability and functional performance. Because the artifact remains at a proof-of-concept stage, the interpretation is consistent with the logic of early Technology Readiness Levels, where the primary task is to demonstrate feasibility before claiming field-level performance effects (Mankins, 1995).

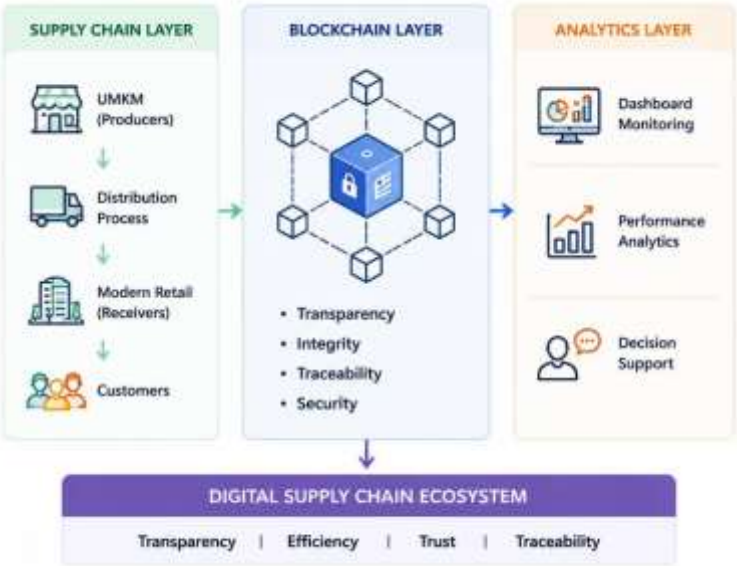

Figure 1. Blockchain-Based Digital Supply Chain Model for MSME Distribution

RESEARCH METHOD

Research Design

This study employed Design Science Research (DSR) to construct and evaluate SerangChain as an information-system artifact addressing a practical distribution-governance problem (Hevner et al., 2004; Peffers et al., 2007). The eight-stage workflow is summarized in Figure 2 and comprises problem identification, requirement analysis, system design, prototype development, testing and validation, evaluation and analysis, documentation, and dissemination/publication. This article reports the completed design, prototype-development, and functional-testing stages; user acceptance and field-based impact evaluation remain ongoing.

The research process consisted of eight operational stages: problem identification, requirement analysis, system design, prototype development, testing and validation, evaluation and analysis, documentation, and dissemination/publication. The current article reports the completed design, prototype-development, and functional-testing stages, while user acceptance validation and full field-based efficiency evaluation are identified as continuing activities.

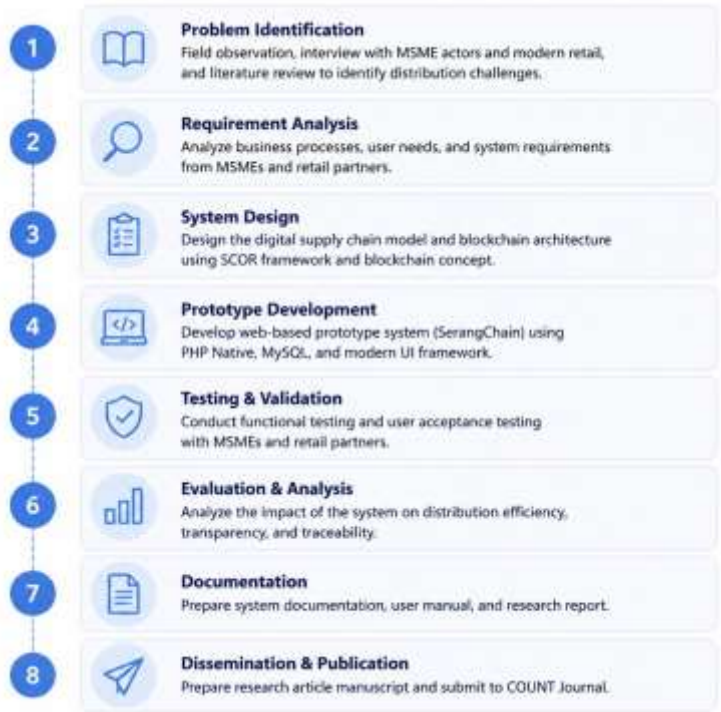

Figure 2. Research Stages and Design Science Research Workflow

Problem Identification and Requirement Analysis

Problem identification involved preliminary observation, review of available distribution documents and workflows, and consultation with prospective MSME and modern-retail users in Serang. Purposive selection targeted individuals involved in product registration, retail ordering, shipment monitoring, or receipt confirmation. The assessment considered three stakeholder categories: MSME representatives, retail representatives, and administrator/research-team evaluators. The submitted evidence does not establish verified participant counts, interview durations, or the number of organizations; these details require confirmation against the original field log before publication. Observation guides, semi-structured needs-assessment prompts, requirement checklists, and functional test-case sheets supported the process. Observed workflow problems were translated into actor permissions, data entities, and operational scenarios. Functional verification compared expected outputs with actual prototype behavior; this was not a statistical test of user perceptions or distribution performance. No personal or sensitive transactional data were used in prototype testing.

