

Research on the Development Path of AI-enabled E-commerce and Supply Chain from the Perspective of Rural Revitalization

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Abstract: Under the background of the rural revitalization strategy, artificial intelligence has become a key driving force for the high-quality development of rural e-commerce and supply chain systems. Focusing on the internal mechanism and practical challenges of AI-enabled rural e-commerce and supply chains, this paper constructs an analytical framework of "technological empowerment, stakeholder cultivation, and ecological synergy" based on digital economy and new quality productive forces theories. Combining with the agricultural e-commerce practice in Wuding County, Yunnan Province, the application scenarios of AI technologies in intelligent recommendation, demand forecasting, supply chain optimization, and brand building are systematically elaborated, and the current practical difficulties such as weak infrastructure, shortage of professional talents, data silos, and shallow application of technologies are deeply analyzed. On this basis, a path construction plan is proposed from the dimensions of building intelligent e-commerce platforms, digital upgrading of supply chains, industry-academia-education collaborative talent cultivation, and multi-agent collaborative governance, aiming to provide theoretical reference and practical guidance for the intelligent transformation of rural e-commerce and supply chains in central and western regions.

1. Introduction

The report to the 20th National Congress of the Communist Party of China has clearly deployed the strategic tasks of comprehensively promoting rural revitalization and accelerating the construction of an agricultural powerhouse. As a core carrier integrating the digital economy and the real agricultural economy, rural e-commerce serves as a key approach to smoothing the circulation of urban and rural factors, facilitating the upward circulation of agricultural products, and increasing farmers' income. It boasts unique advantages in expanding the circulation radius of agricultural products, reducing transaction costs, and upgrading the agricultural value chain. The traditional agricultural product circulation system suffers from structural problems such as excessive circulation links, high commodity loss rates, and low operational efficiency. By establishing online circulation channels directly targeting end consumers, rural e-commerce effectively eliminates intermediate links,

greatly reduces agricultural product circulation losses and transaction costs, optimizes the efficiency of agricultural product resource allocation, and provides important support for the digital transformation of rural industries [1][2]. Nevertheless, the development of rural e-commerce in China still has prominent shortcomings at this stage. Prevailing problems including information asymmetry, high county-level logistics costs, lagging brand building of agricultural products, and inefficient supply chain systems make the traditional e-commerce model incapable of adapting to the complex and volatile market environment, with development bottlenecks becoming increasingly prominent [3].

The rapid iteration and practical application of artificial intelligence (AI) technology have provided a brand-new technical path to solve the dilemmas of rural e-commerce development and promote supply chain upgrading. Core AI technologies including machine learning, deep learning, and natural language processing have comprehensively reshaped the traditional e-commerce industrial chain and profoundly optimized and innovated the traditional agricultural business model [4][5]. In the field of agricultural product supply chains, AI-enabled digital platforms realize full-traceability of agricultural products from field production to terminal consumption, effectively improving supply chain transparency, market response efficiency and risk early warning capability, and significantly enhancing the overall resilience of the agricultural industrial chain. Meanwhile, the construction level of digital infrastructure is positively synergistic with the application effect of AI technology, laying a solid theoretical and practical foundation for the intelligent transformation of rural e-commerce supply chains [6]. Against the backdrop of in-depth integration of digital technologies into agricultural industrial chains, AI not only optimizes the intelligent decision-making system for agricultural production, but also realizes precise scheduling of warehousing and logistics and personalized matching of terminal consumption. It participates in the full-process reconstruction of agricultural product supply chains covering information perception, quantitative decision-making and intelligent execution, acting as the core engine for the modernization and upgrading of agricultural industrial chains [7]. The mature implementation of new-generation information technologies has also established a sound technical support system for the digital and intelligent transformation of agricultural supply chains [8].

