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Digitalization of Industrial Chains: Research on Innovative Pathways for Rural Industry Integration and Rural Revitalization

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Abstract

In the context of the digital economy driving China's high-quality development, the digital transformation of rural industries is of great significance for coordinated urban-rural development and rural revitalization. Various regions have actively implemented the "High-Quality Development Project for Hundreds of Counties, Thousands of Towns, and Tens of Thousands of Villages," achieving initial successes in the integration of agriculture, culture, and tourism industries as well as in rural revitalization. By constructing diversified industrial systems and establishing industrial alliances, some regions have seen significant investments in multiple agricultural and cultural tourism projects from January to October 2024, creating distinctive brands and promoting a number of enterprises to scale up and integrate into the statistical system, thereby enhancing industrial scale and standardization. However, rural digital development still faces challenges such as insufficient elements for industrial integration, lagging digital infrastructure, and inadequate empowerment of digital inclusive finance. To address these issues, local governments have built digital financial sharing platforms by improving residents' digital literacy, strengthening the integration of digital assets and finance, and fostering cooperation among financial entities, thereby supporting the digital development of rural industries. This paper analyzes the development status, mechanisms, problems, and solutions in some regions, aiming to provide references for other areas to promote rural revitalization and common prosperity.

Keywords: kaiping city, digitalization of industrial chain, rural industry integration, rural revitalization, digital finance

1. Introduction

Under the vigorous development of the digital economy, which features high innovation, strong permeability, and broad coverage, it has profoundly transformed traditional industrial models and emerged as a core driving force for economic growth and industrial structure optimization. This transformation also presents new opportunities for rural industrial development. China has been actively implementing the rural revitalization strategy to address issues concerning agriculture, rural areas, and farmers ("Three Rurals") while narrowing the urban-rural gap. Although this strategy has created multiple opportunities for agricultural and rural development, challenges persist in the "Three Rurals" sector, including low agricultural productivity, inadequate rural infrastructure, and slow income growth among farmers. Additionally, rural industrial integration faces multiple constraints. Against this backdrop, researching pathways for industrial chain digitalization to promote rural industrial integration and rural revitalization holds significant practical implications.

2. Problem Statement

The rural revitalization strategy is steadily advancing, with the development of rural industries being the core of achieving rural prosperity. In vast rural areas, although there is widespread development potential, numerous challenges persist. In recent years, the per capita disposable income of rural residents has shown a growth trend. However, compared to the income levels of urban residents, the gap remains significant, highlighting the imbalance in urban-rural development. The rural industrial structure is also relatively homogeneous, dominated by traditional agriculture with low industrial added value, making it difficult for farmers to increase their incomes and posing a major challenge to the implementation of rural revitalization. Against this backdrop, digital technology has become a key driver for rural industrial development. In recent years, China’s digital economy has grown rapidly. In 2022, the scale of China’s digital economy exceeded 50 trillion yuan, with a year-on-year growth rate of over 10%, demonstrating strong momentum and widespread application across sectors. Many regions have

actively embraced digitalization by promoting digital technologies in rural areas, such as introducing digital management systems for agricultural production and developing rural e-commerce. However, the overall level of digitalization still needs improvement.

Rural industrial integration is a critical measure for achieving rural revitalization. It can optimize industrial structures, enhance agricultural efficiency, increase farmers' incomes, and promote comprehensive rural development. However, current efforts to advance rural industrial integration face the following challenges:Integration elements: Land transfer standardization continues to progress, but contract signing rates in some remote areas need improvement, and historical disputes remain unresolved;Capital participation: While social capital involvement has increased, financing channels for small agricultural enterprises need expansion;Labor force: Rural areas face significant aging populations. Although vocational training and industrial upgrades have attracted some young people to return, the proportion of highly educated talent remains low; Integration depth: Agriculture-culture-tourism integration and branding have achieved notable results, but small and medium-sized enterprises (SMEs) need to transition to deep processing; Digital infrastructure: Smart agriculture pilot projects have been implemented in central towns, but network coverage and stability in remote areas require strengthening; The advancement of digital inclusive finance also faces universal challenges, including low financial literacy among farmers, underutilization of relevant financial products, a scarcity of financial products tailored to rural industries, fragmented services, and insufficient support for industrial integration.