Table 1. Main Actors and System Roles

Actor	Role in SerangChain
Administrator / Research Team	Manages master data, monitors distribution transactions, ledger records, analytics, and reports.
MSME / Producer	Manages products, responds to retail requests, updates shipment information, and monitors distribution status.

Modern Retail	Monitors suppliers, creates or reviews product requests, verifies receipt, and accesses distribution information.

System Design and Prototype Development

The conceptual model was implemented as a web-based prototype using PHP Native, MySQL, HTML, Bootstrap, and JavaScript. The system architecture is shown in Figure 3, while the principal prototype modules and their functions are summarized in Table 2. This lightweight stack was selected to reduce infrastructure demands and keep the proof of concept focused on governance workflow and transaction integrity.

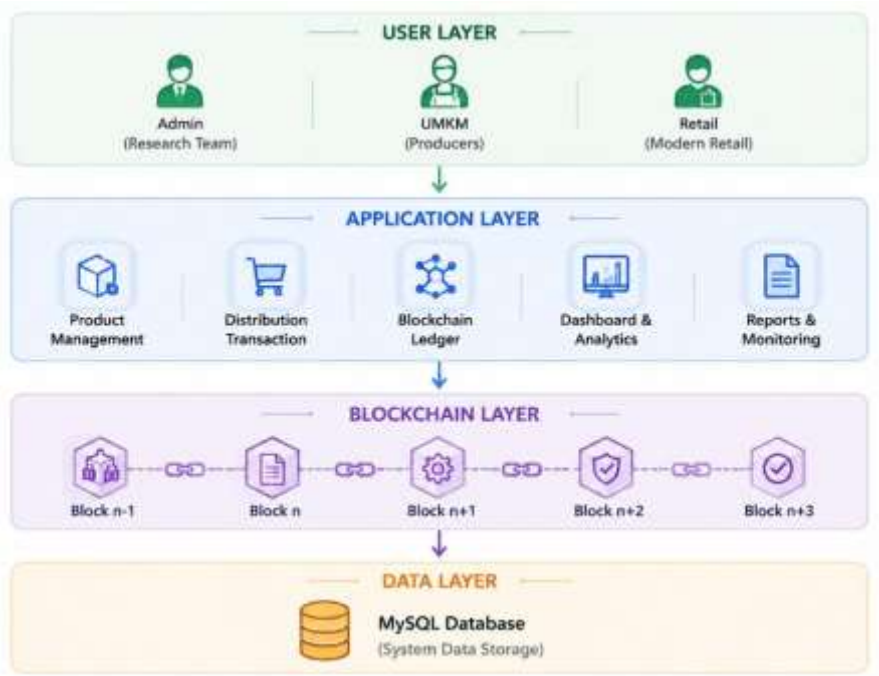

Figure 3. Serang Chain System Architecture

Table 2. Core Prototype Components

System Component	Primary Function
Authentication and User Roles	Provides controlled access for administrator, MSME, and retail users.
MSME Management	Stores and manages MSME profile and supplier information.
Retail Management	Stores retail-partner and receiving-party information.
Product Management	Maintains product identity, stock-related information, and product records.
Distribution Transactions	Records retail requests, shipment activity, and receipt confirmation.
Blockchain Ledger	Creates linked distribution records using transaction/block identifiers, timestamps, hashes, and verification status.
Dashboard and Analytics	Provides summaries of transactions, status, distribution activity, and monitoring indicators.

Blockchain Ledger Mechanism

The blockchain component is a private, blockchain-inspired ledger simulation implemented within the web prototype, not a distributed blockchain network. Distribution events are associated with transaction and block identifiers, timestamps, actor and product fields, verification status, and a reference to the previous record hash. Figure 4 illustrates the intended transition from retail request to confirmation, shipment, receipt, and ledger registration. The available manuscript does not document the hashing algorithm, canonical payload serialization, validation routine, node topology, consensus protocol, key management, or independent tamper-detection experiments. Consequently, the implementation supports demonstration of linked audit records but should not be described as cryptographically proven immutable or equivalent to a deployed permissioned blockchain.