Existing academic research has yielded fruitful achievements in the development of rural e-commerce, digital economy empowerment, and the integration of new quality productive forces with e-commerce. Numerous scholars have systematically explained the implementation paths of digital technologies empowering rural industrial revitalization, constructed analytical frameworks for the collaborative development of rural e-commerce, and thoroughly analyzed the value logic and operation mechanism of AI empowering agricultural industrial chains [9]. However, most existing studies focus on macro-level theoretical discussions, while empirical research on the localized application paths of AI technologies, industry-university-research collaboration mechanisms, and full-chain intelligent integration of supply chains in specific county-level scenarios of central and western China remains insufficient. Based on the practice of agricultural product e-commerce development in Wuding County, Yunnan Province and targeted survey data, this paper mainly explores the empowerment mechanism of AI technologies in rural e-commerce and supply chains, analyzes the practical dilemmas of the intelligent transformation of rural e-commerce in county-level areas of central and western China, and constructs an AI-enabled e-commerce and supply chain development system adapted to the development characteristics of central and western counties. This study enriches the theoretical achievements at the intersection of digital economy and rural revitalization, and provides operable references for the agricultural governance of local governments and the digital transformation of agricultural enterprises.

2. Theoretical Basis and Mechanism Analysis of AI-enabled Rural E-commerce and Supply Chain Development

2.1. Definition of Core Concepts and Theoretical Basis

AI-enabled e-commerce and supply chain development takes artificial intelligence technology as the core driving force. It reshapes the value creation model of the e-commerce industrial chain through data collection, algorithm modeling and intelligent decision-making, realizing the upgrading of industrial functions from simple information transmission to intelligent knowledge generation [4][5]. This concept consists of three core elements. At the technical level, it covers intelligent algorithm systems including machine learning, natural language processing, computer vision, and large language models. At the application level, it penetrates full business scenarios such as e-commerce operation, supply chain management and control, product traceability, precision marketing, and intelligent customer service. At the value level, it focuses on cost reduction and efficiency improvement, user experience optimization, and farmers' income growth, so as to support the high-quality development of rural e-commerce. This research is carried out based on three core theories: transaction cost theory, new quality productive force theory, and digital empowerment theory. The transaction cost theory indicates that the multi-level structure of traditional agricultural product circulation leads to information asymmetry, excessive transaction costs and lack of trust, which restrict the growth of farmers' income. In contrast, AI technology can effectively reduce information frictions and break the constraints on the upward circulation of agricultural products through user profiling, intelligent recommendation and supply chain visualization [10]. The new quality productive force theory emphasizes the core value of the in-depth integration of digital technology and the real economy. As a new type of production tool, AI reconstructs the combination mode of agricultural production factors, promotes the transformation of rural e-commerce from labor-intensive to intelligence-driven development, and fully empowers the innovation, collaboration and digital upgrading of industrial chains[11][12]. The digital empowerment theory suggests that digital technology can optimize resource allocation, innovate industrial governance models and improve the digital literacy of market entities. Agricultural e-commerce platforms can integrate industrial chain resources, and the in-depth application of AI technology can reconstruct the rural industrial ecosystem, break the barriers between production and sales, and facilitate the integrated transformation and upgrading of rural industries [13].

2.2. Internal Mechanism of AI Empowerment

The empowering effect of AI technology on rural e-commerce and supply chains is mainly realized through three core mechanisms: supply-demand matching, supply chain optimization, and user experience improvement. First, the data-driven precise supply-demand matching mechanism. AI integrates multi-dimensional data on consumption, production and circulation to build a data closed loop of "demand perception – supply optimization – precise reach". With machine learning technology to depict user consumption characteristics, it realizes personalized recommendation and precision marketing, effectively alleviating the bullwhip effect in traditional supply chains [13]. Meanwhile, prediction models such as Long Short-Term Memory (LSTM) can conduct demand forecasting based on market, climate and sales data, providing scientific support for farmers' planting planning and output management and alleviating the imbalance between agricultural product supply and demand [7]. Second, the intelligent decision-driven supply chain optimization mechanism. Targeting the pain points of extensive inventory management and inefficient logistics scheduling in traditional supply chains, AI intelligent management platforms realize dynamic inventory regulation, intelligent logistics route planning and efficient scheduling of distribution nodes based on real-time

