

Research on the Real Dilemmas and Optimization Strategies of Agricultural Digital Transformation under the Background of Rural Revitalization

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Abstract: Rural revitalization is the overarching guiding principle for agricultural work in the new era. Agricultural digitalization, as a core business model deeply integrating the digital economy with modern agriculture, is a crucial lever for cultivating new agricultural productivity, promoting agricultural industrial upgrading, and achieving agricultural and rural modernization. This paper, based on the five dimensions of rural revitalization, elucidates the contemporary value of agricultural digital transformation, systematically analyzes the core dilemmas and underlying causes in the transformation process, and, combined with the realities of agricultural and rural development, proposes targeted optimization strategies from five aspects: infrastructure, talent development, data integration, entity activation, and institutional guarantees. The aim is to break through the bottlenecks of agricultural digital transformation, promote the transformation of traditional agriculture towards digitalization, intelligence, and greening, and provide theoretical reference and practical support for comprehensively advancing rural revitalization and accelerating agricultural and rural modernization.

Keywords: Rural revitalization, Agricultural digitalization, Transformation and development, Current challenges, Optimization strategies.

1. Introduction

The digital economy has become a core driving force for China's high-quality economic development, and the widespread application of digital technologies is profoundly reshaping the development of agriculture and rural areas. Traditional agriculture has long suffered from shortcomings such as extensive production methods, high resource consumption, weak risk resistance, and low added value in the industrial chain. The small-scale farming model, relying on experience and the weather, is no longer suitable for the development requirements of agricultural modernization and rural revitalization in the new era. Against this backdrop, promoting the digital transformation of agriculture has become an inevitable choice for addressing the pain points of rural development, revitalizing rural industries, and consolidating the foundation for rural revitalization [1].

The state attaches great importance to the construction of digital agriculture and digital villages, and has successively issued policy documents such as the "Digital Village Development Action Plan (2022-2025)" and the "14th Five-Year Plan for Digital Economy Development," which clearly require the promotion of the deep integration of digital technology with agricultural production, operation, management, and services, so as to empower the comprehensive revitalization of rural areas through agricultural digitalization. Under the guidance of policies and driven by the market, digital projects such as smart farmland, agricultural product traceability platforms, and rural e-commerce have been continuously implemented in various regions, and new forms of agricultural digitalization are constantly emerging.

Rural revitalization encompasses four core directions: industry, talent, ecology, and organization. Agricultural digitalization can comprehensively empower the coordinated advancement of rural revitalization. However, at present,

China's rural areas exhibit significant regional development disparities, with small-scale, fragmented farming being a prominent characteristic. The urban-rural digital divide has not yet been eliminated, and agricultural digitalization construction generally suffers from problems of "emphasizing construction over application, and focusing on form over substance." Numerous deep-seated challenges hinder transformation, quality improvement, and efficiency enhancement. Based on this, this paper systematically reviews the value and dilemmas of agricultural digital transformation and constructs a scientifically feasible optimization path, which has significant practical implications for promoting high-quality agricultural development and assisting in the comprehensive revitalization of rural areas.

2. The Contemporary Value of Agricultural Digital Transformation in the Context of Rural Revitalization

2.1. Empowering Industrial Revitalization and Promoting High-Quality Agricultural Development

A thriving industry is the core foundation of rural revitalization. Traditional agriculture in my country is characterized by extensive management practices, with indiscriminate use of water, fertilizer, and pesticides at the production end, resulting in low resource utilization; processing at the processing end is mainly primary processing with low added value; and information asymmetry between production and sales at the distribution end leads to frequent unsold products and weak industrial competitiveness. Agricultural digitalization can restructure the entire agricultural industry chain, achieving quality improvement,

efficiency enhancement, and upgrading. In the production stage, the Internet of Things, intelligent agricultural machinery, and dynamic monitoring equipment can achieve precision fertilization, irrigation, and plant protection, significantly reducing production costs, improving production efficiency, and promoting green production. In the processing stage, intelligent sorting and advanced processing digital technologies effectively extend the industry chain and increase the premium value of agricultural products. In the distribution stage, e-commerce platforms, live-streaming sales, and smart logistics break down geographical and information barriers, opening up direct sales channels, solving the problem of unsold agricultural products, and comprehensively activating the driving force for rural industrial development [2].