Transaction ID	Block ID	Timestamp	From	To	Product	Status	Hash
TRX-2024-0001	00023	2024-05-20 10:15:30	UMKM_01	Retail_05	Keripik Singkong	Verified	a1b2c3d4e5f6...
TRX-2024-0002	00024	2024-05-20 11:05:12	UMKM_02	Retail_03	Kopi Banten	Verified	b2c3d4e5f6a7...
TRX-2024-0003	00025	2024-05-20 14:22:08	UMKM_03	Retail_02	Dodol Durian	Verified	c3d4e5f6a7b8...
TRX-2024-0004	00026	2024-05-21 09:40:45	UMKM_01	Retail_01	Kue Kering	Pending	d4e5f6a7b8c9...
TRX-2024-0005	00027	2024-05-21 13:18:24	UMKM_02	Retail_04	Abon Sapi	Pending	e5f6a7b8c9d0...

Figure 4. Distribution Transaction Flow and Blockchain Ledger Record

Functional Evaluation and Data Analysis

The initial functional evaluation covered seven predefined scenarios: authentication and role-based access; MSME record management; retail-partner management; product management; distribution transaction recording; ledger creation and linkage; and dashboard display. Each scenario was assessed against its stated input, expected persisted record, retrieval permission, and displayed output. A pass was recorded only when the specified workflow and outputs matched the expected result. Seven of seven scenarios were reported as passing (Table 3). This binary scenario-level summary is not a reliability estimate and does not establish resistance to malicious modification, multi-node consensus, usability, scalability, or operational effectiveness. Independent replication

would require the test-case scripts, test data, software version, execution environment, and logs.

RESULTS AND DISCUSSION

Existing Distribution Conditions and Governance Problems

The initial assessment showed that distribution from MSMEs to retail still depended heavily on direct communication and manually maintained records. Product availability, transaction status, and shipment information were not consistently consolidated in a shared information environment. As a result, supply-chain actors could hold different versions of the same operational information, while historical distribution records were difficult to reconstruct. This pattern is consistent with earlier Indonesian studies describing fragmented digital practices and limited integration in MSME supply chains (Handayani et al., 2022; Fitrani & Rahman, 2022; Wibowo & Nugroho, 2021).

These findings suggest that MSME supply-chain transformation should begin with the structure of information flows and responsibility points, not with technology selection alone. Modern retail integration requires timely and verifiable information from suppliers; visibility, documentation, and traceability are therefore part of the commercial relationship itself. Previous work on MSME partnerships and technology-enabled retail integration reaches a similar conclusion: stronger market access depends on better coordination between small suppliers and organized retail networks (Wibowo & Prasetyo, 2021; Kurniawan & Putri, 2022).

The first major result is the Blockchain-Based Digital Supply Chain Model for MSME Distribution, which combines a supply-chain layer, a blockchain layer, and an analytics layer. The supply-chain layer represents the operational relationship among MSMEs, distribution activities, modern retail, and downstream customers. The blockchain layer provides integrity-oriented records intended to support transparency, traceability, and security. The analytics layer converts recorded activities into monitoring information that can support managerial decisions. Similar research has argued that digital supply-chain value arises when transaction visibility and logistics information are brought together rather than maintained as isolated systems (Rahman et al., 2023; Yusuf & Halim, 2022).

The layered design connects operational activity to information-integrity controls while preserving distinct system responsibilities. This is consistent with recent evidence that blockchain adoption among SMEs is influenced by its ability to improve transparency, agility, connectivity, and inter-organizational information sharing (Iranmanesh et al., 2023; Wong et al., 2024). Recent MSME studies also stress that adoption depends on organizational readiness, governance arrangements, cost, skills, and ecosystem support rather than technological capability alone (Kaur et al., 2024; Paliwal et al., 2024). SerangChain addresses part of this challenge by reducing technical complexity at the prototype stage, but it does not eliminate broader adoption and interoperability constraints.

SerangChain translates the conceptual model into an operational prototype. Administrators can manage master data and monitor overall supply-chain activity; MSMEs can maintain product data, review retail demand, and update shipment status; retail users can review suppliers and requests, monitor shipments, and verify receipt. Bringing these activities into one environment reduces the need to reconstruct transaction status from separate spreadsheets, paper records, or messaging histories. This kind of integration reflects the broader direction of digital supply-chain and smart-logistics research, where shared information spaces are used to improve coordination across organizational boundaries (Pranata & Surya, 2023; Rahman et al., 2023).