Therefore, researching the pathways for promoting rural industrial integration and revitalization through the digitalization of rural industrial chains is of great significance. By digitizing industrial chains, integrating resources, and enhancing synergies, it is possible to break down barriers between rural industries, foster deeper integration, and contribute to comprehensive rural revitalization. This study will delve into this theme to provide insights for rural industrial development.

3. Literature Review

3.1 Research on Digitalization of Industrial Chains

3.1.1 Connotation and Characteristics of Industrial Chain Digitalization

Industrial chain digitalization refers to the comprehensive and deep integration of digital technologies into all segments of industrial chains, enabling real-time information sharing, intelligent process coordination, and efficient resource allocation. Key characteristics include data-driven decision-making, supply chain visualization, flexible production, and innovation ecosystemization. For example, IoT technologies allow real-time data collection and transmission in production, while big data analytics optimize production planning, and AI enables smart equipment maintenance.

3.1.2 Drivers of Industrial Chain Digitalization

The convergence of next-generation technologies (5G, cloud computing, blockchain) is reshaping the digital paradigm of industrial chains. Their techno-economic attributes empower dual mechanisms of cost-efficiency (reducing transformation costs by 23%-37%) and scenario diversification (e.g., annual expansion rate of agricultural digital applications exceeding 15%). The driving logic reflects market-policy synergy: at the micro level, consumption upgrades compel enterprises to adopt digital technologies for personalized demand (customized production accounts for 28%); at the macro level, institutional safeguards like digital infrastructure bonds accelerate technology penetration (narrowing the penetration gradient gap by 9.2 percentage points in 2023).

3.1.3 Impacts of Industrial Chain Digitalization on Industrial Development

Digitalization enhances industrial efficiency, reduces transaction costs, and improves risk resilience. In manufacturing, it shortens production cycles and elevates product quality; in services, it fosters service innovation and customer experience. However, challenges such as technical complexity and talent shortages may hinder transformation outcomes.

3.2 Research on Rural Industrial Integration

3.2.1 Concept and Models of Rural Industrial Integration

Rural industrial integration refers to the dynamic process of restructuring primary, secondary, and tertiary industries through agricultural foundations, industrial linkages, factor agglomeration, and innovation-driven mechanisms. Common models include: Agricultural industrial chain extension (e.g., integrating production with processing and sales); Agricultural multifunctionality expansion (e.g., leisure agriculture, rural tourism);Technology-driven integration (e.g., rural e-commerce via internet platforms).

3.2.2 Influencing Factors of Rural Industrial Integration

Key factors include resource endowments, policy environments, market demand, and operational capabilities. Natural resources and specialty products provide the foundation; fiscal policies guide integration; market demand for diversified, high-quality products drives growth; and the innovation capacity of new agricultural entities determines integration efficacy.

3.2.3 Role of Rural Industrial Integration in Rural Economic Development

The integration of rural industries has significantly enhanced the added value of agricultural products, created substantial employment opportunities, and effectively promoted the return of rural labor forces by extending the agricultural industrial chain and developing integrated sectors such as agricultural product processing and rural tourism. It also diversifies rural economies and facilitates structural upgrades toward multi-value development.

3.3 Research on Rural Revitalization

3.3.1 Connotation and Goals of Rural Revitalization

Rural revitalization encompasses five dimensions-industry, ecology, culture, governance, and livelihood—aiming to achieve holistic rural development and narrow urban-rural gaps.

3.3.2 Pathways to Rural Revitalization

Scholars have proposed multiple pathways to achieve rural revitalization, encompassing industrial development, talent cultivation, cultural preservation, ecological conservation, and organizational innovation. In terms of industrial development, initiatives such as promoting specialized agriculture and rural e-commerce drive industrial upgrading. For talent cultivation, enhancing rural education and vocational training aims to attract skilled workers back to rural areas. Cultural preservation focuses on inheriting and promoting rural cultural heritage to cultivate a civilized rural ethos, while ecological conservation involves improving environmental management and advancing green agricultural practices. Additionally, organizational innovation requires strengthening rural grassroots Party organizations and empowering institutions like farmers' professional cooperatives.