2.2. Supporting Talent Revitalization and Cultivating New Agricultural Business Entities

Talent is the primary resource for rural revitalization. An aging workforce, low skills, and severe brain drain are core bottlenecks hindering agricultural development. Traditional agriculture is labor-intensive with low technical barriers, making it difficult to cultivate specialized management talent. Agricultural digitalization is driving the transformation of agriculture from a labor-intensive to a technology- and knowledge-intensive industry, creating new positions such as intelligent agricultural machinery maintenance, agricultural data analysis, e-commerce operations, and brand digital operations. These positions offer significantly improved salaries and career development opportunities, effectively attracting young talent and college graduates to return to their hometowns to start businesses. Simultaneously, regular digital skills training can sustainably improve the digital literacy of traditional farmers, promoting their transformation into new types of professional farmers who understand technology, know how to operate, and are good at management, thus laying a solid foundation for rural talent revitalization.

2.3. Promote Ecological Revitalization and Practice the Concept of Green Agricultural Development

Ecological livability is a crucial goal of rural revitalization. The excessive use of chemical fertilizers and pesticides in traditional agriculture not only wastes agricultural resources but also causes ecological problems such as soil pollution and eutrophication, hindering sustainable rural development. Digital agriculture, relying on precision agriculture technology, can accurately deliver agricultural inputs based on crop growth needs, reducing pollutant emissions at the source and lowering agricultural non-point source pollution. Simultaneously, remote sensing and IoT dynamic monitoring technologies can monitor farmland ecology, water and soil resources, and pest and disease dynamics in real time, providing precise data support for farmland protection, ecological restoration, and pollution control. This promotes the transformation of agriculture from extensive and resource-intensive to green and intensive, building an eco-friendly and sustainable modern agricultural system and solidifying the foundation for rural ecological revitalization [3].

2.4. Strengthen Organizational Revitalization and Improve the Level of Modernization of Rural Governance

Organizational revitalization is the fundamental guarantee for the comprehensive revitalization of rural areas. Traditional rural governance suffers from problems such as information lag, cumbersome procedures, inefficient services, and poor communication between cadres and the masses. Agricultural digitalization promotes the digital upgrade of rural governance. By building an integrated digital governance platform, functions such as agricultural supervision, product traceability, policy application, public services, and feedback are integrated, enabling online and intelligent handling of rural governance matters, simplifying governance processes, and reducing governance costs. At the same time, the digital platform breaks down information barriers between the government, village collectives, farmers, and market entities, achieving resource sharing, policy transparency, and rapid response to requests, effectively strengthening the service capacity and governance efficiency of grassroots organizations, and consolidating the institutional and practical foundation for rural organizational revitalization.

3. The Real Challenges of Agricultural Digital Transformation under the Background of Rural Revitalization

3.1. Uneven Distribution of Digital Infrastructure and Weak Hardware Support Capabilities

Digital infrastructure is the prerequisite for the digital transformation of agriculture. Currently, the imbalance of infrastructure between urban and rural areas and between different regions in my country is a prominent issue. While digital networks are fully covered in cities and suburban villages, remote mountainous areas and traditional agricultural production areas generally suffer from weak 5G signals, numerous network blind spots, and insufficient base stations. Some farmland and livestock bases also lack adequate power and network infrastructure, making it impossible to support the routine operation of intelligent monitoring and unmanned agricultural machinery. Data shows that the effective 5G coverage rate in remote rural farmland in western my country is less than 30%, the deployment density of agricultural IoT terminals is extremely low, and an integrated agricultural monitoring network has not yet been fully established, resulting in inaccurate and untimely data collection and updates [4].

Meanwhile, rural infrastructure generally suffers from the problem of "emphasizing construction but neglecting operation and maintenance." In most areas, only basic hardware has been built, lacking a regular maintenance and upgrade mechanism. Equipment is aging, malfunctions are frequent, and the idle rate remains high. In addition, the investment cost of agricultural digitalization hardware and software equipment is high, and the payback period is long. Small and medium-sized farmers and small cooperatives have weak financial strength and cannot afford the transformation costs. Moreover, most existing equipment is adapted to civilian scenarios, and there is a shortage of dedicated digital facilities for agricultural production. Insufficient hardware

compatibility has become the primary bottleneck for digital transformation.