data and optimization algorithms [14]. Specifically, computer vision technology enables intelligent grading of agricultural products and improves product standardization. The integrated application of the Internet of Things and blockchain technology realizes full-link traceability of agricultural products and ensures circulation transparency, which comprehensively optimizes supply chain management modes and deepens industrial embedding [15]. Third, the intelligent interaction-driven user experience improvement mechanism. AI technology is applied in diverse scenarios such as intelligent customer service, virtual anchors and intelligent content generation. It adapts to rural consumption scenarios through sentiment analysis and dialect recognition, and provides all-weather intelligent consulting services based on large language models, improving service efficiency and user satisfaction. Furthermore, AI can automatically generate short video scripts and plan live-streaming content, lowering the threshold for brand marketing creation of agricultural products, broadening product communication channels, and supporting the brand development of rural e-commerce.

3. Practical Dilemmas of AI-enabled Rural E-commerce and Supply Chain Development

Although AI technology shows great potential in empowering rural e-commerce and supply chains, county-level areas in central and western China still face numerous structural obstacles in practical application. Combined with field research in Wuding County, Yunnan Province and existing literature [16], these dilemmas can be summarized into the following four dimensions.

3.1. Insufficient Digital Infrastructure and Technology Adaptability

The effective application of AI technology relies on stable, high-speed network support and sufficient computing power guarantees. However, network infrastructure in some county-level areas of central and western China remains imperfect, and the 5G coverage and broadband access speed in remote towns cannot meet the real-time requirements of big data transmission and cloud computing. As indicated in existing research, digital infrastructure construction covering data centers, artificial intelligence, 5G networks, and industrial Internet plays a vital role in promoting the modernization of agricultural industrial chains and supply chains, yet the imbalance of digital infrastructure development across regions remains prominent [17]. Meanwhile, rural areas generally lack localized computing infrastructure, resulting in high computing costs for AI model training and hindering the efficient implementation of relevant technologies. In addition, the adaptability of current AI technologies to rural e-commerce scenarios is insufficient. Most AI products and services are developed for urban commercial scenarios, lacking customized solutions for the non-standard characteristics of agricultural products, dialect interaction demands, and offline inference capabilities under low-network conditions.

3.2. Data Isolation and Inadequate Supply Chain Collaboration

Serious data barriers and data isolation exist across all links of the agricultural product supply chain, including production, processing, warehousing, logistics, and sales. Macro-level studies have confirmed the intrinsic correlation between AI and industrial chain collaboration; nevertheless, the problems of inconsistent data standards and disconnected systems across supply chain links are particularly prominent in the agricultural sector. Without high-quality and structured data accumulation, the training and optimization of AI algorithm models lack solid foundations. Further research has pointed out that one of the core challenges of the digital transformation of agricultural supply chains is realizing cross-link information sharing and business collaboration. Moreover, the understanding of supply chain digital transformation among some agricultural enterprises remains superficial, limited to basic practices such as building websites and opening online stores. These

enterprises show low willingness to adopt advanced functions including full-chain digital integration, intelligent forecasting, and dynamic scheduling.

3.3. Weak Brand Building and Market Expansion Capabilities

Agricultural products in central and western China generally suffer from low brand visibility and severe homogeneous competition. Although several regions have launched regional public brand construction initiatives, they lack effective AI support in precision marketing, multi-channel integrated promotion, and social media data analysis. Agricultural enterprises are deficient in data-driven decision-making capabilities in user profiling, market positioning, and brand promotion, leading to limited brand communication effects and slow growth in market share. Furthermore, the application of AI technologies in content generation, virtual anchor operation, and social media data analysis is still in its initial stage, failing to fully release its enormous potential for brand building and market promotion.

