Development Economics of China
2025, VOL. 9, NO. 7, 5-8
DOI: 10.47297/wspdecWSP2515-797301.20250907

From Sharing to Co-Governance: Research on the Design of Quality Chain System Based on Artificial Intelligence

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ABSTRACT

This paper addresses critical food safety challenges in modern agricultural supply chain management by proposing an AI-driven quality chain system design. The system integrates five key chains—agricultural product quality, capital flow, logistics, and accountability—into a unified accounting information framework through artificial intelligence and multidimensional accounting theories, achieving "five-chain integration". Centered on "quality accountability", the intelligent open, decentralized, and industry-finance integrated agricultural supply chain management system enhances transparency, traceability, precision, and collaboration within the sector. It plays a vital role in establishing fair market competition, guiding industrial cycles, optimizing resource allocation, and building market confidence while reinforcing social responsibility.

KEYWORDS

Food safety; Multi-dimensional accounting; Quality Cloud Chain; Agricultural product supply chain management

1 Introduction

The quality and safety of agricultural products are directly related to the health and life safety of the general public, and constitute an indispensable part of building a strong agricultural country and achieving agricultural modernization. However, food safety issues have continued to emerge in recent years. Whether it was the melamine-tainted milk adulteration incident in 2008, or the 2024 food safety incidents involving alkaline yellow in durian, preservatives in cherries, preservatives in pre-made dishes, <barbary wolfberry> dyeing, industrial bottling of edible oils, or the Jiangxi rat-head duck neck incident that sparked intense public concern, these events and their lack of transparency have posed significant challenges and hazards to agricultural supply chain management. The traditional single-dimensional, fragmented management model can no longer meet the demands of agricultural product supply chain management, making it imperative to establish a multi-dimensional, full-cycle quality management system.

This study explores the application of multi-dimensional accounting in agricultural supply chain management. By integrating product quality chains, logistics networks, capital flows, and accountability systems into the accounting information framework, we develop a comprehensive, full-process, and highly accountable agricultural product quality credit management system. This research not only contributes to enriching and refining agricultural supply chain management theories, but also provides innovative approaches and methodologies for food safety governance in practical applications.

2 Problems existing in agricultural product supply chain management

The product supply chain encompasses the entire process from harvesting, grading , packaging, pre-treatment, warehousing, transportation, distribution to after-sales services. China's agricultural supply chains are characterized by their extensive reach, numerous stakeholders, cross-regional operations, seasonal demands, diverse product categories, and stringent quality requirements. However, current supply chain management in this sector faces challenges including weak traceability mechanisms, inefficient logistics operations, inadequate financing precision, and ambiguous accountability frameworks.

First, weak traceability of quality. Firstly, the lack of standardized and authoritative China 3C mandatory product certification throughout the agricultural supply chain business activities leads to lax quality control, false advertising, frequent disputes, and difficulties in rights protection. For instance, food ingredients should disclose the time, quantity, and hazards of additives. Secondly, consumers cannot access real-time video recordings, and there is no electronic signature confirmation during property rights transfer at each stage, making production processes untraceable and responsible parties hard to hold accountable. For example, seafood ingredients lack comparison before transportation and after delivery, making it difficult to determine where food spoilage occurs. Thirdly, inadequate strictness in identifying, controlling, monitoring, and improving key chain nodes results in unstable product quality. For instance, takeout food lacking sealing labels complicates the delineation of responsibilities between producers and delivery

personnel.

Second, weak accountability and supervision. First, although there are numerous domestic laws on food safety, law enforcement supervision struggles to ensure objectivity and independence. Many food safety incidents initially involve local testing institutions conducting qualified tests, such as the detection and publication of results for problematic products like rat-headed duck necks and head-shaped milk powder. Second, while government oversight platforms, consumer hotlines, third-party complaint channels, and news media have tracked and exposed food safety issues, local governments prioritize fiscal stability and employment security, while Chinese enterprises prioritize profits over recalling defective products or even continuing production despite paying substantial PR costs. Third, the lack of intelligent rapid testing supervision platforms makes it difficult for independent third-party testing institutions to integrate into the entire process supervision from farm to table, resulting in challenges in sharing, tracing, and transmitting food testing information.

Third, low logistics efficiency. Firstly, indicators such as agricultural product damage rates, cold chain compliance rates, cold chain circulation rates, and cold chain transportation rates still lag significantly behind those of developed countries. Secondly, there is a lack of integrated planning for multimodal transport coordination, with insufficient holistic arrangements across all links and failure to establish effective collaborative mechanisms. Thirdly, substantial disparities exist in digitalization levels between upstream and downstream sectors, resulting in significant information gaps. The smoothness and accuracy of information exchange are hindered, with data from warehouses, order systems, transportation, finance, banking, and contracts failing to integrate seamlessly or maintain real-time correlation.