3.2. Imbalance Between Supply and Demand for Digital Talent and Lack of Talent Support System

The shortage of multi-skilled digital agriculture professionals is a core pain point hindering the transformation. Agricultural digitalization requires practitioners to possess both agricultural expertise and digital technology skills, but currently, there is a severe mismatch between talent supply and market demand. The scale of talent training in digital agriculture-related majors in universities is limited, and the output of talent lags behind the industry's development needs. At the same time, digital technology professionals prioritize high-paying urban positions, making rural grassroots positions less attractive. The proportion of multi-skilled digital agriculture professionals at the grassroots level is extremely low, and the talent gap continues to widen.[5]

From the perspective of existing practitioners, agricultural operators are mainly middle-aged and elderly farmers with low levels of education and weak digital literacy. They have low acceptance and insufficient operational skills regarding smart devices, big data platforms, and online business models, facing the problem of "not knowing how to use them and being afraid to switch." The rural digital training system is incomplete, with training content divorced from production realities, lacking variety in format, and with weak practical application. The training coverage rate is less than 30%, making it difficult to effectively improve farmers' skills. At the same time, the rural talent incentive and security mechanisms are imperfect, with limited salaries and development opportunities, resulting in a prominent problem of talent loss and creating a vicious cycle of talent shortage and lagging transformation.

3.3. Agricultural Data Resources Are Fragmented, Making It Difficult to Realize the Value of the Data

Data is a core production factor in digital agriculture. Currently, agricultural data in my country generally suffers from fragmentation, silos, and underutilization. Various agricultural departments have independently built data platforms, resulting in a lack of data sharing between departments such as agriculture and rural affairs, meteorology, water resources, and market supervision. There are significant departmental barriers and a lack of unified standards for data collection, storage, and sharing. Grassroots data collection equipment has low coverage and is scattered, resulting in data that is limited in scope, lacks accuracy, and is outdated, failing to comprehensively reflect the true state of agricultural industry development.

At the data application level, most agricultural digital platforms have limited functions, focusing only on online sales of agricultural products and lacking full-chain digital service capabilities. The massive amounts of raw agricultural data lack professional mining, analysis, and utilization, failing to provide data support for production decisions, industry planning, and risk control, resulting in a serious waste of data resources. Simultaneously, the agricultural data security system is incomplete, lacking standardized management systems and protection technologies, leading to significant risks of data leakage, tampering, and misuse,

further restricting the release of the value of data elements.

3.4. Business Entities Lack Motivation and Have a Weak Willingness to Participate in Digitalization

Various agricultural business entities are the main implementers of digital transformation, but their overall enthusiasm for transformation is generally low. Small and medium-sized farmers, as the core business entities, have small-scale operations and are highly decentralized. They are deeply rooted in traditional small-scale farming thinking, lack understanding of digital transformation, and believe that digital equipment requires high investment, carries high risks, and has slow returns. They rely on traditional farming experience and have a weak willingness to actively transform.

Most new agricultural business entities, such as family farms and cooperatives, are small in scale, lack sufficient capital and technological reserves, and have limited capacity for independent digital upgrading. Regional leading agricultural enterprises are few in number and have weak radiating and driving capabilities, making it difficult to form a large-scale, collaborative transformation pattern. At the same time, the long return cycle for agricultural digital transformation, coupled with risks such as natural disasters and market price fluctuations, further reduces the willingness of these entities to transform. Furthermore, existing digital equipment and platforms are mostly designed for large-scale farms, are complex to operate, have poor adaptability, do not conform to the production habits of small and medium-sized farmers, and have too high a barrier to entry, making it difficult to implement digital technologies [6].

3.5. Policy and Institutional Safeguards Are Lagging Behind, And the Environment for Transformation and Development is Limited

A sound policy system is crucial for digital transformation, but the current policy framework has significant shortcomings. At the national level, digital agriculture policies are mostly macro-level guiding documents, lacking detailed implementation rules and assessment standards. Local governments often simply copy policies from higher levels without developing differentiated solutions tailored to local agricultural characteristics, resulting in insufficient policy adaptability and operability. Furthermore, policies from various agricultural departments are fragmented, lacking coordination and collaboration, making it difficult to form a unified force for transformation.