4. Path Construction of AI-enabled E-commerce and Supply Chain Development from the Perspective of Rural Revitalization

Based on the above theoretical analysis and investigation of practical dilemmas, this paper constructs a four-dimensional collaborative development framework of AI empowerment covering "technology, industry, talent, and governance". With intelligent technology as the underlying support, industrial upgrading as the core carrier, talent cultivation as the key driving force, and multi-subject collaborative governance as the institutional guarantee, the framework forms a closed-loop development system for rural e-commerce and supply chain intelligent transformation.

4.1. Technological Path: Construction of Intelligent E-commerce and Supply Chain Platforms

Intelligent e-commerce and supply chain platforms serve as the core carriers for AI-enabled rural e-commerce development, which require systematic construction and iterative upgrading centering on three major modules: demand perception, intelligent operation, and precision marketing. In the demand perception stage, relying on big data and machine learning technologies, this study integrates multi-dimensional variables including sales volume, seasons, climate, and holidays, and adopts time-series models such as LSTM and Prophet to build an intelligent forecasting system for accurate market demand assessment. The practice of Wuding Yongyin Agricultural Products Company verifies that AI forecasting can scientifically arrange the processing batches of characteristic agricultural products, effectively alleviate inventory backlogs and reduce product losses. The popularization of the digital economy also provides sufficient data support and application scenarios for the implementation of such technologies. In the intelligent operation stage, based on user behavior data, algorithms including collaborative filtering and deep interest networks are adopted to establish a personalized recommendation system. Meanwhile, 7×24-hour AI intelligent customer service is deployed to significantly improve user conversion and repurchase rates and reduce operational costs. The innovative application of AI technologies effectively optimizes the operational mode of e-commerce supply chains. In the precision marketing stage, leveraging large language models, intelligent image recognition, and AI dialect voice interaction technologies, the platform automatically generates marketing content and visually displays product quality to expand the coverage of rural customer groups. Taking the opportunity of digital rural construction, it innovates e-commerce marketing modes and facilitates the upward circulation of agricultural products.

4.2. Industrial Path: Full-chain Digital Upgrading of Supply Chains

The digital upgrading of agricultural product supply chains takes end-to-end full-link intelligent management and control as its core concept, connects the entire chain of production, warehousing and logistics, and quality traceability, and realizes full-process intelligent transformation through diverse digital technologies. At the production end, IoT sensors, UAV inspection, satellite remote sensing and other equipment are used to collect agricultural production environment data, and AI models generate precise planting decisions, practicing the core development model of "digital empowerment + intelligent equipment" for smart agriculture. Meanwhile, AI visual recognition and large model technologies are introduced to realize intelligent grading of agricultural products, process optimization and formula iteration, and promote the standardization of processing links. In the warehousing and logistics sector, RFID and computer vision technologies are applied to build an intelligent warehousing and sorting system. Combined with real-time data, the system dynamically optimizes distribution routes and monitors cold chain storage and transportation parameters via AI algorithms to realize abnormal early warnings and effectively reduce circulation losses. In terms of quality traceability, the government, agricultural management departments, agricultural enterprises, etc. should jointly build a traceability platform that integrates Internet of Things and blockchain technology. Throughout the entire process, the technical department collects all data related to agricultural products and stores such data on the blockchain for evidentiary purposes. Meanwhile, relevant agricultural enterprises can leverage the immutability of blockchain to achieve end-to-end traceability, which helps consumers verify product information, enhances brand reputation, and further realizes the intelligent integration of perception, decision-making, and execution links in the supply chain.

5. Conclusion

The development and widespread application of artificial intelligence technologies have created opportunities and provided technical support for the advancement of rural e-commerce and supply chains. Particularly in the context of rural revitalization, policy support has enabled artificial intelligence technologies to deliver greater impetus to rural economic development. Combining the actual conditions of Wuding County, Yunnan Province, this paper summarizes the existing problems in the current application of artificial intelligence technologies in the development of rural e-commerce and supply chains, and puts forward targeted and feasible solutions, which can provide a reference for the application of artificial intelligence technologies in the development of rural e-commerce and supply chains in other regions. In future research, further in-depth application of artificial intelligence technologies in the development of rural e-commerce can be promoted.

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