3.4 Research on Relationships Among Industrial Chain Digitalization, Rural Industrial Integration, and Rural Revitalization

3.4.1 Promotion of Rural Industrial Integration by Industrial Chain Digitalization

Digitalization provides technical and innovative impetus for rural integration. Digital platforms enable efficient coordination across production, processing, and sales, enhancing supply chain synergy. Rural e-commerce breaks spatiotemporal sales barriers and integrates agriculture with services. Big data analytics further guide diversified, demand-driven agricultural transformation, extending and upgrading industrial chains.

3.4.2 Synergistic Effects of Digitalization and Integration on Rural Revitalization

Digitalization and rural industrial integration mutually reinforce rural revitalization. Digitally empowered integration boosts rural competitiveness, increases farmer incomes, improves infrastructure and public services, and modernizes governance. Concurrently, rural revitalization policies create favorable environments for digitalization and integration, attracting resource agglomeration and sustaining industrial growth.

4. The Internal Mechanism of Industrial Chain Digitalization Driving Rural Industry Integration and Rural Revitalization

4.1 The Core of Industrial Chain Digitalization

Industrial chain digitalization serves as the core driving force for rural industrial development in the digital era. Leveraging cutting-edge technologies such as big data, artificial intelligence, and the Internet of Things (IoT), it comprehensively reshapes rural industrial chains and elevates rural industries to new heights.

4.1.1 Digital Technology Across the "Production-Processing-Sales" Chain

The Internet of Things (IoT) empowers smart cultivation at the production stage, intelligent equipment enhances standardized quality control in processing, and live-streaming e-commerce revolutionizes marketing networks across the circulation phase, thereby systematically boosting the operational efficiency of the entire agricultural industry chain.

4.1.2 Data-Driven Industrial Chain Optimization

Data constitutes the core element of industrial chain digitalization. Through collection and analysis of production, processing, and sales data, market trends become discernible and production bottlenecks identifiable. Agricultural big data assists producers in rational production planning to avoid supply-demand imbalances. Enterprises

optimize processing techniques and reduce costs using processing data. Sales data guide precision marketing, effectively boosting conversion rates and optimizing resource allocation across the industrial chain.

4.1.3 Promoting Synergy Across Industrial Chain Segments

Industrial chain digitalization breaks traditional information barriers, facilitating deep integration between agriculture and secondary/tertiary industries. Vertical integration enhances value-added rates in processing through agriculture-agroprocessing convergence. Rural e-commerce bridges production, processing, and sales. Rural tourism leverages agricultural landscapes and cultural resources to drive service sector development. Han Chunxia and Lu Zhenzhen (2024) found that rural digitalization expands industrial functions, enables resource sharing, and accelerates rural industry integration.

4.1.4 Catalyzing Industrial Chain Innovation

Digital technologies inject innovation into industrial chains, spawning new formats like smart agriculture, rural e-commerce, and agricultural product traceability systems. Blockchain-based traceability enhances consumer trust, while agricultural crowdfunding and customized agriculture meet personalized demands, propelling industrial chains toward high-end and intelligent upgrades.

4.2 Mechanism of Industrial Chain Digitalization in Promoting Rural Industry Integration

4.2.1 Extending Agricultural Industrial Chains

Digital technologies integrate agriculture with the internet, accelerating information flow through digital platforms. Farmers adjust production via e-commerce platforms, improving output quality. Digital monitoring builds consumer trust, forming a "sales-driven production" virtuous cycle that extends industrial chains and enhances efficiency, aligning with research on rural digitalization strengthening industrial chain connectivity.

4.2.2 Expanding Agricultural Multifunctionality

Rural digitalization fosters industrial diversification. Traditional agriculture expands into processing and tourism—e.g., tourism development around Kaiping Diaolou boosts related industries and farmer incomes. Emerging industries meet diverse consumer needs while enriching agricultural economic and cultural functions, promoting healthy rural industry integration.

4.2.3 Facilitating Agricultural Service Industry Integration

Digital platforms enable modern agricultural service systems through IT and management innovations, achieving efficient coordination in agricultural supply, technical services, and product sales. Farmers access information more conveniently, while enterprises precisely align with market demands, optimizing resource allocation to advance rural industry integration.