In terms of funding, the scale of special fiscal support funds is limited, with a focus on large-scale pilot projects and leading enterprises, leaving small and medium-sized business entities struggling to obtain financial support. The rural financial service system is lagging behind, with a scarcity of special loans and insurance products for digital agriculture, highlighting the difficulties and high costs of financing for farmers. Regarding regulatory incentives, industry standards and operational norms for agricultural digitalization are still incomplete, leading to frequent market irregularities. Furthermore, the lack of positive incentive mechanisms and insufficient support for entities with outstanding transformation achievements hinders the full mobilization of market enthusiasm, and the overall business environment for transformation needs optimization.

4. Optimization Strategies for Agricultural Digital Transformation under the Background of Rural Revitalization

4.1. Coordinate Infrastructure Construction and Strengthen Digital Hardware Support

To address the uneven development and insufficient adaptability of rural digital infrastructure, it is necessary to precisely address shortcomings and strengthen weaknesses. First, we must promote balanced development of urban and rural digital infrastructure, increase funding for remote villages and specialty agricultural production areas, improve basic infrastructure such as 5G networks, gigabit broadband, and smart grids, and eliminate network coverage blind spots. In conjunction with the development of major grain-producing areas and specialty agricultural product bases, we should deploy dedicated IoT devices for soil monitoring, pest and disease early warning, and product traceability, and build an integrated agricultural dynamic monitoring network to ensure accurate and comprehensive data collection.

Second, establish a routine operation and maintenance mechanism, clarify the responsibilities of the government, enterprises, and village collectives, and regularly conduct equipment inspections, system upgrades, and troubleshooting to prevent equipment from becoming idle and aging, and improve equipment utilization. Third, reduce transformation costs by lowering the application costs of digital equipment through government subsidies, bulk purchases, and equipment leasing, and launching inclusive support policies for small and medium-sized farmers. At the same time, encourage technology companies to develop specialized equipment adapted to small and medium-sized agricultural production scenarios, improve hardware compatibility, and solidify the hardware foundation for digital transformation.

4.2. Building a Diversified Talent System and Strengthening Digital Talent Support

Addressing the pain point of talent shortage, we are building a three-pronged talent system encompassing "cultivation, introduction, and retention." First, we are deeply committed to cultivating local talent by establishing a tiered, hands-on training system. For ordinary farmers, we provide basic training in smart equipment operation and e-commerce management; for new business entities, we offer advanced training in big data analysis, digital management, and brand operation. We employ field practice, case studies, and one-on-one guidance to enhance training effectiveness and comprehensively improve farmers' digital literacy.

Second, we will precisely attract professional talent, introduce special support policies for rural digital talent, and provide preferential treatment in areas such as salary subsidies, housing security, and entrepreneurship support to attract college graduates and digital technology experts to return to their hometowns for employment. We will deepen cooperation between universities and local governments, and between universities and enterprises, and establish a targeted training and delivery mechanism for digital agriculture talent to ensure a continuous supply of talent. Third, we will improve the talent incentive and retention mechanism, facilitate talent promotion channels, establish special reward funds to recognize outstanding digital practitioners, build a platform for technological innovation and achievement

transformation, optimize the rural talent development environment, and create a multi-skilled agricultural digital talent team.

4.3. Integrate the Data Resource System and Activate the Value of Digital Elements

With the core objective of breaking down data barriers and unlocking the value of data, we will improve the agricultural big data application system. First, we will establish a unified county-level agricultural big data sharing platform to integrate data resources from various agricultural departments, unify data collection, storage, and sharing standards, break down departmental data silos, and achieve interconnectivity of production, meteorological, market, traceability, and policy data. We will also optimize grassroots data collection equipment and technologies to build a dynamically updated, accurate, and comprehensive agricultural big data database.

Second, we will deepen the application of data scenarios and improve the platform's full-chain service functions. Relying on big data and artificial intelligence technologies, we will accurately analyze crop growth, pest and disease patterns, and market supply and demand changes, providing data support for agricultural production, industrial planning, and risk prevention and control. We will also build a full-process traceability system for agricultural products using blockchain technology to ensure product quality and safety and enhance brand competitiveness. Third, we will improve the data security system, clarify the rights and responsibilities for data use, and utilize encryption and risk warning technologies to prevent data leakage and misuse, building a safe and standardized data application environment and fully releasing the empowering value of data elements [8].