The dashboard summarizes MSME participation, retail partners, transactions, blockchain records, transaction status, recent activities, and distributed products. Figure 5 presents the administrator dashboard overview. Its value is not simply visual: at prototype level, the dashboard establishes a common operational view from which users can interpret current distribution conditions and trace supporting records. This managerial function parallels the role of analytics in enterprise systems, where consolidated information can improve monitoring and decision support when linked to reliable transaction data (Appelbaum et al., 2017).

Figure 5. SerangChain Administrator Dashboard Overview

Blockchain Ledger and Product Traceability

A central prototype result is the blockchain-ledger simulation for product traceability. Each distribution transaction produces a digital record containing the product, sender, recipient, transaction time, status, and hash-related ledger information. Figure 6 shows the product traceability view and the linked ledger evidence used to reconstruct a chronological product journey. This design is consistent with recent

traceability research emphasizing the importance of both the breadth and granularity of blockchain-enabled records across supply-chain stages (Ahmed & MacCarthy, 2023; Zhang et al., 2024).

At artifact level, this structure improves traceability because product history no longer depends on disconnected administrative notes. It also strengthens accountability: each event is tied to an actor, a time record, and a verification state. This matters for governance because a traceable record can support both coordination and retrospective review. In accounting and auditing research, blockchain has similarly been discussed as an infrastructure for strengthening the reliability and inspectability of transaction evidence (Bonsón & Bednárová, 2019).

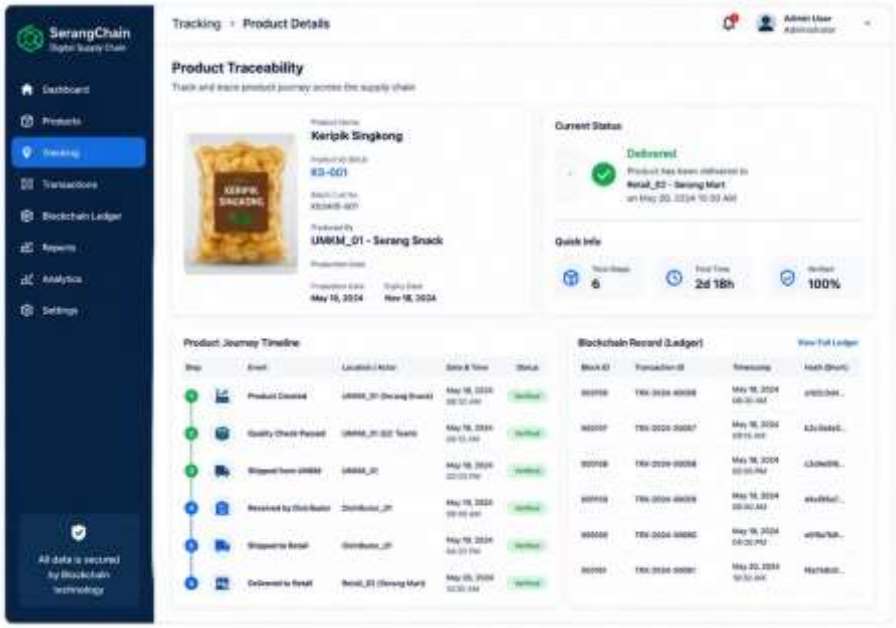

Figure 6. Product Traceability View and Blockchain Ledger in SerangChain

Functional Evaluation Results

In the reported controlled prototype evaluation, all seven specified functional scenarios passed (7/7; a 100% pass rate for the selected scenarios). The checks covered authorized navigation, creation and retrieval of master records, transaction status changes, linked ledger record generation, and dashboard summaries. This result establishes conformity with the selected functional test cases only. It does not quantify general software quality, cybersecurity, end-user acceptance, distribution lead-time reductions, order accuracy, or economic returns; these outcomes require separate measurements.