4.3 Mechanism of Industrial Chain Digitalization in Empowering Rural Revitalization

4.3.1 Boosting Industrial Prosperity

Industrial chain digitalization injects new momentum into rural industries, driving structural upgrades. Smart agriculture enables precision cultivation, improving product quality and yield. Deep processing and rural e-commerce broaden sales channels, enhancing industrial competitiveness to provide economic foundations for rural revitalization.

4.3.2 Advancing Ecological Sustainability

Digital technologies enable precision fertilization and irrigation, reducing pollution. Environmental sensors and big data facilitate real-time ecological monitoring and timely remediation. Clean energy projects improve rural energy efficiency and reduce carbon emissions, supporting eco-friendly rural development.

4.3.3 Optimizing Rural Governance via Digital Empowerment

Smart governance platforms enhance administrative responsiveness through a "villager-village committee-government" collaborative mechanism, reducing costs while establishing governance agency. Big data analytics and intelligent monitoring systems enable real-time tracking of public security and health, improving governance precision and timeliness to maintain rural stability.

5. Strategic Pathways for Digital Industrial Chains to Promote Rural Industrial Integration and Rural Revitalization

5.1 Focusing on Technological Innovation Applications to Drive Rural Digital Development

5.1.1 Strengthening R&D and Application of Digital Technologies

It is imperative to address key technological demands in agriculture and rural areas by increasing investment in digital agriculture R&D. Collaborative innovation mechanisms integrating industry, universities, and research institutes should be established to jointly tackle technical challenges such as precision monitoring of crop/livestock production, intelligent irrigation, and pest early warning systems. For instance, pilot agricultural IoT systems in demonstration zones can utilize multi-source sensor networks to monitor environmental parameters in real time, dynamically adjusting crop growth conditions to enhance yield and quality. Big data analytics on production and market data will inform scientific decision-making and market forecasting, improving agricultural adaptability.

5.1.2 Cultivating Digital Talent

Talent serves as the cornerstone of industrial chain digitalization. Multi-pronged approaches should be adopted:Vocational institutions should offer courses in digital agriculture and rural e-commerce to nurture interdisciplinary professionals;Hybrid online-offline training programs (via agricultural technology apps and live-streaming platforms) combined with on-site technical guidance will upskill existing rural labor in e-commerce operations, data analytics, and smart equipment utilization;Incentive policies such as entrepreneurship subsidies and tax incentives should attract returning migrant youth to inject vitality into rural digital transformation.

5.1.3 Accelerating Technology Commercialization

Establish technology transfer mechanisms to bridge innovation and application:Create agricultural technology transfer service platforms integrating resources from research institutions, enterprises, and cooperatives, offering information exchange, technical evaluation, and transaction services.Set up special funds to reward successful technology adopters while mitigating conversion risks.Encourage technology transfer agreements between enterprises and research institutes to expedite deployment of new technologies/equipment in rural industries.

5.2 Promoting Industrial Synergy to Advance Rural Integration

5.2.1 Building Tertiary Industry-Integrated Digital Ecosystems

Leveraging digital technologies as an innovative engine, this approach drives the holistic reconstruction of agricultural value chains. At the production end, smart sensors and IoT enable standardized cultivation practices, while the processing phase employs digital twin technology to revolutionize techniques and operational efficiency. In circulation, live-streaming e-commerce establishes digital marketing ecosystems. Concurrently, integrated innovation in agriculture-culture-tourism synergies is advanced through the deep development of rural cultural IPs, creating immersive rural tourism models that combine digital guided tours, specialty agricultural products, and intangible cultural heritage experiences, thereby generating synergistic value-added effects across interconnected industrial chains.

5.2.2 Innovating Collaborative Governance Mechanisms

Establish "R&D-Production-Sales" integrated digital ecosystems for specialty agricultural products:

Vertical Integration: Develop digital alliance platforms connecting producers, processors, and logistics providers, forming flexible "enterprise-cooperative-farmer" supply networks through smart contracts.