4.4. Activate the Vitality of Market Entities and Enhance the Endogenous Driving Force for Transformation

Focusing on various business entities, we will comprehensively activate the endogenous driving force for digital transformation. First, we will strengthen publicity and guidance by popularizing the policy dividends and income-increasing effects of digital transformation through field lectures, case demonstrations, and short video popularization, breaking farmers' traditional small-scale farming mindset, dispelling their concerns about transformation, and enhancing their awareness of proactive transformation.

Second, we will leverage the leading role of key agricultural enterprises and exemplary cooperatives to take the lead in completing digital upgrades and creating digital agriculture demonstration bases. Through technical assistance and resource sharing, we will encourage small and medium-sized farmers to collectively transform their businesses. We will promote the "leading enterprise + cooperative + farmer" model to integrate scattered production resources, achieve large-scale, standardized, and digitalized production, and reduce the transformation costs and risks for individual households.

Third, optimize the supply of products and services, guide technology companies to develop user-friendly and cost-effective digital equipment and platforms to lower the barriers to entry. Establish a regular on-site guidance and after-sales maintenance service mechanism to promptly resolve application difficulties and continuously improve the effectiveness of digital technology implementation [7].

4.5. Improve the Policy and Institutional System and Optimize the Environment for Transformation and Development

Establish a comprehensive and implementable policy support system to safeguard digital transformation. First, refine implementation policies. Local governments should formulate special development plans for digital agriculture based on their local agricultural characteristics and resource endowments, detailing transformation goals, tasks, and assessment standards. Establish multi-departmental linkage mechanisms to strengthen policy coordination and address the problems of fragmented policies and difficulties in implementation.

Second, we will strengthen financial support, expand the coverage of special fiscal subsidies, and focus on grassroots and small and medium-sized business entities. We will innovate rural financial services, launch special loans for digital agriculture and agricultural insurance products, optimize approval processes, and lower financing thresholds. We will improve the agricultural risk-sharing mechanism, add special insurance products for digital transformation, and effectively share operational risks.

Third, we will regulate the industry's development order, formulate technical standards and operational norms for agricultural digitalization, and severely crack down on market irregularities such as false advertising and substandard products. We will establish a positive incentive mechanism to reward and provide policy support to regions, enterprises, and farmers with outstanding transformation results, creating a favorable transformation environment guided by the government, driven by the market, and with the participation of all citizens.

5. Conclusion

Digital transformation of agriculture is an inevitable trend in agricultural modernization in the digital economy era, and a core measure to empower the comprehensive revitalization of rural areas and cultivate new agricultural productivity. The deep integration of digital technology with the entire agricultural industry chain can effectively address the shortcomings of traditional extensive agricultural development, and has significant value in areas such as industrial upgrading, talent cultivation, ecological protection, and rural governance. It is a key path to promote high-quality agricultural development.

While my country's agricultural digital transformation has achieved initial success, it remains in its early stages. Multiple challenges, including weak infrastructure, a significant talent gap, fragmented data resources, insufficient motivation among agricultural stakeholders, and lagging institutional safeguards, are intertwined and hinder the transformation's improvement in quality and efficiency. To promote high-

quality development of agricultural digitalization, we must adhere to a problem-oriented approach, focus on the overall development of rural revitalization, and implement systematic measures across five dimensions: addressing hardware shortcomings, cultivating talent, activating data value, stimulating the vitality of agricultural stakeholders, and improving institutional safeguards. This comprehensive approach will effectively overcome the bottlenecks in the transformation.

In the future, with the continuous iteration of digital technology, the constant improvement of policy systems, and the sustained efforts of market entities, agricultural digitalization will be deeply integrated into the entire process of agricultural production and operation and rural governance, continuously releasing new momentum for agricultural development, promoting the comprehensive leap of traditional agriculture towards digitalization, intelligence, greening, and modernization, and providing solid support for the comprehensive revitalization of rural areas and the modernization of agriculture and rural areas.

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