Table 3. Functional Testing Results

Test scenario	Expected and Measurable Criterion	Recorded Evidence	Result
Authentication and role access	Valid credentials open only the authorized role dashboard	Authorized dashboard displayed;	Pass

		restricted menus hidden	
MSME data management	Create, edit, retrieve, and validate an MSME record	Record stored and retrieved with submitted fields	Pass
Retail-partner management	Create, edit, retrieve, and validate a retail-partner record	Record stored and retrieved with submitted fields	Pass
Product management	Create, update, and retrieve a product record	Product record and updated status displayed	Pass
Distribution transaction	Record request, shipment, and receipt-status changes	Transaction persisted and status sequence displayed	Pass
Blockchain-inspired ledger	Generate IDs, timestamp, previous-hash link, and verification status	Linked ledger record generated and retrievable	Pass
Dashboard and analytics	Aggregate current records and statuses consistently	Summary counts and recent activity rendered	Pass

Initial Business and Management Implications

The prototype points to three preliminary management benefits. First, integrated digital records reduce the need to reconcile product, request, shipment, and receipt information across separate sources. Second, ledger-based histories make responsibility easier to follow because distribution events are associated with actors, timestamps, and verification records. Third, analytical dashboards give managers a more concise view of current distribution activity. These are capability-level benefits at this stage, but they are consistent with the operational logic of digital supply-chain systems that seek to improve information accessibility and coordination (Christopher, 2016; Chopra & Meindl, 2020).

These capabilities are relevant to MSME market integration because modern retail depends on consistent documentation, supplier performance, and timely resolution of information differences. The findings support studies that connect blockchain adoption with trust and inter-organizational information sharing (Queiroz et al., 2021; Kshetri, 2021). At the same time, the prototype does not yet resolve adoption barriers identified in the literature, including partner readiness, data governance, interoperability, skills, and implementation cost. SerangChain should therefore be understood as a testable governance design, not evidence that blockchain alone improves performance.

Limitations and Validation Requirements

The findings remain prototype-level evidence. Functional testing shows that SerangChain works as specified, but it does not establish improvements in lead time, order accuracy, traceability performance, or distribution efficiency. Future evaluation should combine user acceptance testing with before-and-after operational measures and should assess security, scalability, data governance, and retailer-system interoperability. Transfer beyond Serang also requires contextual reconfiguration of actor roles, product

standards, privacy rules, infrastructure, and regulatory requirements; global applicability is therefore conceptual rather than empirically demonstrated.

The principal novelty of SerangChain lies in coupling a role-based MSME-retail governance workflow with a blockchain-inspired digital audit trail and a shared analytics layer in one lightweight prototype. Recent studies have separately examined blockchain adoption determinants in SMEs, blockchain-enabled traceability scope, and blockchain-supported tracking architectures (Iranmanesh et al., 2023; Ahmed & MacCarthy, 2023; Wong et al., 2024; Zhang et al., 2024). SerangChain extends this stream by embedding ledger generation directly into concrete handoffs—retail request, shipment, receipt confirmation, and monitoring—so that traceability evidence and managerial visibility are produced from the same operational workflow. This governance-centered integration is the study's key design contribution.

Broader Implications of the Study

The broader implications of this study suggest that lightweight blockchain-inspired governance offers a potentially accessible and scalable pathway for micro, small, and medium enterprises (MSMEs) to strengthen digital accountability, supply chain transparency, and inter-organizational coordination without requiring immediate investment in complex public blockchain infrastructures. Recent studies have emphasized that supply chain transparency, organizational agility, technological compatibility, and institutional readiness are critical determinants of blockchain adoption and supply chain performance among SMEs and MSMEs (Iranmanesh et al., 2023; Wong et al., 2024; Paliwal et al., 2024). From a practical perspective, the proposed SerangChain model provides a preliminary digital governance framework that may be adapted by cooperatives, local distributors, agricultural producer groups, and small-scale suppliers seeking integration into modern retail distribution networks. Furthermore, the integration of transaction monitoring, blockchain-inspired traceability, and analytical dashboards may support more transparent information exchange, clearer operational responsibilities, and evidence-based managerial decision-making. Nevertheless, these implications remain conceptual and prototype-based rather than empirically established improvements in organizational performance. Future implementation should therefore prioritize user acceptance testing, system interoperability, data security, implementation costs, organizational readiness, and measurable distribution outcomes to determine the model's practical effectiveness and transferability across different sectors and geographical contexts.

CONCLUSION

This study developed SerangChain as a web-based governance prototype connecting MSME and retail roles, distribution events, linked ledger records, and operational dashboards in Serang, Banten. All seven reported functional test scenarios passed, providing preliminary evidence that the specified functions can operate together in a controlled setting. The principal contribution is a role-based governance design in

which event records and managerial visibility are produced within one distribution workflow. However, the ledger is a blockchain-inspired simulation rather than a validated distributed blockchain, and neither field effectiveness nor security and scalability has been demonstrated. Subsequent work should document participant and test metadata, conduct independent integrity and security tests, assess user acceptance, and compare operational outcomes before and after deployment.

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