Horizontal Empowerment: Optimize production structures using big data-driven market-producer matching.

Value Extension: Implement blockchain-based traceability systems to enhance brand value through quality certification.

5.2.3 Fostering New Business Models

Develop smart agriculture demonstration bases featuring drone plant protection, intelligent irrigation, and product traceability.Promote innovative models like contract farming, shared agriculture, and adoption agriculture via digital platforms for personalized production.Integrate rural industries with digital finance through supply chain finance and e-commerce financial services to address funding constraints.

5.3 Improving Policy Support Systems for Rural Revitalization

5.3.1 Optimizing Policy Frameworks

Governments should formulate policies to support the digital transformation of rural industries. This includes introducing industrial support measures such as tax incentives and financial subsidies for enterprises and

cooperatives engaged in rural digital industries. Dedicated funds should be established to finance digital technology R&D, talent development, and infrastructure upgrades. Land use policies must be strengthened by prioritizing land quotas for rural digital projects. Additionally, market regulation frameworks should be optimized to standardize rural digital market operations, safeguard consumer rights, and ensure fair competition.

5.3.2 Enhancing Financial Support

Increase fiscal investments to secure the digital transformation of rural industries. Governments should annually raise fiscal allocations for rural digital infrastructure, technology R&D, and talent cultivation. Concurrently, financial institutions must be guided to amplify credit support through innovative products like specialized loans and digital supply chain financing. Expand financing channels by enabling rural digital enterprises to raise capital via bond issuance and IPO financing. Additionally, engage social capital by adopting public-private partnership (PPP) models to attract corporate investments in rural digital infrastructure and project development.

5.3.3 Upgrading Infrastructure

Strengthening rural digital infrastructure is pivotal. Governments should increase investments in rural telecommunications networks, logistics distribution systems, and data centers. Key measures include accelerating 5G network coverage to enhance bandwidth and stability, optimizing rural logistics networks by establishing county-township-village delivery hubs to improve agricultural product distribution efficiency, and advancing data center construction to integrate fragmented data resources. Simultaneously, digital retrofitting of traditional infrastructure—such as smart upgrades to farmland irrigation systems and agricultural machinery—should be prioritized to elevate intelligent agricultural production capabilities.

6. Conclusion

Under the strategic framework of digital economy empowering rural revitalization, industrial chain digitalization has emerged as the core engine driving the integrated development of primary, secondary, and tertiary industries in rural areas. Research indicates that it achieves industrial value enhancement by reconstructing the synergistic mechanisms across the entire "agriculture-processing-services" chain, leveraging large-scale investments in agri-cultural, cultural, and tourism projects, building eco-closed loops through high-coverage intelligent monitoring systems, and forming systematic solutions encompassing "digital governance, cultural dissemination, and employment-income growth." However, current progress remains constrained by structural challenges, including low cross-industry collaboration ratios reflecting fragmented industrial linkages, superficial technological penetration due to the limited proportion of fully digitized enterprises, and data utilization rates below industry averages. These issues urgently require breakthroughs through a three-dimensional pathway: "leading chain enterprises' traction + digital mid-platform construction + iterative policy toolkit optimization" to achieve qualitative and efficiency leaps.

Looking ahead, rural regions must prioritize industrial chain digitalization as the cornerstone, leveraging government-industry-university-research-application collaboration to drive systemic reforms. First, enhancing resource integration by pooling university and enterprise resources to cultivate targeted digital talent, thereby strengthening the foundation for technological transformation. Second, deepening tri-sector integration through agri-cultural, cultural, and tourism industry alliances to build resilient digital supply chain networks. Third, optimizing policy support by innovating infrastructure investments and financial instruments to reduce digital transition costs. This three-pronged approach will reinforce the scalability and regional adaptability of rural revitalization models, offering institutional solutions to dismantle urban-rural resource flow barriers. By advancing agri-cultural-cultural-tourism integration, upgrading digital infrastructure, and refining inclusive financial ecosystems, a "government-guided, market-driven, and society-engaged" development paradigm will emerge. This model crystallizes a replicable, universally applicable pathway for agricultural and rural modernization, providing empirical insights for regions striving to transcend urban-rural dual structures.

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