Fourth, financing precision remains inadequate. Firstly, financial institutions and state-backed subsidy agencies lack comprehensive monitoring of agricultural supply chain information. In 2024, agricultural insurance premiums reached 54.75 billion yuan, while the balance of agricultural loans stood at 51.13 trillion yuan by Q32024, with credit loans accounting for approximately 35%. Although tech-driven platforms like Zhongqilian (China Enterprise Chain) have established close system integrations with major supply chain organizations, most financing still relies on the creditworthiness of core enterprises or industry leaders. Secondly, dominant enterprises monopolize supply chain funding through their market power, creating financing bottlenecks for vulnerable farmers, suppressing purchase prices, and ultimately leading to product quality deterioration. Thirdly, China's current financial system lacks a dedicated blacklist mechanism for food safety violations. Some agricultural enterprises sacrifice product quality and safety to cut costs, inadvertently allowing unscrupulous businesses to crowd out ethical ones in loan allocation.

3 Design of artificial intelligence based agricultural product supply chain system

Multidimensional Accounting is a business-oriented framework that integrates accounting processes, cash flows, and management workflows through technologies like artificial intelligence and smart contracts. It creates a unified information system that combines contracts, finance, human resources, operational procedures, and customer metrics to achieve real-time data synchronization. Unlike traditional accounting systems, multidimensional Accounting features intelligent openness, decentralization, and business-finance integration. By implementing quality and accountability account systems, it connects and integrates information across different accounting units and business processes in industrial chains. The agricultural supply chain management system based on multidimensional Accounting is a comprehensive framework specifically designed to address product quality issues. Its core philosophy involves designing and integrating quality chains, capital chains, logistics chains, and responsibility chains. Through the multidimensional Accounting system's capabilities for recording, analyzing, and evaluating data, it achieves alignment of responsibilities, financial resources, and material flows among enterprises within the supply chain.

3.1 Five-chain composition

Responsibility is the guarantee of product quality. Only by forming a new quality responsibility governance model based on transparency, openness, cooperation and coordination can we establish a transparent, mutual trust and perfect quality assurance co-governance system among the government, enterprises and consumers, so as to realize the rapid response of all responsible parties.

The Product Quality Chain is a third-party public service platform for comprehensive quality data, built on next-generation information technologies including cloud computing, big data, blockchain, AI, and IoT. The Product Liability Chain connects responsible entities or processors involved in product design, production, sales, and after-sales services through specific mechanisms, forming a chain of accountability and resolution. The Product Logistics Chain represents a linear structure connecting logistics nodes and routes, designed to ensure efficient and cost-effective transportation from origin to destination. The Capital Chain encompasses all transactions and fund transfers between raw material suppliers and end consumers.

3.2 The advantages of the integration of the five chains

In the product quality chain, cross-departmental and cross-enterprise accounting units or processes are interconnected through mutual quality agreements to form a responsibility chain. These nodes encompass all organizations and processes involved in the product's entire lifecycle. Supported by product standards, inspection and testing, quality traceability, quality credit systems, and quality assurance mechanisms, this integrated approach aims to enhance product quality through holistic, systematic, and coordinated management throughout the product's entire lifecycle and operational processes.

3.3 Steps to build the "Five-Link Integration"

(1) Establish operational standards for agricultural product quality chains. Implement ISO-certified platform protocols covering enterprise access, food quality grading, procurement, production, processing, testing, storage, transportation, and sales procedures, with all documentation entered into an initial database. Simultaneously, rigorously screen and dynamically select participating institutions according to these established criteria.

(2) Achieve full-process traceability. By leveraging blockchain technology, every step of food production—from farm to table—is documented, including seed origins, fertilizer and pesticide usage, processing methods, and storage logistics. When food safety issues arise, the system can quickly pinpoint problematic stages and identify root causes. Consumers can scan QR codes or use search functions to track a product's entire journey, including its origin, production date, manufacturing process, and transportation conditions. Legal relationships and liability transfers are formalized through electronic contracts, with each handover requiring digital signatures to confirm responsibility transfers.

(3) Optimizing quality control strategies. By analyzing blockchain data, companies can promptly identify quality issues in production processes and drive product innovation. For instance, through dynamic quality analysis, platforms can detect potential operational risks in specific business processes that may arise after prolonged operation. This enables early corrective actions and scheduled replacements, while implementing centralized procurement and inspection of problematic raw materials. Additionally, AI-powered 24/7 monitoring and intensified random inspections are deployed to address recurring vulnerabilities.

(4) Credit evaluation of capital efficiency and quality. For manufacturing enterprises, quantitative credit assessment indicators are established based on multiple dimensions including customer orders, product quality, corporate reputation, social responsibility, and complaint rates. For logistics companies, service quality evaluation metrics cover delivery punctuality, product damage rate, order processing accuracy, customer service, transportation time, cost-effectiveness, technology application, as well as compliance rates for cold chain standards, circulation rates, and transportation rates. By leveraging intelligent cloud chain technology, real-time monitoring of corporate capital inflows, outflows, and balances is implemented to assess debt repayment capacity, financial stability, and working capital management. Through capital pools, the system maximizes capital efficiency while ensuring operational sustainability.

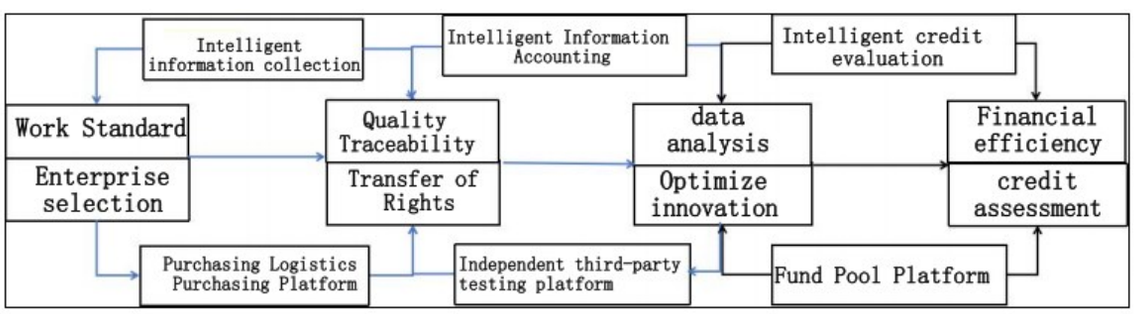

Figure 1 "Five chains" fusion system design

4 Summary and implications

This paper addresses food safety challenges in modern agricultural supply chain management by proposing an intelligent multi-dimensional accounting-based system design. By integrating the quality chain, capital chain, logistics chain, responsibility chain, and accounting information chain, it achieves "five-chain integration". The system leverages advanced technologies such as blockchain, smart contracts, and IoT to enhance supply chain transparency, traceability, precision, and collaboration, providing a groundbreaking solution for agricultural supply chain management. The core contributions of this study include:

First, the framework introduces a "Five-Chain Integration" lifecycle management system. By integrating quality control,

capital flow, logistics networks, accountability mechanisms, and accounting information systems, it establishes a multi-dimensional supply chain management platform that enables end-to-end monitoring from farm to table. Second, a multidimensional accounting system centered on "quality accountability" has been developed. Through blockchain and smart contract technologies, this system achieves structured, quantified, and process-driven management of asset quality and responsibilities, ensuring traceable accountability and risk control across supply chain operations. Third, the concept of "co-governance" is proposed. A collaborative governance mechanism involving governments, enterprises, and consumers has been established, creating transparent and mutually trusted quality assurance systems that enhance market confidence and social responsibility awareness.

The design of agricultural product supply chain system based on multi-dimensional accounting proposed in this paper not only provides new ideas and methods for food safety management, but also provides important theoretical support and practical guidance for the digital transformation and sustainable development of agricultural supply chain of government enterprises.

The system has expanded its application in multidimensional accounting. Through the implementation of "Quality Responsibility Journal Entries", it integrates the quality chain, capital chain, logistics chain, responsibility chain, and accounting information chain. This enables comprehensive supply chain management, effectively addressing issues of information asymmetry and unclear accountability in traditional supply chain practices. Such integration significantly enhances corporate operational efficiency and market competitiveness.

The second aspect involves fostering a collaborative governance framework, social responsibility, and market confidence. In supply chain management, a quality governance system involving joint participation from governments, enterprises, and consumers can effectively enhance food safety standards and strengthen market confidence. By cracking down on non-compliant practices and establishing transparent quality traceability systems, we can boost consumer trust in agricultural product quality and promote the healthy development of markets.

The third is data-driven decision optimization. Through big data analysis and smart contracts, enterprises can monitor the quality and capital flow of each link in the supply chain in real time, find problems and optimize them in time, and improve the overall operation efficiency.

About the Author

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